

Draft Annex IV
Intergovernmental Agreement on the Asian Highway Network

**ASIAN HIGHWAY DESIGN STANDARDS FOR
ROAD INFRASTRUCTURE SAFETY FACILITIES**

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PREFACE

This document shall be read in conjunction with other documents forming the Intergovernmental Agreement on the Asian Highway Network. These include the Annex II- “Asian Highway Classification and Design Standards”.

The contents of this document consist of both mandatory requirements and recommendations. Mandatory requirements are given in this part of the document and recommendations are given in the accompanying guidelines.

Asian Highway Network member countries shall make every effort to comply with the mandatory requirements and to give thorough consideration in adopting the recommendations.

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

It will be necessary to avoid excessive use of signage which could undermine their value. Adequate attention shall be given to the integration of road infrastructure safety facilities with streetscape and the landscape as well as mitigation of any adverse impacts on the environment.

Countries shall take advantage of road improvement projects to elevate road safety in the Asian Highway Network over the course of time. These schemes encompass:

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

Items of these projects which do not satisfy the mandatory requirements are considered “Departure from Standard”. Authorities should document and address such items individually with adequate justifications.

This document is based on driving on the right side. For countries where driving is on the left side, adjustments should be made as appropriate.

It is at the liberty of member countries and other bodies to make use of this document for other roads and incorporation into their national standards.

I GENERAL REQUIREMENTS

1. Principles

Road safety shall be improved for the Asian Highway Network through both active and passive measures for road design and safety facilities. Active measures aim to reduce the probability of crashes whereas passive measures provide opportunities for drivers to rectify momentary errors and minimize the potential for serious injuries in case a crash happens.

2. Road Types

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

Table 1

Mode of Operation	Primary	Class I	Class II	Class III
Controlled-access	Full	No ¹	No ¹	No
At-grade intersections	X	Yes ¹	Yes ¹	Yes
Overtaking on opposing lane	X	X	Yes ³	Yes ³
Pedestrians	X	Yes ¹	Yes ¹	Yes
Slow vehicles ²	X	Yes ¹	Yes ¹	Yes

1 unless specially designed for controlled-access operation

2 Bicycles, low power motorcycles, agricultural vehicles, mopeds, animal-drawn carts, animal herds

3 permitted unless prohibited by signs or markings

X not permitted

Primary roads shall be signed as expressways. Controlled-access Class I roads may be signed as express roads. These signs should be legally defined for exclusive use of motor vehicles.

Roadside stopping shall be restricted on Asian Highway routes except:

- on hard shoulders in an emergency
- at designated parking areas
- within urbanized areas with adequate capacity and reduced traffic speeds

3. Change of Road Category or Design Speed

Asian Highway routes shall have homogeneous characteristics over a sufficiently long section of road. Changes of road category, design speed or speed limit shall be located at a change in road environment or condition which is obvious to drivers. Examples are approach to built-up areas, changes of topography, intersections, toll plazas, border control points etc. Road and traffic design at such transitions shall encourage drivers to adopt appropriate behavior commensurate with the changes.

4. Speed Limits

Speed limits outside built-up areas shall be defined on Asian Highway routes with appropriate signing and clearly defined regulations. They shall be determined on the basis of design speed, 85th percentile operating speeds and safety provisions and are conceived by drivers to be reasonable.

5. Summary of Key Requirements

Asian Highway routes shall conform to the framework of Road Infrastructure Safety Facilities (RIFs) set out in Table 1.

Table 1

Highway classification	PRIMARY				CLASS I			CLASS II				CLASS III				
	120	100	80	60	100	80	60	50	80	60	50	40	60	50	40	30
Delineation	Good line marking, raised reflectorized pavement markers, flexible delineator posts, chevron markers on curves															
Rumble strips	Shoulder rumble strips						Shoulder rumble strips at curves									
Roadsides	Clear zone (5-10m) or safety barrier with safe end treatment						Clear zone (5-10m) or safety barrier with safe end treatment particularly at curves									
Median treatment	Median safety barrier with safe end treatment				Island 1-5m wide			Wide center-line	Centerline (rumble strips at curves)							
Lighting	Street lighting at intersections, at pedestrian crossings and where bicyclists are present															
Priority Intersection protected turn lanes	N/A				Possible but to be minimized			Protected turning pockets at intersections								
Side Road channelization islands	N/A				Side road channelization islands at major intersections and crossroads											
Roundabout	N/A				Possible			Roundabouts								
Pedestrian footpath	Separate systems				Footpath where pedestrians are present											
Pedestrian/Slow Vehicle crossing	Grade-separated				Grade-separated or Signalized			Signalized/Marked/Unmarked crossings with/without refuge island								
Slow vehicle route	Separate systems				Segregated tracks for high traffic speeds or traffic volume, Slow vehicle lanes or mixed traffic for low traffic speeds and volume											
Motorcycle lane	Exclusive lanes where motorcycle volumes are high				Non-exclusive motorcycle lanes where motorcycle volumes are high											
Traffic Calming	N/A				Visual traffic calming and/or vertical speed reduction facilities in built-up areas											
Speed reduction on free-flow sections	Visual traffic calming and/or transverse rumble strips for curves, intersections and/or transition to lower class roads															

II. ROAD INFRASTRUCTURE SAFETY FACILITIES

1. Road Infrastructure

Visibility

Adequate visibility shall be provided to ensure that drivers are able to react to road features, pavement conditions and maneuvers of other vehicles or road-users. Key visibility requirements are given in Table 2. Additional visibility requirements may apply for specific road infrastructure facilities.

