

Annex II bis

Asian highway design standards for road safety*

I. Preface

This document shall be read in conjunction with other documents forming the Intergovernmental Agreement on the Asian Highway Network.

The contents of this document are structured in the following wording:

- “Shall” and “shall not” give mandatory requirements
- “Should” and “should not” give recommendations which are expected to be adopted unless there is a strong reason otherwise
- “May” and “need not” indicate potentially desirable options depending on circumstances

Asian Highway network member countries shall make every effort to comply with the design standards and are encouraged to give thorough consideration in adopting the recommendations given in the related design guidelines.

Member countries are encouraged to ensure that new roads of the Asian Highway network are 3-star or better (based on star ratings of the International Road Assessment Programme) for all road users and that more than 75 per cent of travel on existing roads is 3-star or better for all road users.

Member countries shall undertake road safety audit for road improvement projects in the Asian Highway network. Member countries shall also conduct road safety inspection (also known as road safety audit in some countries) for designated Asian Highway routes, within a reasonable time frame and at regular intervals, in accordance with practices in the respective countries.

Road safety infrastructure facilities shall be provided in the network with the view of optimized provision and consistency. The need for adequate flexibility is acknowledged given the existing road conditions and diverse circumstances among member countries.

Adequate attention should be given to the integration of road safety infrastructure facilities with streetscape design and the landscape as well as mitigation of any adverse impacts on the environment.

Countries shall take advantage of the following road improvement projects and activities to elevate road safety in the Asian Highway network:

- Online road improvement or upgrading projects
- New bypass projects
- New addition of roads to the Asian Highway network
- Dedicated road safety improvement projects
- Routine maintenance activities

Where design speed or speed limit are quoted as criteria, due consideration should be given to the actual operating speeds of traffic.

The terms “nearside” and “offside” refer to the right side and left side respectively in the direction of travel where driving is on the right side of a

road. They refer to the left side and right side respectively in the direction of travel where driving is on the left side of a road. Nearside and offside are equivalent to passenger side and driver side respectively.

It is at the liberty of member countries and other bodies to make use of this document for roads other than Asian Highway routes.

II. General requirements

A. Principles

The “Safe System” approach is adopted in this document to enhance road safety for the Asian Highway network. This approach consists of both active and passive measures, taking into account the frailty of human beings to making errors and their limited tolerance of injury to impact forces in a collision.

Active measures aim to reduce the likelihood of crashes with specific facilities, reduction of exposures and conflicts, provision of adequate visibility and promotion of self-explaining road design. Passive measures aim to help drivers rectifying momentary errors and to minimize the severity of injuries in a crash through forgiving roadside designs. For all these measures, speed management has a core role.

The role of road safety education, enforcement and vehicle safety standards, which is beyond the scope of this document, is also of paramount importance.

B. Road types

The mode of operation for each Asian Highway class shall be in accordance with table 1.

Table 1

<i>Mode of Operation</i>	<i>Primary Class</i>	<i>Class I</i>	<i>Class II</i>	<i>Class III</i>
Access control	Yes	No ¹	No ¹	No
Stopping and parking on the roadside	X	Yes ^{1,2}	Yes ²	Yes ²
At-grade intersections	X	Yes ¹	Yes ¹	Yes
Pedestrians	X	Yes ¹	Yes ¹	Yes
Slow vehicles ³	X	Yes ¹	Yes ¹	Yes
Agricultural vehicles, low power motorcycles and mopeds	X	Yes ¹	Yes ¹	Yes

¹ unless designated for access-controlled operation

² subject to road conditions and regulations

³ bicycles, electric bicycles, animal-drawn carts, animal herds etc.

X not permitted

Primary class roads and access-controlled Class I roads shall be signed as expressways or express roads for the exclusive use of motor vehicles.

Road classes and functions shall be clearly recognizable to road users

with consistent design characteristics. A review of classification should be undertaken from time to time to address changing usage of Asian Highway routes with the view of timely upgrading of safety facilities.

Land-use planning is an important factor for road safety along Asian Highway routes. Efforts should be made to limit the proliferation of ribbon developments, frontage activities and direct frontage accesses as these could adversely undermine road safety.

C. Overall framework

The overall framework of road safety infrastructure safety facilities is set out in table 2.

Further requirements are given in section III of this document.