Table 2

Visibility Type	Primary	Class I	Class II	Class III
Forward visibility distance	✓	✓	✓	✓
Overtaking visibility			✓	✓
Visibility towards diverge gores	✓	✓		
Visibility at merging	✓	✓		
Intersection visibility		✓	✓	✓
Signalized intersection inter-visibility		✓	✓	✓
Visibility towards specific road features including tunnels, toll plazas, escape ramps, laybys etc.	✓	✓	✓	✓
Visibility towards pedestrian crossings		✓	✓	✓
Visibility towards road signage	✓	✓	✓	✓

✓ generally applicable

Horizontal and Vertical Alignments

For roads with design speed of 60km/h or above, horizontal curves of smaller radii shall, as far as possible, be preceded by curves of larger radii in the ratio of 1:1.5 or less. Such sequencing of horizontal curves are particularly encouraged where road environment changes and on the approach to long steep grades.

On roads with speed limit of 60km/h or above, horizontal and vertical curves shall be coordinated for better visual guidance.

Cross-sections

Adequate width of hardened verges shall be provided beyond paved shoulders for the following purposes:

- Clear zone and installation of safety barriers
- Space for signs, lighting columns, underground utilities, drainage systems
- Refuge area for stranded road-users
- Passage of pedestrians, maintenance staff or animal herds
- Visibility needs

Pavement slopes on straight sections shall not be less than 2% to facilitate surface run-off and to minimize the risk of aquaplaning. Longitudinal gradients should not be less than 0.67% to facilitate edge drainage.

On road sections with pavement slope changing to super-elevation on curves and between opposing curves on super-elevation, changes shall be introduced such that road areas with gradients less than 2% are minimized.

Adequate horizontal clearance shall be provided for the following purposes:

- Rooms for vehicles momentarily deviating from the carriageway
- Accommodation of protruded side mirrors
- Opening of vehicle doors in an emergency
- Additional margin in case the shoulder is used for running traffic or during emergency

A combination of the following measures shall be provided to enhance the conspicuity of traffic islands:

- “Keep right” traffic sign or other reflective devices
- Line markings guiding traffic to travel past the island
- Surface color in contrast with the general pavement
- Highlighting kerbs facing approach traffic in reflective materials
- Road Lighting

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 with advance warning signs, tapers and buffer areas shall be provided to assist drivers adapting to the changes.

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

Overtaking

Overtaking opportunities shall be systematically provided on Classes II and III roads. Overtaking zones and non-overtaking zones shall, as far as possible, be clear-cut in terms of overtaking visibility distance.

Overtaking opportunities for Classes II and III roads may consist of:

- Opposing lane overtaking sections
- Divided road sections
- Climbing lanes
- Downhill auxiliary lanes
- “2+1” roads or overtaking sections
- Laybys

At high traffic volume where usage of opposing lane overtaking sections becomes difficult and risky, overtaking should be restricted or discouraged in one or both directions. Other forms of overtaking opportunities shall then be considered.

Sharp Curves

The following alignments shall be avoided for new roads:

- Long straight section leading to a sharp curve
- Steep gradient leading to a sharp curve
- Continuous curves in reverse directions with inadequate transition
- Smaller radius curve within a large radius curve
- Pronounced crest leading to a sharp curve
- Hairpins

On the approach to sharp curves which are not conspicuous or where substantial reduction in speeds is required, comprehensive treatments shall be provided to assist traffic safely negotiating the curves. Such treatments may include curve signing system, clear zones, visibility enhancement, high friction surfacing, increased super-elevation etc. Curve signing systems shall consist of different levels of signing commensurate with the severity of the curves and are consistently applied along a route.

Curves in the form of a hairpin shall not normally be adopted for divided roads and wherever there is more than one traffic lane in a direction.

Where unavoidable on Classes II and III roads, hairpins shall be clearly visible on the approach. Additionally, particular attention shall be given to curve widening, signing and roadside safety. Where hairpins coincide with long steep grades, comprehensive safety schemes shall be formulated.

Steep Downhill Gradients

On primary, Classes I, II roads and where appropriate Class III roads on long steep grades, the road shall be designed with the following characteristics for downhill traffic:

- Avoidance of straight or long and large radii curves
- Avoidance of sharp curves
- Avoidance of interchanges, parking areas, at-grade intersections and built-up areas within the long steep grades and up to several hundred meters thereafter
- Avoidance of a vertical profile where road sections on steep gradients are interspersed with short sections of gentle gradients

A long steep grade management strategy shall be formulated with the following measures:

- Signing system
- Laybys and inspection areas
- Escape ramps, as appropriate, in conjunction with a signing strategy

Climbing Lanes

Climbing lanes shall be provided where slow-moving vehicles result in unacceptable traffic queues and risky overtaking maneuvers. Climbing lanes may be continuous or in discreet sections.

Parking Areas

Parking laybys, emergency laybys, service areas, rest areas and filling stations shall be provided at regular intervals on a strategic basis. Sufficient facilities are very important to enable drivers to refuel their vehicles, take rest breaks, handle various issues and continue their journey with full concentration.

Bus stop facilities shall be provided in the proximity where passengers wish to board or alight from a bus. They shall be connected with adequate pedestrian facilities.

On primary roads and where appropriate, other road types, there shall be adequate signs so that road-users are well informed about available services at the upcoming facilities. The distance to reach these facilities shall also be indicated.

Toll Plazas, Ports and Border Control Points

On the approach to toll plazas, sea ports, dry ports and border control points, drivers shall be prompted to slow down by signing, rumble strips or other appropriate speed reduction measures. Adequate directional signs shall be provided if specific traffic lanes are assigned for different vehicle types. U-turn or diversion opportunities should be provided if drivers wish to turn back on the approach to ports or border control points.

The immediate approach to mainline toll plazas should have a straight alignment on gentle gradients. They shall not be located on or at the bottom of significant downhill gradients.

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.

Other Issues

For primary roads, an emergency access strategy shall be formulated to facilitate efficient response to incidents.

Where conflict between traffic and animals is a safety problem, appropriate measures shall be implemented to minimize the risks.

2. Intersections

At-grade intersections shall be regulated in accordance with Table 3. They shall be planned on a route-wide basis with consistent types and patterns.

Table 3

Intersection Category	Intersection Type	Primary	Class I	Class II	Class III
Priority	Direct Accesses	X	#	#	#
Priority	Priority Intersections	X	#	✓	✓
Priority	U-turn Facilities	X	#	^	^
Signalized, Grade-separated	U-turn Facilities	X	✓	^	^
Roundabouts	Roundabouts	X	✓	✓	✓
Signalized	Signalized Intersections	X	✓	✓	✓
Grade-separation	Grade-separated Intersections	✓	✓	^	^
Grade-separation	Interchanges	✓	✓	^	^

- ✓ Generally suitable
- X Not permitted
- # Tolerated but to be minimized
- ^ Possible

Intersections shall, as far as practical, be located on straight and relatively level sections of a road with good visibility and are spaced well apart outside built-up areas.

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

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

- Layouts with excessive pavement area or corner radii
- Intersections linking more than two roads
- Addition of through traffic lanes at an intersection

- Channelization which encourages left turning in a smooth and generous path
- Complex channelization layouts
- Skewed layouts
- Tangential or Y layouts

Side roads shall have gentle gradients at and in the proximity of their intersection with the main road in order to reduce the risk of overshoot or slow maneuvers.

Direct Accesses

Direct accesses shall be stringently controlled in terms of density, traffic volume and usage by heavy vehicles. Left turning for direct accesses on Class I roads shall only be permitted exceptionally on divided 4-lane roads in conjunction with a wide median. Considerations shall be given to combining individual accesses, relocation to secondary roads or provision of a service road.

Side Road Channelizing Islands

Channelization islands shall be provided, as appropriate, over the center of side roads at:

- major priority and signalized intersections
- crossroads where there is a high risk of crossing traffic failing to give way
- right angle intersections with a skewed approach

Protected Left Turn Lane

Protected left turn lane shall be provided, as appropriate, to provide a refuge for turning vehicles at:

- intersections where left turning traffic exceeds a few hundred of vehicles per day
- intersections located on curves with impaired visibility
- road sections where direct accesses are closely spaced

For lower turning traffic volume, protected left turn lane may be demarcated by hatched markings. For higher turning traffic volume, traffic islands should be adopted.

Roundabouts

Roundabouts shall be adopted, as appropriate, for intersections with high turning or crossing traffic. They are also desirable for lower turning flows:

- at the start of a bypass
- to highlight the change of road class and design speed
- to replace a priority crossroad
- to define the start and end of an urbanized section

The following roundabout types shall not be adopted without strong justifications:

- Mini-roundabouts
- Roundabouts on Class I roads with six or more lanes, unless they are signalized
- Roundabouts with oval or irregular central islands

The design of roundabouts shall adhere to strict safety principles including:

- Limitation of entry path radius
- Avoidance of drivers seeing through the roundabout on a straight alignment

- Adequate signs and speed reduction measures on the approach
- Appropriate visibility at entries and within the roundabout
- Passive safety for the central island, splitter islands and the roadside

Preference should be given to single lane or 2-lane compact roundabouts wherever capacity permits. Addition of traffic lanes at the entrance to a roundabout should not be adopted unless this practice is already widely in operation without problem.

If there are pedestrians and slow traffic at the roundabout, the following precautions shall apply:

- Preference for single lane compact roundabout
- Preference for single lane exit at 2-lane roundabouts
- Provision of pedestrian footpaths and appropriate crossing facilities
- Provision of separate slow vehicle tracks and appropriate crossing facilities
- Provision of traffic calming measures

Signalized Intersections

Signalized intersections shall be adopted, as appropriate, for intersections with high turning or crossing traffic. They are also appropriate with any turning flows on multi-lane roads and to facilitate pedestrians or slow vehicles to cross a road.

Traffic signals shall have 3-aspect displays in red, amber and green colors. Pedestrian signals shall be in red and green color. Flashing display may be adopted according to national standard.

Cycle time of signalized intersections shall normally be limited to 120 seconds and preferably not more than 100 seconds. Adequate intergreen period shall be provided to separate green signal displays between conflicting traffic streams, pedestrians or slow vehicles.

Signalized pedestrian crossings shall be positively controlled with pedestrian signals. The overall green period on pedestrian signals shall be adequate for pedestrians to cross between safe refuges at normal walking speeds.

Adequate visibility distance shall be provided towards traffic signals, pedestrian crossings and within the intersection intervisibility zone. Drivers on a particular traffic stream shall be able to readily identify traffic signals for them with minimal risk of misinterpretation of traffic signals for other traffic streams or other intersections in the proximity.

Under no circumstances shall signalization be adopted on roads with approach speeds exceeding 100km/h. Special precautions shall apply to signalized intersections on high speed roads with approach speeds exceeding 70km/h. This would include the need to reduce approach traffic speeds smoothly and provision of segregated turn lanes for heavy turning traffic.

Grade-separated Intersections

Grade-separated intersections shall present drivers with 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 onto grade-separated intersections.

Merging areas shall have adequate acceleration lanes and visibility for converging traffic. Diverging areas shall have adequate deceleration lanes and approach visibility towards diverge gores. Auxiliary lanes shall be provided where merging or diverging areas are located on unfavorable alignment.

Non-typical layouts, notably those involving merging or diverging areas on the left and complex weaving layouts shall not be adopted unless there are no practical alternatives. Where loops are adopted, adequate measures should be provided for the safety of the small radii curves.