Table 2

Topics	Highway classification	Primary ¹				Class I			Class II				Class III			
	Design speed (km/h)	120	100	80	60	100	80	50	80	60	50	40	60	50	40	30
Road infrastructure	Curve	Coordination of neighbouring curve radii				Avoidance of isolated sharp curves			Avoidance of isolated sharp curves; hairpins subject to comprehensive treatments							
	Overtaking section	Possible restriction for unfavourable alignment and tunnel							Systematic overtaking management							
	Long steep grade	Strategic measures				Comprehensive measures			Comprehensive measures depending on circumstances							
	Climbing lane	Climbing lane subject to conditions							Continuous or discrete climbing lane subject to conditions							
	Parking facility	Service area/rest area/emergency layby				Possible service area for Class I roads, rest area/parking layby/emergency layby/bus facility/filling station										
Roadside safety	Roadside	Clear zone or safety barrier with transition and end treatment							Clear zone or safety barrier with transition, end treatment particularly at curves							
	Median	Wide median or median safety barrier				Median with segregation and/or safety barrier			Wide centreline		Centreline					
	Intersections	Clear zone or crash cushion at diverge gores				Possibly clear zone at intersections										
Intersections	Priority intersection	Not applicable				Protected offside turn lane subject to conditions			Protected offside turn lane generally appropriate							
	Side road Channelization island					Side road channelization island generally appropriate										
	Roundabout					Roundabout subject to conditions			Roundabouts generally appropriate at major intersections and crossroads							
	Signalized intersection					Signalized intersection generally appropriate at major intersections and crossroads										
	U-turn facility					Systematic provision of U-turn facilities			U-turn opportunities as needed							
	Grade-separation	Grade-separation only				Grade-separation desirable at higher traffic volume			Generally not applicable							
Pedestrians, slow vehicles and traffic calming	Pedestrian footpath	Not applicable				Footpath where pedestrians are present, segregated footpaths for high traffic speeds or traffic volume										
	Pedestrian/slow vehicle crossing	Grade-separated				Grade-separated or signalized			Signalized/pedestrian priority/uncontrolled crossing, possibly with central refuge island							
	Slow vehicle route	Not applicable				Segregated track or service roads for high traffic speeds or traffic volume, slow vehicle lanes for lower traffic speeds and volume, mixed traffic for very low traffic speeds or very low traffic volume										
	Motorcycle lane	Possible exclusive motorcycle lanes				Possible non-exclusive motorcycle lanes										
	Traffic calming	Not applicable				Traffic calming schemes, possibly with vertical speed reduction facilities within built-up areas										
Delineation	Delineation	Line marking for all roads, chevron signs/delineators/raised pavement markers subject to conditions														
	Rumble strip	Edge line/transverse rumble strips desirable				Edge line/centreline/transverse rumble strips if deemed appropriate and at curves										
	Road lighting	Road lighting if deemed appropriate within built-up areas/at intersections/with frequent pedestrians or slow vehicles at night-time, road lighting needed for toll plazas/tunnels/special bridges/border control points etc.														

¹ Considerations for Primary class roads are also applicable to access-controlled Class I roads.

III. Specific requirements

A. Road network

Asian Highway routes shall have homogeneous characteristics over a sufficiently long section of road. Changes of road class, design speed or speed limit shall be located at a change in road environment or conditions which is obvious to drivers. Examples are approach to built-up areas, boundaries of topography, intersections, toll plazas, border control points etc.

1. Network development

The Asian Highway network has an important role as international transport linkages and key regional road corridors. For both efficiency and safety, the network over time preferably consists of Primary class, Class I or Class II roads and desirably, access-controlled roads. If mixed usage or conflicts with local traffic, pedestrians and slow vehicles cannot be avoided, adequate measures shall be formulated to minimize the safety risks.

2. Bypass of population centres

Bypasses should be planned around cities along Asian Highway routes. They should also be planned around major towns and villages where through traffic poses excessive safety risks. Bypasses are preferably in the form of access-controlled roads, otherwise the number of accesses should be limited.

3. Interfaces

At the interface between road improvement projects and existing roads, a transition zone shall be introduced and designed to encourage drivers adapting their speeds and behaviour accordingly. Such interfaces shall not be located where the existing road geometry is significantly inferior to the new road.

Where a Primary class road or access-controlled Class I road terminates onto a road of lower class or lower design speed or at an intersection, particular attention shall be given to the design of the transition zone. Appropriate treatments generally include changes to cross-sections and visual appearance of the road which are obvious to drivers in conjunction with advance “end of expressway” signs, warning signs and speed reduction measures etc.

4. Speed limits

Speed limits shall be consistently applied for roads of similar characteristics and should be conceived by drivers to be reasonable. Preferably national speed limits are set for access-controlled roads, roads outside built-up areas and roads within built-up areas. Such speed limits may be raised or lowered for individual roads to accord with operating considerations and safety risks. The default speed limit through densely populated built-up areas should not exceed 50km/h.

B. Road infrastructure

1. Visibility

Adequate visibility shall be provided to ensure that road users are able to see and react to road layouts, road features, pavement conditions and manoeuvres of other road users. Visibility requirements, which are based on appropriate observer eye-heights, target heights and reference positions, encompass but are not limited to the following categories:

- Forward visibility
- Overtaking visibility
- Visibility at intersections, signalized intersections, merges and diverges
- Visibility towards road features including tunnels, toll plazas, escape ramps, laybys, traffic islands etc.
- Visibility towards pedestrian and slow vehicle crossings
- Visibility towards road signage

2. Shoulders

Shoulders may consist of two portions, namely paved shoulder and verge (unpaved shoulder). Verges should be hardened and stabilized, and may be grassed or laid with gravels.

The width of paved shoulders shall not be smaller than 0.25m for the proper placement of edge line marking. A much larger width is generally recommended at higher traffic speeds, for access-controlled roads and to accommodate slow vehicles.

Outside built-up areas adequate horizontal clearance (setback) shall be provided for roadside objects including safety barriers with respect to the edge of carriageway and the outside of the paved shoulder. This is subject to additional criteria pertaining to shoulder widths, clear zones and vehicle restraint systems.

3. Changes in cross-sections

Where there is a significant change in cross-section or a reduction of traffic lanes at high traffic speeds, a transition zone shall be provided to assist drivers adapting to the changes.

Where cross-sections are redistributed on urbanized sections to facilitate pedestrians, slow vehicles, local traffic or for traffic calming purposes, the reasons for the changes shall be obvious and supported by signs, markings and traffic calming measures.

4. Overtaking

Overtaking opportunities shall be systematically provided and uniformly distributed on Classes II and III roads. Overtaking zones and non-overtaking zones should, as far as possible, be clear-cut in terms of overtaking visibility distance. These zones shall be clearly delineated by centreline marking systems consisting of solid lines and dotted lines.

Overtaking should be restricted or discouraged on narrow bridges or viaducts and road sections with heavy traffic.

5. Pavement drainage

Adequate pavement drainage shall be provided to avoid ponding and aquaplaning. At transitions between pavement slope (i.e. crossfall or camber) and superelevation, the pavement shall not consist of a large area of flat gradients or kinks.

6. Sharp curves

Sharp curves shall be avoided on new roads, especially where they are used at isolated sites, along steep gradients or around a substandard crest profile. Curves of smaller radii should, as far as possible, be preceded by curves of larger radii in ratio not exceeding 1:1.5 in both traffic directions.

On the approach to sharp curves which are not conspicuous or where substantial reduction in speeds is required, curve signing systems based on curve warning sign, delineator and chevron sign shall be provided to assist traffic safely negotiating the curves. The level of signing should reflect the severity of the curves and be consistently applied along a route.

Additional treatments including clear zones, visibility enhancement, high friction surfacing, correction of superelevation etc. may be applied.

Where hairpins are unavoidable on Classes II and III roads, they shall be conspicuous and clearly visible on the approach. Particular attention should also be given to curve widening, signing and roadside safety. Hairpins should not be adopted for divided roads and wherever there is more than one traffic lane in one direction.

7. Steep downhill gradients

On Primary class, Classes I or II roads and where appropriate Class III roads with continuous long steep downhill gradients, i.e. average gradient > 3% with level difference >130m or otherwise determined, the safety risk of brake failure of heavy vehicles shall be adequately mitigated by:

- A self-explaining road alignment
- Avoidance of critical curves which an out-of-control vehicle may fail to negotiate
- Avoidance of short sections of gentle gradients between steep sections on divided roads
- Avoidance of intersections, tunnels as well as facilities and conditions requiring traffic to stop or slow down substantially
- Avoidance of built-up areas along critical sections of the road

A long steep grade management strategy shall be formulated and should consist of the following measures:

- Steep grade signing systems
- Inspection areas, laybys or auxiliary lanes
- Escape ramps, if deemed appropriate, and associated signing
- Enhanced safety barriers

8. Climbing lanes

Climbing lanes should be provided where slow-moving vehicles result in unacceptable traffic queues and risky overtaking manoeuvres. Climbing lanes may be continuous or in discrete sections.

Key considerations for the need of climbing lanes are:

- Moderate to high volume of traffic and/or heavy vehicles
- Large speed differentials
- Poor level of service on the gradient
- Substantial reduction of level of service on the approach

9. Parking areas

Parking laybys, emergency laybys, service areas, rest areas and filling stations shall be provided at regular intervals and on a strategic basis along Asian Highway routes. The need of temporary shelters for motorcyclists should be considered in areas with frequent heavy rains.

Bus stop facilities should be provided with the following considerations:

- In the proximity where passengers wish to board or alight from a bus
- Traffic calming with well-connected footpaths and pedestrian crossings
- Adequate space, shelter and protection for waiting passengers
- Adequate length of kerbside
- Minimal interference to traffic on the main road and at intersections

The proliferation of roadside stalls should be regulated along road sections of high traffic speeds outside built-up areas. Safety risks may be reduced through roadside widening and traffic calming.

10. Other issues

On the approach to toll plazas, adequate measures shall be provided to alert approaching drivers and to reduce their speeds progressively.

An emergency access strategy shall be formulated for Primary class roads and tunnels to facilitate efficient response to incidents. The safety risks of illegal U-turns, errant vehicles crossing over and end terminals of safety barriers should be adequately mitigated at median openings.

Where the side of driving changes after a border control point, adequate measures shall be provided to alert drivers and to assist them adapting to the change.

Where conflicts between traffic and animals constitute a safety problem, appropriate measures shall be implemented to minimize the risks. These measures may include warning signs, fences and/or grade-separated animal crossings.

C. Intersections

Intersections shall be planned on a network and route-wide basis with consistent patterns and design. Asian Highway routes normally shall have priority at intersections except at interchanges, roundabouts and where dictated by traffic volume or the road network. Table 3 is a summary of appropriate intersection types outside built-up areas.

Table 3

		<i>Intersecting Road*</i>			
		<i>Primary class**</i>	<i>Class I</i>	<i>Class II</i>	<i>Class III or below</i>
Asian Highway Route	Primary class**	I	I, G	G	G, N
	Class I	G	G, S, R	S, R, U, (G, P)	S, R, U, N (G, P)
	Class II	G	G, S, R	S, R, P	S, R, P
	Class III or below	G	G, S, R	S, R, P	S, R, P

* based on Asian Highway network road classification

** including access-controlled Class I roads

() usage may be justified in some circumstances

I: Interchange (free flow)

U: U-turn facility

P: Priority intersection

G: Grade-separated intersection

S: Signalized intersection

N: Grade-separated crossing without connection

R: Roundabout

Intersections should be located on straight and relatively level sections of a road with good visibility and should be spaced well apart outside built-up areas.