At major interchanges with heavy merging traffic or multi-lane slip roads, merging areas shall facilitate orderly and smooth convergence of traffic. Appropriate measures include successive lane reduction or merging lanes in conjunction with buffer areas. At diverging areas, diverge points shall be spaced apart in conjunction with clear guidance towards different directions.

Where pedestrian and slow vehicle routes intersect a grade-separated intersection, the crossings shall be located away from high speed traffic with adequate visibility.

Compact grade-separated intersections shall be adopted, where appropriate, for Class I roads to substitute the need for left-turning or crossing movements. They are also desirable as part of a local road network strategy to divert pedestrians and slow vehicles away from the main road. They may be adopted throughout a route or on an individual basis.

Railway Level Crossings

There shall be no railway level crossing for new roads constructed for the Asian Highway Network. Existing railway level crossings shall be equipped with adequate safety provisions commensurate with the risk of collisions between trains and vehicles, pedestrians, slow vehicles or animals. Active safety systems based on automatic signals and barriers activated by the approach of trains shall be provided for all trunk and regional railways.

3. Roadside Areas

Roadside areas covering mainlines and intersections shall be designed to constitute a forgiving roadside. The objective is to enable drivers to regain control upon deviating from the normal travel paths and to limit the adverse consequences of an errant vehicle crashing onto the roadside through:

- Creation of clear zones
- Management of aggressive roadside features
- Use of vehicle restraint systems

Clear Zones

A clear zone is a traversable roadside area beyond the outermost traffic lane to be clear of aggressive roadside features which can readily:

- penetrate or abruptly stop an errant vehicle
- destabilize an errant vehicle leading to rollover or fallover
- collapse or become projectiles leading to adverse secondary consequences

Clear zones may be formed from a combination of paved shoulder, verge and side slope with a width commensurate with traffic speeds and traffic volume. Any objects within the clear zone shall be passively safe. The extent of the clear zone shall take into account the likely trajectory of an errant vehicle. The bottom of an embankment side slope should also be free of aggressive features if this is likely to be reached by an errant vehicle.

Where clear zones cannot be provided, an appropriate vehicle restraint system shall be provided to contain an errant vehicle and to redirect it back to the normal travel path.

Road rehabilitation shall not result in significant edge drops which could cause an errant vehicle to

lose control. If there are any significant raisings of the pavement, the side slope shall be re-profiled with appropriate gradients or else guarded by a safety barrier.

Diverge gores on primary and Class I roads or similar areas shall be designed in the form of a longitudinal clear zone of adequate length. Where such clear zone cannot be provided, the risk of a collision shall be minimized with effective safety measures which may include the use of crash cushions.

Safety Barriers

If a clear zone cannot be satisfactorily provided on the roadside or the median, safety barriers shall be installed if the safety benefits outweigh any undesirable effects. Roadside of bridges and retaining walls shall be equipped with parapets.

Safety barriers shall be provided on the basis of containment level, vehicle occupant injury severity, redirective performance and vehicle stability. They shall conform to NCHRP 350/MASH (US), EN1317 (EU) or equivalent national standard and may be flexible, semi-rigid or rigid systems.

At very high risk locations, inter alia, high bridges, roads above railways or deep water bodies and sections along sheer drops, safety barriers or parapets of high containment level shall be adopted, especially if these locations coincide with unfavorable alignments, high traffic speeds and high volume of buses and 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 be installed with adequate length to prevent an errant vehicle reaching aggressive roadside features. They shall be separated laterally from these features with adequate width specific to the safety barrier type. On primary roads and other roads with high design speeds, safety barriers of lower containment level shall be strengthened around highly aggressive roadside features such as bridge piers.

Where a safety barrier towards approach traffic is flared away from the carriageway, the taper shall be at a shallow angle to minimize the risk of high angle impact. The maximum taper angle shall be determined according to traffic speeds, type of safety barriers and their lateral distance from the carriageway.

Median Safety Barriers

On primary roads and controlled-access Class I roads with speed limit of 70km/h or above, median safety barriers shall be installed unless the central reserve is at least 15m wide.

For Class I roads with speed limit less than 70km/h, the following options should be considered:

- Installation of a median safety barrier where the road has a high volume of heavy vehicles
- Installation of a low containment median barrier
- Adoption of a wider median in the order of 5m to 10m

Median barriers shall be based on roadside safety barriers as two single-sided units or a double-sided unit.

End Treatments

Upstream terminals of safety barriers shall not constitute a hazard by stopping an errant vehicle abruptly, penetrating into a vehicle or launching the vehicle air-borne.

The number of safety barrier end terminals shall be reduced to a minimum by closing short gaps and extending the safety barriers upstream to less risky locations. The remaining end terminals shall have appropriate treatments, including:

- Anchoring to uphill side slopes with flaring
- Lapping without connection
- Installation of crash cushion
- Installation of crashworthy end terminal

For any remaining safety barrier end terminals at speed limit of 60km/h or below, the following end treatments may be tolerated provided that they are located on straight sections well away of curves:

- Blunt end terminals with flaring
- Ramped down terminals gentler than 1:10 with flaring and clear zone

Transitions

Where an upstream flexible or semi-rigid safety barrier terminates and a rigid safety barrier commences, the upstream safety barrier shall be progressively strengthened and connected to the downstream safety barrier with a transition tested to NCHRP350/MASH (US), EN1317-5 (EU) or equivalent national standard.

Crash Cushions

Crash cushions shall be used for diverge gores on primary and Class 1 roads with design speed of 80km/h or above where a clear zone cannot be created. They should also be adopted at lower speed limits for other high risk situations where no other solutions are practical.

Other potential applications for crash cushions are

- Isolated bridge piers in the middle of a road
- Commencements of median or median openings
- Toll islands
- Tunnel portals
- Hazards on traffic islands

Crash cushions shall effectively prevent an errant vehicle colliding with roadside aggressive features in a frontal or sideways impact. They shall be based on energy absorption or momentum transfer and tested to NCHRP 350/MASH (US), EN1317-3 (EU) or equivalent national standard.