The possibility of phased implementation of grade-separated intersections should be considered for Class I roads with adequate allowance in the alignment and right of way.

Channelization should be adopted at higher traffic volume to regulate the paths of different traffic streams and to reduce the risk of collisions.

Side road traffic shall be adequately alerted and slowed down on the approach to an intersection. Side roads should have gentle gradients at their intersection with the main road in order to reduce the risk of overshoot or slow manoeuvre.

The layout of priority intersections shall be simple, consistent and readily understood by drivers. They shall be designed to encourage turning or crossing traffic to slow down and give way to main road traffic. The following priority intersection layouts should not be adopted:

- Layouts with excessive pavement area or corner radii
- Layouts with more than four branches
- Addition of through traffic lanes ahead of the intersection
- Channelization which encourages offside turning in a smooth and generous path
- Complex channelization layouts
- Skewed, tangential or Y intersections
- Multi-lane side roads directly terminating at or crossing a two-lane main road

1. Priority intersections on Class I roads

Priority intersections with median openings should not be adopted on Class I roads where:

- Speed limit is 80km/h or above
- There are three or more traffic lanes in either direction
- Traffic is heavy and uninterrupted

Where such priority intersections are deemed appropriate, the median should be widened to permit the prevailing vehicle types to turn in two steps.

Crossroad priority intersections should be avoided on Class I roads and shall not be permitted where:

- There are three or more traffic lanes in either direction
- The median is not wide enough to permit the prevailing vehicle types to cross in two steps

2. Direct frontage accesses

Direct frontage accesses should be stringently controlled in terms of density, traffic generation and usage by heavy vehicles. This may be achieved by grouping of individual direct frontage accesses, relocation to secondary roads or provision of service roads (frontage roads).

3. Side road channelizing islands

Side road channelization islands shall be provided, if deemed appropriate, over the centre of side roads at:

- Major priority and signalized intersections
- Crossroads where there is a high risk of crossing traffic failing to give way
- Intersections with a skewed approach

4. Protected offside turn lane

Protected offside turn lane shall be adopted, if deemed appropriate, to provide a refuge for turning vehicles at:

- Intersections with frequent offside turning traffic
- Intersections located on curves
- Road sections where direct frontage accesses or intersections are closely spaced

Physical traffic islands are preferred to painted traffic islands at higher volume of main road or offside turning traffic.

5. Roundabouts

Roundabouts shall be adopted, if deemed appropriate, for intersections with a high proportion of turning or crossing traffic. They are also desirable:

- At the start of a bypass
- To highlight a change of road class or design speed
- To connect more than four branches of traffic
- To define the start and end of an urbanized section

The design of roundabouts shall adhere to safety principles pertaining to geometry, entry path radius, perception, visibility, signing and forgiving roadside.

6. Signalized intersections

Signalized intersections shall be adopted, if deemed appropriate, for intersections with heavy turning or crossing traffic. Signalization may also be appropriate with lower turning flows on multi-lane roads and to facilitate pedestrians or slow vehicles to cross a road.

Signalized intersections with approach speeds exceeding 70km/h shall be adequately treated to alert approaching traffic and to reduce their speeds progressively.

Adequate intergreen time shall be provided to separate green signal displays between conflicting traffic streams, pedestrians or slow vehicles. The overall green period on pedestrian signals shall be adequate for pedestrians to cross between safe refuges at normal walking speed.

Adequate visibility distance should be provided towards traffic signals, pedestrian crossings and between conflicting road users at the intersection. Road users on a particular traffic stream should be able to readily identify the correct traffic signals for them with minimal risk of misinterpretation.

7. U-turn facilities

U-turning is preferably facilitated by roundabouts, grade-separated intersections or signalized intersections. U-turn facilities should be provided at regular intervals and in coordination with nearside-in nearside-out intersections to minimize detour.

U-turn facilities in the form of median openings on Class I roads should have the following features:

- Widened median to accommodate at least one vehicle waiting to make a U-turn
- Provision of an offside turn lane, if a queue of U-turning traffic is likely to form
- Adequate manoeuvring space for the prevailing vehicle types without the need to reverse

8. Grade-separated intersections (inclusive of interchanges)

Grade-separated intersections shall have consistent characteristics and present drivers with simple and clear decision points. Changes to a lower design speed on connector roads shall be predictable and obvious to drivers. Adequate measures shall be incorporated to minimize the risk of wrong-way driving at grade-separated intersections.

Merging areas shall have adequate length of acceleration lanes and visibility between converging traffic. Diverging areas shall have adequate length of deceleration lanes and approach visibility towards diverge gores.

Auxiliary lanes of sufficient length should be provided where merging or diverging areas are located in the proximity or on unfavourable alignment such as significant curves and steep gradients. Connector roads should be of sufficient capacity to avoid traffic queues extending onto the mainline.

Non-typical layouts, notably those involving merging or diverging areas on the offside and complex weaving layouts, should not be adopted unless there are no practical alternatives.

At major interchanges with heavy traffic or multi-lane connector roads, merging and diverging areas should be designed to facilitate orderly and smooth convergence or divergence of traffic. Successive lane reduction should be spaced apart in conjunction with buffer areas. Successive diverge points should be spaced apart in conjunction with clear directional signing guiding traffic towards the different directions.