Crash cushions shall be specified as redirective or non-redirective according to applications and site conditions.

4. Pedestrians, Slow Vehicles and Traffic Calming

Built-up areas directly traversed by Asian Highway routes shall be identified and categorized in terms of safety risks for all users. Accordingly, appropriate pedestrian and slow traffic facilities shall be provided in conjunction with traffic calming schemes.

Speed Limits

The speed limit of Asian Highway routes traversing built-up areas shall be reduced to levels commensurate with the safety risks. The default speed limit of built-up areas shall normally not exceed 50km/h. Authorities should also be able to raise or lower the speed limit to suit the actual circumstances.

Traffic Calming

Urbanized sections shall be designed to be distinctly recognizable by drivers. Visual traffic calming shall be implemented through built-up areas and their peripheries.

The beginning of built-up areas shall have an information sign displaying the name of the city, town or village. This should be reinforced by other measures, engineering or non-engineering, to highlight the start of a change in the nature of the road.

Where there are frequent pedestrians or slow vehicles travelling along or crossing the road, consideration shall be given to physical traffic calming measures including vertical speed reduction facilities. Physical measures shall only be provided where traffic speeds have been reduced to appropriate levels. The measures shall be acceptable to all road-users with adequate signing and delineation.

Non-engineering measures shall be encouraged to reinforce the image of built-up areas in conjunction with streetscape design. Such measures may include trees, landscaping, lighting, benches, decorations etc. Adequate considerations should also be given to passive safety.

Non-engineering measures shall also be encouraged along the periphery of built-up areas to provide a transition for high speed traffic approaching built-up areas. Such measures may include a subtle change of plantings and roadside features.

Universal Accessibility

Wherever pedestrian facilities are provided, adequate consideration shall be given to the needs of all users including the visually impaired, elderlies, wheelchair users and those with luggage or children etc. At the edge of footpaths and refuge islands fronting pedestrian crossings, the following features shall be provided:

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

Adequate consideration shall be given to universal accessibility at grade-separated pedestrian facilities crossing busy, multi-lane or high speed roads. Tactile paving blocks shall be provided ahead of staircase or ramps.

Pedestrian Footpaths

Pedestrian footpaths shall be provided, as appropriate, along urbanized sections of Asian Highway routes and their peripheries. Footpaths shall also be provided around crossings and on other road sections where pedestrians are regularly present such as those along roadside tourist attractions.

On bridge crossings, roads with heavy traffic or traffic speeds exceeding 60km/h, consideration shall be given to a segregated footpath separated from the main road with a safety barrier, planter walls or at least a grass verge. At urban centers, along wide busy roads and where space is available on other sections of the main road, consideration should be given to providing a wider pedestrian corridor

comprising a landscaped belt, footpath and frontage zone for buildings.

Pedestrian footpaths shall be continuous forming a walking network to serve the needs of pedestrians within built-up areas and their peripheries. Appropriate treatments such as drop kerbs and colored surfacing shall be adopted where a footpath intersects an access or a side road.

The desirable minimum width of a basic footpath is 2m with a clear passage width not less than 1.2m. A larger width should be provided for high pedestrian demands to achieve a reasonable level of service.

Pedestrian Crossings

Pedestrian crossing facilities shall be provided, where necessary, to assist pedestrians crossing the road safely and comfortably. The need for pedestrian crossings may be determined 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:

- Zebra crossings
- Informal crossings
- 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 and local conditions. Consideration shall be given to reducing traffic speeds or the number of traffic lanes to enhance the safety of at-grade crossings.

Grade-separated crossings shall be provided for controlled-access Class I roads and, as far as practical, other Class I roads with multiple traffic lanes, high traffic speeds, high volume of traffic or frequent heavy vehicles.

Pedestrian Refuge Islands

Pedestrian refuge islands shall be provided, as appropriate, to assist pedestrians crossing a bidirectional road in two steps in the following situations:

- Urbanized sections of Classes II or III roads with high traffic volume
- Wide urbanized sections
- Class I roads without a median

On Class I roads with a median, pedestrian refuge islands shall be provided as an extension of the median. A right hand staggered arrangement is preferred such that pedestrians are guided to be facing approaching traffic.

Pedestrian refuge islands shall only be provided where the speed limit does not exceed 70km/h and preferably, 60km/h. Adequate consideration shall be given to visibility, delineation, lighting and passive safety.

Where refuge islands for pedestrians or other purposes are provided on Classes II or III roads with frequent slow vehicle traffic, adequate effective lane width or a slow vehicle bypass lane should be provided for main road traffic and slow vehicles to travel in parallel.

Pedestrian Fences

Pedestrian fences shall be provided, as appropriate, to:

- highlight crossing points
- encourage crossing at right angle
- prevent pedestrians crossing Class I roads between designated crossings
- guide pedestrians towards footbridges or subways
- divert pedestrians away from intersections and road sections not suitable to cross
- avoid pedestrians spilling onto the road

Pedestrian fences may be substituted by safety barriers or planter walls of appropriate characteristics. They may be provided along footpaths, medians or both according to actual needs. Their design and construction shall take into account the following considerations:

- Balance between safety and convenience
- Design should discourage climbing over or crossing through gaps where this is likely
- Passive safety if an errant vehicle collides with the fence
- Need for visibility at intersections and on their approaches
- Implications on aesthetics and streetscape

Slow Vehicle Routes

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

Slow vehicle routes may be provided as segregated slow vehicle tracks or slow vehicle lanes, depending on the volume of traffic and slow vehicles as well as traffic speeds. Segregated slow vehicles tracks shall be considered for traffic speeds exceeding 60km/h and where traffic volume is high.