9. Railway level crossings

There shall be no railway level crossing on new roads constructed for the Asian Highway network. Existing railway level crossings shall be equipped with adequate safety systems commensurate with the risk of collisions between trains and vehicles, pedestrians, slow vehicles or animals.

D. Roadside safety

Roadside areas covering mainlines and intersections shall be proactively designed to constitute a forgiving roadside. The objective is to enable drivers to regain control upon deviating from their normal travel path and to minimize any adverse consequences when an errant vehicle crashes onto the roadside.

Vehicle restraint systems shall be tested to satisfy relevant international or national standards on the basis of containment level, vehicle occupant injury severity, redirective performance, vehicle stability and other applicable criteria.

1. Clear zones

A clear zone is a traversable roadside area to be clear of aggressive roadside features which can readily:

- Penetrate, crush or abruptly stop an errant vehicle
- Destabilize or launch an errant vehicle into the air leading to rollover or falls
- Collapse or become projectiles leading to adverse secondary consequences

Clear zones shall be formed from the optimal combination of paved shoulder, verge and/or embankment side slope of gradient not steeper than 1:4 (possibly up to 1:3 but desirably 1:6 or flatter). Their widths should be commensurate with traffic speeds and traffic volume.

The ground surface, drainage features and any objects within the clear zone shall be traversable or passively safe. Similar considerations should be extended to cyclists and motorcyclists to minimize their risk of serious injuries at locations prone to loss of control or crashes.

Where safety barriers are not provided, the bottom part of uphill side slopes (cut slopes) within a clear zone should be smooth and free of projections such as rock outcrops.

The periphery of clear zones and the bottom of embankment side slopes should be free of highly aggressive features if these are likely to be reached by an errant vehicle.

Road rehabilitation shall not result in significant edge drops at the boundaries of the carriageway, shoulders or side slopes which can cause an errant vehicle to lose control. Such edge drops should be flushed or reprofiled with appropriate gradients or else guarded by a safety barrier.

Diverge gores on Primary class and Class I roads or similar areas should be designed in the form of a longitudinal clear zone of adequate length for an errant vehicle to recover.

Where clear zones cannot be satisfactorily provided, alternative solutions shall be formulated to minimize the safety risks. These may include set back of aggressive features, speed reduction or the use of vehicle restraint systems.

Outside built-up areas, any aggressive features, inter alia, trees, utilities poles, sign mounting structures etc. which cannot be relocated or guarded by vehicle restraint systems, should be separated from the edge of carriageway by at least 3m in conjunction with a minimum horizontal clearance of 0.6m from the outside edge of the paved shoulder. In such circumstances, speed limits should be limited to 70km/h or below in conjunction with other active measures to enhance safety.

Outside built-up areas where the speed limit is 80km/h or above, any kerbs on the roadside and traffic islands should be semi-mountable or mountable.

2. Safety barriers

Safety barriers may be flexible, semi-rigid or rigid systems. Selection of safety barrier types and their containment level on a particular road section shall accord with roadside safety risks including both the likelihood of crashes and the consequences.

Safety barrier types and performance shall accord with the characteristics of traffic using the road including:

- Vehicle composition and traffic volume
- Maximum permissible weight, vehicle dimensions and relevant technical parameters
- Operational characteristics including compliance to traffic law
- Trends of vehicle types, composition and traffic volume including growth of international cross-border traffic
- Prevalence of buses

At very high-risk locations, inter alia, bridges and retaining structures, roads above railways, presence of crowds of people, deep water bodies, rigid constructions and sections along sheer drops, safety barriers or parapets of high to very high-containment level shall be adopted, especially if these locations coincide with unfavourable alignments, high traffic speeds and high volume of buses or heavy vehicles.

At the interface of different safety barrier types, transitions shall be provided such that an errant vehicle will be continuously contained, guided and redirected by the safety barrier.

Safety barriers shall have adequate length and may be locally strengthened to prevent an errant vehicle reaching aggressive roadside features. They shall be separated laterally from these features with adequate width for dynamic deflection or vehicle intrusion.

Where a safety barrier is flared away from approaching traffic, the taper angle shall be minimized to reduce the risk of high-angle impacts or redirection onto opposing traffic. Where gaps or access openings are required, upstream safety barriers shall lap over downstream safety barriers in the direction of traffic.

Consideration should be given to discontinuation of roadside safety barriers at the bottom of uphill side slopes and other suitable terrain conditions to provide additional refuge areas on the verge.

It is preferable to set the traffic face of safety barriers back from the outer edge of the paved shoulder with additional horizontal clearance. Non-mountable kerbs should not be used in front of semi-rigid safety barriers where speed limit is 80km/h or more.

Safety barriers shall be free of excessive protrusions, indentations or gaps which could severely undermine their performance.

3. Median safety barriers

All Primary class roads and Class I roads shall be divided roads with a median. On Primary class roads and Class I roads with speed limit of 70km/h or above, safety barriers of appropriate containment level shall be installed on the median unless it is adequately wide such that the risk of an errant vehicle crossing over to the opposing carriageway is negligible.

Other than median width, the need and containment level for median safety barriers should be based on the volume of traffic and heavy vehicles as well as the presence of unfavourable alignment.

4. End treatments

Upstream terminals of safety barriers shall not constitute a roadside aggressive feature, especially on roads with speed limit of 70km/h or above.

The safety risks of end terminals may be minimized by closing short gaps and extending safety barriers to terminate at less risky locations. The remaining end terminals should have appropriate treatments such as anchoring onto uphill side slope, flared layout or the use of crashworthy end terminals.

5. Crash cushions

Crash cushions shall be used for diverge gores on Primary class and Class I roads with design speed of 80km/h or above where a clear zone cannot be created and there is a high risk of collision. They may also be needed for:

- Isolated bridge piers in the middle of a road
- Commencement of median safety barriers
- Toll islands
- Tunnel portals
- Hazards on traffic islands

E. Pedestrians, slow vehicles and traffic calming

Along built-up areas and their peripheries directly traversed by Asian Highway routes, adequate pedestrian and slow vehicle facilities shall be provided in conjunction with traffic calming schemes. In order to increase their acceptability and effectiveness, local communities should be adequately engaged.

1. Traffic calming

Urbanized sections and their peripheries shall be distinctly recognizable by drivers. The beginning of built-up areas should have a sign displaying the name of the city, town or village. This should be further supported by traffic calming measures to highlight the start of a change in the nature of the road and to foster appropriate traffic speeds and behaviour.

Road sections traversing smaller settlements with scattered population and activities should be treated proportionately and may include signing, reduced speed limits, provision of footpaths and improvements of visibility at intersections and crossings etc.

At core areas of built-up areas and where there are frequent pedestrians or slow vehicles travelling along or crossing the road, physical traffic calming measures including vertical speed reduction facilities may be adopted. Such measures shall only be provided where traffic speeds have been reduced to appropriate levels. They should be acceptable to all road users with adequate signing and delineation.

Non-engineering measures are encouraged to reinforce the image of built-up areas in conjunction with streetscape design. These measures should also be adopted along the peripheries of built-up areas to provide a transition for high-speed traffic approaching built-up areas.

Where a Class I road passes through a built-up area with ample frontage activities, the character of the road should be substantially modified to highlight the urban nature of the road section.

2. Universal accessibility

Adequate consideration shall be given to the needs of all road users including school children, the visually and mobility impaired, elderly, wheelchair users and those with luggage or children etc. to walk along or cross the road.

At the edge of footpaths and refuge islands fronting pedestrian crossings, the following features should be provided:

- A strip of tactile paving blocks with adequate visual contrast
- Drop kerbs or flushed surface

3. Pedestrian footpaths

Pedestrian footpaths shall be provided, if deemed appropriate, along urbanized sections and their peripheries. Footpaths should also be provided around crossings and on other road sections where pedestrians are regularly present such as roadside tourist attractions.

On major bridges, roads with heavy traffic or high traffic speeds, consideration should be given to a footpath separated from the main road with a safety barrier, a planter wall or a grass verge. At urban centres, along wide busy roads and where space is available on other roads with frequent pedestrians, consideration should be given to providing a wider pedestrian corridor.

Pedestrian footpaths should be continuous forming a walking network to serve the needs of pedestrians within built-up areas and their peripheries.

Where footpaths cannot be practically provided due to inadequate width of the road cross-section, alternative solutions shall be formulated. These may include reduction of traffic speeds to the level of 30km/h and provision of discrete footpaths or refuge space etc.

4. Pedestrian crossings

Pedestrian crossings shall be provided, where necessary, to assist pedestrians crossing the road safely and comfortably. The need for pedestrian crossings may be established by the intensity of conflicts based on pedestrian demand and traffic volume, with additional considerations of the difficulty to cross, collision history, pedestrian characteristics and volume of heavy vehicles etc.

Pedestrian crossings include:

- Pedestrian priority crossings (zebra crossings)
- Uncontrolled crossings (pedestrians do not have priority)
- Signalized crossings
- Grade-separated crossings (footbridges or underpasses)

Selection of crossing types shall be based on road class, number of traffic lanes, traffic volume, traffic speeds, drivers' expectation and local conditions. Adequate consideration shall be given to reducing traffic speeds and possibly road widths and the number of traffic lanes to enhance the safety of any at-grade crossings.

At-grade crossing facilities shall be conspicuous with adequate visibility and well expected by drivers. Additionally, they should be supported by traffic calming, delineation and signing. Pedestrian priority crossings shall only be provided where the speed limit does not exceed 50km/h.

Adequate grade-separated crossings shall be provided for all access-controlled roads. If there is heavy pedestrian demand, grade-separated crossings should also be provided for Class I roads with multiple traffic lanes, speed limits of 70km/h or above and high volume of traffic or frequent heavy vehicles.

5. Central refuge islands

Central refuge islands shall be provided, if deemed appropriate, to assist pedestrians crossing a bidirectional road in two steps at the following locations:

- Urbanized sections of Classes II or III roads with high traffic volume
- Wide urbanized sections
- Class I roads with a median
- Protected turn lanes or side road channelization islands

6. Pedestrian fences

Pedestrian fences or equivalent linear facilities such as planters or safety barriers shall be provided, if deemed appropriate, to:

- Highlight crossing points
- Encourage crossing at right angle

- Prevent pedestrians crossing Class I roads between designated crossings
- Guide pedestrians towards grade-separated crossings
- Divert pedestrians away from intersections and road sections not suitable to cross
- Avoid pedestrians spilling onto the road

Their design and construction should take into account the following considerations:

- Balance among safety, convenience and streetscape
- Design should discourage climbing over or crossing through any gaps or discontinuities
- Passive safety if an errant vehicle collides with the fence
- Need for visibility through the fence

7. Slow vehicle routes

Adequate facilities shall be provided where slow vehicles including bicycles, low-power or electric motorcycles, electric tricycles, animal-drawn carts and animal herds are regularly present on the road.