Slow Vehicle Crossings

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

- Marked crossings
- Unmarked crossings
- Signalized crossings
- Grade-separated crossings

Where both pedestrians and slow vehicle need to cross the road at the same location, the crossing shall be designed with adequate width.

The priority for at-grade crossings shall be clearly established and understood by road-users. Slow vehicles normally do not have priority at 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 should be provided.

In general, side road traffic is required to give way to slow vehicle traffic alongside the main road. This arrangement is preferably reinforced by traffic calming measures. Where the traffic volume of the side road is high, it is desirable to bend the slow vehicle route outward with a set-back from the main road.

A system of exclusive unidirectional motorcycle lanes or tracks should be considered if there is a high demand of motorcycle traffic on primary or Class I roads.

5. Delineation

Adequate delineation shall be provided to assist drivers in identifying the layout and boundary of road pavements, traffic lanes and intersections. In addition to the essential provision of line markings, other delineation facilities shall be adopted, as appropriate, in the optimum combination to enhance safety for all users.

Chevron Signs

Chevron signs shall be provided on the outside of sharp curves which:

- requires approach traffic to reduce speed substantially
- are not conspicuous due to an open background
- are confusing due to presence of intersections or tangential features
- have poor visibility
- have a history of collisions related to loss of control

Chevron signs shall be used as part of a curve signing system with various levels which are consistently used for curves of similar risks.

Chevron signs shall have a retroreflective sign face of adequate size to be clearly visible to drivers approaching the curve. They may be enhanced with a bright color border, flashing lights or embedded light-emitting elements.

Delineators

Delineators shall be provided on road sections without road lighting outside built-up areas for the following purposes:

- Highlighting road alignment and curves
- Demarcating direct accesses and intersections

They shall also be provided, where appropriate, to separate opposing traffic or slow vehicles and to highlight roadside hazards. They may be provided at diverge gores on high speed roads.

Delineator posts and the colors of reflectors for different purposes shall be distinctly different and consistently applied according to their functions. Delineation posts for alignments and curves may be substituted by reflectors directly attached to safety barriers or retaining walls.

Delineators shall be frangible or flexible for passive safety at high traffic speeds. To reduce maintenance needs, self-restoring delineation posts should be encouraged at high impact sites and on high speed roads.

Anti-glare Systems

Anti-glare facilities should be provided on primary and Class I roads without road lighting in the following situations:

- Median less than 9m in width
- Relatively heavy night time traffic
- Low standard horizontal curves
- Low standard sag curves
- Opposing traffic at a different level smaller than 2m
- Central reserve or parallel roads

- Near tunnel portals where tunnel tubes are at close proximity
- Glare from other light sources

Anti-glare systems may be provided in the following forms:

- Manufactured screens
- Manufactured nets
- Median barrier of adequate height
- Hedges

Anti-glare systems shall not result in unacceptable visibility required on curves, around intersections, tunnel entrances and for any signs on the median. Where hedges are adopted, adequate consideration shall be given to maintenance needs and safety.

Line Markings

The following line markings shall be provided:

- Edge line (possible omission within built-up areas)
- Lane line
- Centerline (for undivided roads with paved width $\geq 5.5\text{m}$)
- Markings for at-grade intersections
- Markings for grade-separated intersections

Centerline markings for Classes II and III roads shall consist of solid lines, dotted lines and mixed solid and dotted lines, and curly arrows. Their use shall be based on availability of overtaking sight distance.

Wide Centerline Markings

Wide centerline markings shall be adopted, as 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 tops with inadequate overtaking visibility
- divided roads with one carriageway constructed for two-way traffic
- sections of roads where there is a history of overtaking crashes

Wide centerlines 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 colored surfacing. It is advisable that rumble strips are laid along the line markings.

With heavy traffic flows or high traffic speeds consideration shall be given to the installation of a median safety barrier provided that there is adequate width for any slow vehicle travelling on the shoulder and for traffic to pass a stopped vehicle.

Raised Pavement Markers

Raised pavement markers shall be used, as appropriate, to supplement edge line markings on all primary roads and Class I roads. They are recommended for use along edge lines and where applicable, centerlines, on other classes of roads outside built-up areas with speed limit of 70km/h or above and without lighting. They should also be used on roads susceptible to poor visibility due to weather conditions.

Priority for their use shall be given to curves or on road sections with increased safety risks, including:

- Undivided multi-lane Class 1 roads
- transition zones with changes in the number of traffic lanes
- transition from divided road to undivided road
- interchange diverges, merges and weaving sections
- intersections with turn lanes
- tunnels and approaches
- narrow bridges and approaches

Rumble Strips

Centerline rumble strips shall be adopted, as appropriate, on:

- on undivided Classes I, II roads with speed limit of 80km/h or above
- at and on the approach to curves
- in conjunction with wide-centerlines

Edgeline rumble strips shall be adopted, as appropriate, on:

- all primary roads
- controlled-access Class I road with speed limit of 80km/h or above
- Undivided Classes I, II roads with speed limit of 80km/h or above

Transverse rumble strips shall be adopted, as appropriate, on

- main road or side road approaches to intersections including roundabouts
- approaches to curves and hazardous road sections
- approaches to toll plazas or border areas etc

The height and usage of rumble strips shall take into account the risk for pedestrians, cyclists or motorcyclists as well as residential houses and premises sensitive to noise or vibration.

Road Lighting

Road lighting shall be provided, as appropriate, on:

- within built-up areas and their peripheries, crossings and other road sections where pedestrians and slow vehicles are frequently encountered at night time
- on road sections with heavy traffic at night time
- at major interchanges or intersections with heavy traffic at night time
- through tunnels, long bridges and their immediate approaches
- at toll plazas and immediate approaches to ports or border crossings

6. Road Signage

Traffic Signs

Traffic signs for the Asian Highway Network shall consist of:

- Warning Signs
- Regulatory Signs
- Supplementary Signs

- Informatory Signs

The meaning of traffic signs other than non-standard informatory signs shall be legally defined in national or local traffic law.

Traffic signs shall be homogeneous and standardized in graphics design. They shall be visible at a distance ahead during day and night and are understandable in a short time.

Symbolic signs shall be adopted wherever possible provided that they are readily understandable. Excessive use of traffic signs shall be avoided to prevent overloading of information and obscuring.

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.

Directional Signs

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

- Advance Direction Sign: informing drivers for route selection ahead
- Direction Sign: guiding drivers to negotiate an intersection
- Confirmatory Sign: confirming drivers the route and destinations ahead with distance after an intersection

Allowance shall be made for the signing of tourist destinations but this should not take priority over directional signs which display main destinations.

Directional signing shall display upcoming city names of importance along Asian Highway routes for the orientation of long distance drivers.

On primary and Class I roads 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.

For successive and complex intersections, directional signing shall provide accurate guidance for drivers to select the appropriate route.

7 Tunnels

Tunnels of 500m or more 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 facilities commensurate with the safety risks.

The design speed of tunnels in terms of alignment and lane width shall be the same as the approach roads, unless special provisions are made for the adaptation of drivers. Tunnels and their approaches shall, as far as possible, be free from unfavorable geometric conditions including sharp curves and steep grades. At-grade intersections shall be located with adequate distance away from tunnels and

grade-separated intersections are not generally permitted inside a tunnel unless a very high level of safety features is incorporated.

Speed limits inside tunnels shall be determined on the basis of safety risks and shall not exceed 110km/h for unidirectional traffic and 80km/h for bidirectional traffic. Overtaking shall not be permitted inside bidirectional tunnels and is generally discouraged inside unidirectional tunnels. No pedestrians or slow vehicles shall be permitted inside tunnels except where operational conditions are suitable or else appropriate facilities are provided.

There shall be adequate facilities and plans to cope with unauthorized vehicles, incidents, fire and maintenance needs through implementation of lane closure, tunnel tube closure, tunnel full closure and, where appropriate, single tube contra-flow operation. Facilities for inspection, emergency parking and emergency response shall be provided at or in the vicinity of tunnel portals of major tunnels.

Consideration shall be given to the provision of laybys and vehicle cross passages inside tunnels exceeding 1,500m in length. Emergency stations consisting of an emergency telephone and at least two fire extinguishers shall be provided at intervals not exceeding 150m. Escape facilities shall be provided at intervals not exceeding 500m. An emergency signing system on separate power source shall be provided to indicate laybys, cross passages, emergency stations, emergency exits and evacuation routes.

Essential traffic signs include speed limits, length of tunnel and, where appropriate, any special restrictions. Where intersections are located in the vicinity of a tunnel, adequate advance direction signs shall be provided ahead of the tunnel and, where appropriate, inside the tunnel as well.

Tunnels shall be equipped with adequate real-time surveillance and control facilities which generally include, inter-alia, CCTV cameras, over-height vehicle control, traffic signals, overhead lane control signals, variable message signs, variable speed limit signs and barrier systems.

Tunnel lighting is required to enable traffic to approach, enter, through and exit a tunnel or similar facilities smoothly and at a safety level equivalent to the adjacent open road, day and night and under all weather conditions. To assist drivers' adaptation, lighting levels in the entrance and exit areas of tunnels shall be automatically controlled with direct continuous monitoring of external ambient conditions

Adequate attention shall be given to achieving a forgiving roadside inside tunnels and at tunnel portal areas where the roadside could be complicated by facilities for operation, maintenance and emergency response.

8. Enforcement Facilities

The following enforcement facilities shall be deployed, as appropriate, at locations or road sections susceptible to violations which pose a high safety risk:

- Red light enforcement cameras
- Speed enforcement cameras
- Combined red light and speed enforcement cameras
- Average speed cameras

III. ROAD NETWORK DEVELOPMENT

1. Phased Development

Bypass of Population Centers

Bypasses are diversion routes which bring through traffic away from population centers. Bypasses may be in the form of Primary, Class I, Class II or Class III roads.

Bypasses shall be planned around major cities for Asian Highway routes and may form part of a ring road system. Bypasses should also be planned around major towns and larger villages where through traffic poses a safety hazard.

Where a bypass is not a controlled-access road, the number of intersections shall be restricted and frontage direct access should not be permitted. Adequate right-of-way should be acquired for future developments and the provision of service roads, grade-separated intersections and crossing facilities.

Allowance for Future Widening

In the design of new primary roads, adequate consideration shall be given to the need for widening in the future. There are two possibilities:

- Providing right-of-way to accommodate additional traffic lanes
- Initial construction of one carriageway only for two-way traffic

For Option 1, symmetrical widening is preferred as asymmetrical widening is generally more prone to safety problems during construction.

Option 2 shall not be adopted unless a high level of safety design and management is ensured. Special treatments are required to reduce the risk of indiscriminate overtaking and drivers' misinterpretation as a unidirectional road.