Slow vehicle routes may be provided as slow vehicle lanes, segregated slow vehicle tracks or service roads, depending on the characteristics and volume of traffic and slow vehicles as well as traffic speeds.

A system of exclusive unidirectional motorcycle lanes or tracks may be provided on busy roads and bridges with a high volume of traffic and motorcycle traffic and there are significant safety issues.

8. Slow vehicle crossings

Where slow vehicles need to cross a road, appropriate facilities shall be provided. These may include:

- Shared pedestrian priority crossings
- Uncontrolled crossings
- Signalized crossings
- Grade-separated crossings

The priority for at-grade slow vehicle crossings shall be clearly established and understood by road users. Slow vehicles normally should not have priority at non-signalized crossings on the main road outside built-up areas, unless effective traffic calming measures are in place. At higher traffic volume on Classes II or III roads, central refuge islands or signalization may be required.

F. Delineation

Delineation facilities assist drivers in identifying the presence, geometry and/or boundary of road pavements, shoulders, traffic lanes, traffic islands, intersections and roadside hazards etc. They shall be adopted consistently in the optimum combination to enhance safety for all road users.

In addition to delineation facilities, other measures, inter alia, visual contrast in paving materials, reflective paints and landscaping features, should be adopted to increase the conspicuity of the road layout and road features.

1. Chevron signs

Chevron signs shall be provided as part of the curve signing system on the outside of sharp curves which:

- Require approaching traffic to reduce speed substantially
- Are inconspicuous or unclear in perception
- Have poor visibility
- Have a history of collisions related to loss of control

Chevron signs shall be of adequate size and clearly visible to drivers approaching the curve.

2. Delineators

Delineators shall be provided on road sections without road lighting outside built-up areas to highlight road alignment or curves, to demarcate intersections and to highlight roadside hazards. They may be provided to separate opposing traffic or slow vehicles and at diverge gores on high-speed roads.

Delineator posts and the colours of reflectors for different purposes shall be distinctly different. They shall be passively safe, being frangible or flexible and desirably self-restoring.

3. Anti-glare systems

Anti-glare systems shall be provided, if deemed appropriate, on Primary class and Class I roads without road lighting in the following situations:

- Median less than 9m in width
- Heavy night-time traffic
- Low standard horizontal curves and sag curves
- Opposing traffic at a different level smaller than 2m
- Existence of a parallel road with opposing traffic
- Near tunnel portals where tunnel tubes are at close proximity
- Glare from other light sources

Adequate consideration should be given to maintenance and any adverse effects on visibility.

4. Line markings

The following line markings shall be provided as a minimum:

- Edge line (possible omission within built-up areas and on roads with lighting or clearly defined edges)
- Lane line
- Centreline (for undivided roads with adequate paved width)
- Markings for intersections

Line markings shall have adequate skid resistance and night-time visibility.

5. Wide centreline markings

Wide centreline markings shall be adopted, if deemed appropriate, to separate opposing traffic flows for:

- Class II roads with speed limit of 80km/h or above
- Sharp curves on Classes II or III roads
- Crest summits with inadequate overtaking visibility
- Climbing lanes or overtaking sections
- Divided roads with one carriageway constructed for two-way traffic
- Tunnels with bidirectional traffic
- Sections of roads where there is a history of crashes related to overtaking

Wide centrelines may be laid as two solid lines, two dotted lines or a mix of dotted line and solid line to regulate overtaking. The gap between the line markings may be infilled with hatched markings or coloured surfacing.

6. Raised pavement markers

Raised pavement markers shall be used, if deemed appropriate, to supplement edge line markings on Primary class roads and Class I roads. They are recommended for use along edge lines and where applicable, centrelines, on other classes of roads outside built-up areas with speed limit of 70km/h or above and without lighting.

Priority situations for their use include curves, changes in cross-sections, intersections and road sections of poor visibility due to weather conditions. Raised pavement markers should not be used at locations which could cause a hazard to pedestrians, cyclists and motorcyclists.

7. Rumble strips (including audio-tactile line markings)

Centreline rumble strips shall be adopted, if deemed appropriate:

- On undivided Classes I, II roads with speed limit of 80km/h or above
- At and on the approach to curves
- For climbing lane and overtaking sections
- In conjunction with wide-centreline markings

Edge line rumble strips shall be adopted, if deemed appropriate:

- On all Primary class roads
- On roads with speed limit of 80km/h or above
- At and on the approach to curves
- On the immediate approach to tunnels

Transverse rumble strips shall be adopted, if deemed appropriate:

- On main road or side road approaches to intersections including roundabouts
- On approaches to curves and hazardous road sections
- On approaches to toll plazas, border control points etc.

Usage of rumble strips shall take into account the risk of ice formation and tripping for pedestrians, cyclists or motorcyclists as well as any implications for receivers sensitive to noise or vibration.