Self-explaining Road Characteristics

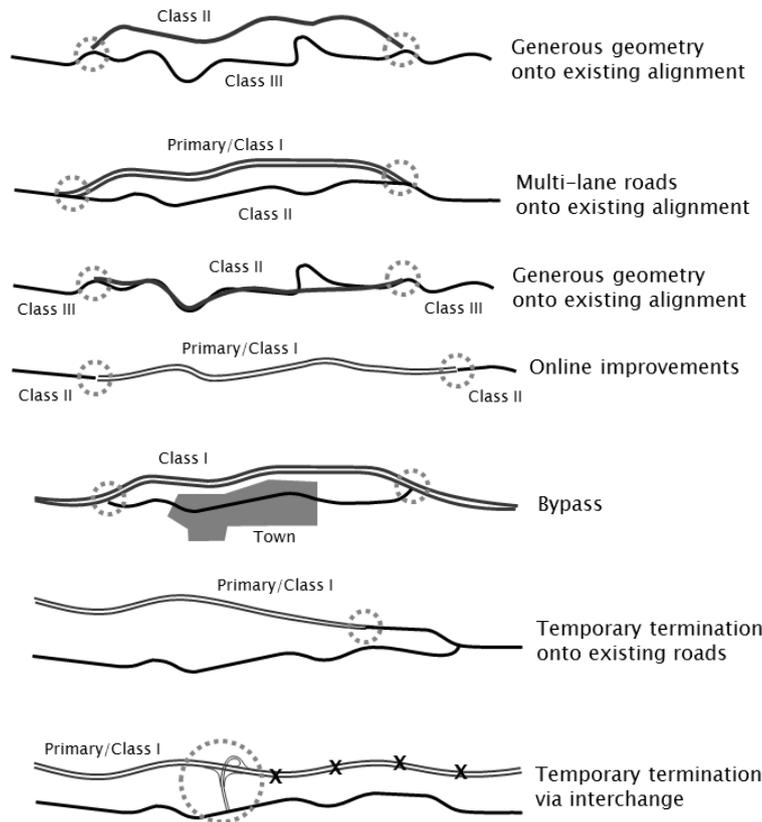
The following road types of different nature or operational characteristics shall be distinctly different in their visual appearance and reinforced by signing:

- Multi-lane controlled-access divided roads: Primary roads and Class I roads
- Multi-lane non controlled-access divided roads: Class I roads
- Two lane undivided roads: Classes II, III roads
- Urbanized road sections

Interface

Phased improvements of Asian Highway routes often gives rise to interfaces between different road types. Typical interfaces are illustrated in Diagram 1.

Diagram 1



The following treatments shall be applied, as appropriate, at interfaces with the objective of inciting drivers to adapt their behavior:

- Cross-section change in conjunction with changes in terrain and landform features
- Provision of roundabouts
- Passage through slip roads of grade-separated intersections

At the interface between road improvement schemes and existing roads, particular attention shall be given to road safety, especially in the direction from the new road onto the existing road. The transition area shall be treated to ensure that drivers will slow down in time and adapt their behavior accordingly.

Interface areas shall not be located where the existing road geometry is significantly inferior to the new road, with the presence of sharp curves, significant crests, complex road environment, constrained visibility etc.

Termination of Primary Roads

Where a primary road or controlled-access Class I road terminates in one of the following arrangements, special treatments are required to alert drivers and to assist them adapting to the change:

- A lower design speed is adopted on the road
- Primary road becoming a Class I road
- The road becomes a Class II or Class III road
- The road terminates directly onto an at-grade intersection
- A grade-separated intersection is partially constructed with mandatory exit onto an at-grade intersection

“End of Expressway” signs shall be erected on the approach to the termination of a primary road, commencing not less than 1500m ahead of an intersection or the point where the design speed or road class changes. In addition, these shall be accompanied by appropriate traffic signs, road markings and speed reduction measures. Lower speed limits should be posted in steps if there is a large reduction of design speeds.

If a primary road terminates at a grade-separated intersection pending completion of the through route, traffic should be positively signed to exit onto the slip road.

Similar but less stringent treatments shall be adopted for the termination of other divided roads with design speed of 70km/h or above.

2. Network for Pedestrians and Slow Vehicles

Mixed traffic of different types, masses and speeds on highways is prone to safety problems. Safety improvements on Asian Highway routes shall, as far as possible, involve a wider optimization of the road network by diverting pedestrians and slow vehicles to local roads and minor corridors away from the main highway. These may be area-wide or localized initiatives.

Outside built-up areas, exposure of pedestrians, local traffic and slow vehicles to highway traffic shall be minimized, as appropriate, with a network strategy comprising one or more of the following measures:

- Restricting the number of at-grade intersections and direct accesses
- Providing alternative or parallel routes
- Grade-separation

3. Re-use of Old Roads

Where improvements of existing Asian Highway routes involve realignment, considerations should be given to the beneficial re-use of abandoned sections of the existing roads.

Such re-use is preferably part of a network strategy to improve safety for pedestrians and slow vehicles. Possible initiatives include:

- Existing road promoted as a local access road with traffic calming if the new road follows an entirely new alignment
- Existing sections of roads and bridges parallel to the new road converted for the use of pedestrians and slow vehicles
- Re-use for public parks, viewpoints, roadside parking areas, rest areas, emergency parking areas or bus stops

Re-use of old bridges should be encouraged provided that they are well maintained. An individual old bridge only benefit one direction of travel, in which case pedestrian and slow vehicle facilities are still required for the other direction of travel.

For successful re-use of existing roads, attention should be given to details so that they are attractive to users. It is generally desirable to ensure that users are within the visibility of the new road for reasons of personal security.

Intersections between the existing road and the new road should be minimized and treated with appropriate safety measures, particularly where crossing movements are expected. They should intersect the main road at right angle and are located on straight sections with adequate visibility.

Where a bypass is provided, the existing urbanized section is preferably converted as an urban main street with traffic calming and pleasant streetscape in favor of pedestrians and slow vehicles. Intersections between the bypass and the existing road shall be designed to clearly distinguish the main road and the side road.

4. Interim Safety Improvements

Interim safety improvements based on low-cost safety measures shall be undertaken, as appropriate, to rectify existing safety problems. They should also be implemented to mitigate significant safety risks, such as those associated with aggressive roadside objects and sheer drops.