8. Road lighting

Road lighting shall be provided, if deemed appropriate:

- Within built-up areas and their peripheries, at crossings, intersections and other road Sections where pedestrians or slow vehicles are frequently encountered at night-time
- On road sections with heavy traffic at night-time
- At major intersections with heavy traffic at night-time
- For tunnels, special bridges and their immediate approaches
- For toll plazas and immediate approaches to ports or border control points

G. Road signage

Road signage shall be homogeneous and standardized in design rules and graphics. Adequate consideration shall be given to the needs of international cross-border traffic and drivers coming from other countries. Graphic symbols are encouraged provided that they are readily understandable.

Signs shall have adequate size with respect to approaching traffic speeds. They shall be positioned to maximize their conspicuity and visibility. The number of signs and their distance of separation shall be regulated to avoid one sign obscuring the other and to prevent overloading drivers with information.

Sign messages shall be readily understandable within available reading time which is generally very short. Night-time visibility of road signage shall be assured with the use of retroreflective materials, external or internal illumination.

Mileage signs shall be erected on Asian Highway routes for the purpose of asset management, maintenance and emergency response.

Any advertisement signs or information signs not related to traffic control and management, if provided, shall not adversely divert drivers' attention from the road conditions and road signage.

1. Traffic signs

Traffic signs consist of warning signs, regulatory signs, supplementary signs, informative signs and road name signs. Their usage shall be systematic and consistent on Asian Highway routes.

The position of traffic signs shall accord with their functions. Warning signs shall be used sparingly and positioned ahead of hazards with adequate advance distance.

2. Directional signs

All intersections on Primary class roads and all major intersections on Classes I, II and III roads shall be equipped with adequate directional signs. These shall normally include:

- Advance direction sign: informing drivers for route selection ahead
- Direction sign: guiding drivers to negotiate through an intersection

- Confirmatory sign: confirming drivers the route and destinations ahead with distance after an intersection

The provision of directional signs should be well-coordinated with dynamic traffic control equipment, inter alia, variable message signs, lane control signals etc., in terms of positioning and information flow.

Directional signs shall display route numbers and important cities, destinations and facilities for the effective orientation of drivers. Allowance shall be made for the signing of tourist destinations.

On Primary class and, where appropriate, other classes of roads, directional signs and confirmatory signs shall be systematically provided for service areas and filling stations.

Directional signs shall be spaced apart with sufficient distance to avoid overloading of information and obscuring. Advance direction signs shall be consistently provided at sufficient distance ahead of an intersection. Direction signs may be omitted in some situations.

At lane drops, weaving sections, successive or complex intersections and along urbanized sections, directional signing shall provide timely and accurate guidance for drivers to select the appropriate route.

H. Tunnels

Tunnels over 500m in length shall be equipped with comprehensive facilities and dedicated management for operation, maintenance and emergency response. Tunnels with lengths not exceeding 500m and roads having characteristics of tunnels, such as underpasses and roads within noise enclosures or under a deck, shall be equipped with adequate facilities commensurate with the safety risks.

The design speed of tunnels in terms of alignment and traffic lane width shall be the same as the approach roads, unless special provisions are made for the adaptation of approaching traffic. Tunnels and their approaches shall, as far as possible, be free from unfavourable alignment including sharp curves and steep gradients. Intersections should be located with adequate distance away from tunnels.

Overtaking shall not be permitted inside bidirectional tunnels and should be prohibited or discouraged inside unidirectional tunnels. Pedestrians or slow vehicles shall not be permitted inside tunnels except where operational conditions are suitable or else appropriate facilities are provided.

Particular attention shall be given to the appropriate design of vehicle restraint systems at tunnel portals, laybys and access openings which may constitute a frontal roadside hazard.

There shall be adequate facilities and plans to cope with unauthorized vehicles, incidents, fire and maintenance needs through implementation of lane closure, partial or full tunnel closure and, where appropriate, single tube bidirectional operation.

The tunnel name or its symbol or length shall be signed ahead of the tunnel. Tunnel speed limits should be signed on the immediate approach or at the tunnel entrance.

Emergency stations, each consisting of an emergency telephone and at least two fire extinguishers, shall be provided at intervals not exceeding 150m. Emergency exits with connection to the outdoor shall be provided at intervals not exceeding 500m. An emergency signing system with active illumination on uninterrupted power source shall be provided to indicate laybys, cross

passages, emergency stations, emergency exits and evacuation routes.

Tunnel lighting shall be provided to enable traffic to approach, enter, travel through and exit a tunnel or similar facilities smoothly and at a safety level comparable to the adjacent open road, day and night, under all weather conditions.

IV. Glossary

Built-up area: A developed area with buildings, structures and concentration of human activities. This may include a city, a town, a village or an industrial zone.

High-speed roads: Roads with speed limit or operating speed of 70km/h or more.

Passively safe: Referring to roadside features which are unlikely to incur serious injuries upon impact by an errant vehicle or road user.

Traffic calming: The promotion of favourable driving behaviour and control of vehicle speeds to be commensurate with the activities taking place along a road using specific measures.

Urbanized section: Section of the road traversing a built-up area with at-grade intersections or crossings and frontage activities.

Vehicle restraint system: Engineering system installed on a road to provide a level of containment for an errant vehicle.

Wide centreline marking: Centreline marking which has an overall width larger than normal, and is generally in the order of 0.6m to 1.0m but may be even wider, e.g. 1.5m to 2m.
