IRC:99-2018

GUIDELINES FOR TRAFFIC CALMING MEASURES IN URBAN AND RURAL AREAS

(First Revision)

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GUIDELINES FOR TRAFFIC CALMING MEASURES IN URBAN AND RURAL AREAS

IRC:99-1988 was entitled "Tentative Guidelines on the Provision of Speed Breakers for Control of Vehicular Speeds on Minor Roads". This document has been reviewed and revised. The revised document is IRC:99 with title "Guidelines for Traffic Calming Measures in Urban & Rural Areas". The task of revision of IRC:99 was assigned to Road Safety and Design Committee (H-7). The revised draft was prepared by the Subgroup comprising Dr. Geetam Tiwari, Shri Jacob George, Shri S.K. Marwah, Shri R.R.D Kirori, and Mrs. Bina C. Balakrishnan. The draft was deliberated in a series of meetings. The H-7 Committee finally approved the draft document in its meeting held on 25th September, 2017 and decided to send the final draft to IRC for placing before the HSS Committee.

The Composition of H-7 Committee is as given below:

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Director General (Road Development) & Special Secretary to Govt. of India	(Kumar, Manoj), Ministry of Road Transport & Highways
Secretary General, Indian Roads Congress	Nirmal, Sanjay Kumar

The Highways Specifications & Standards Committee considered and approved the draft document in its meeting held on 13th October, 2017. The Executive Committee in its meeting held on 2nd November, 2017 considered and approved the same for placing it before the Council. The Council of IRC in its 213th meeting held at Bengaluru on 3rd November, 2017 considered and approved the draft of IRC:99 “Guidelines for Traffic Calming Measures in Urban & Rural Areas” (First Revision) for printing. The valuable contribution made by Dr. Sanjay Wakchaure, SE MoRTH regarding review of detailed document deserves special mention.

1 INTRODUCTION

1.1 Road categories and their specific designs are determined by considering the maximum permitted speeds of vehicles that will travel on them with convenience and safety. At certain locations like approaches to sharp curves, congested/accident-prone locations and residential streets, towards manned and unmanned level crossings, control of speed becomes necessary to promote orderly movement of traffic and to enhance safety.

1.2 Traffic Calming techniques have emerged primarily as a society’s requirement for safety. It is widely accepted that differences and variations in the speed, direction, and mass of vehicles are some of the key determinants of severity of road accidents. These techniques have played an important role in enhancing road safety by ensuring lower driving speeds and smaller speed differences between different road users. Over the last 25 years, the residential areas in Europe have become much safer with the creation of 30 km/hr zones despite the considerable variation in the direction and mass of vehicles plying on them. Several such experiences from around the world have established that the use of Traffic Calming techniques to influence road design significantly reduces accidents, pollution and makes neighbourhoods more liveable.

1.3 However, the case in India is quite different given the heterogeneity of modes of traffic on most roads (see **Table 1.2**). The vehicles plying on urban roads, National Highways (NHs) and State Highways (SHs) vary widely in terms of operating characteristics. Sometimes tractors and animal carts share the carriageway with fast moving motorised traffic. The highways that pass through villages and towns are also shared with local traffic - resulting in wide variations in direction, speed and vehicle mass.

1.4 Given the context of socio-economic conditions across the country, it is difficult to restrict access of non-motorised vehicles to highways. The Traffic Calming techniques have to be adapted to the Indian context to achieve the goals of managing efficient traffic flow at the same time ensuring safety of all road users especially around areas where the Highways pass through the villages and towns.

1.5 Road construction and maintenance are expensive public expenditure items and the costs on the road users and overall society is also substantial. The social costs comprising of accidents involving injuries and deaths and pollution in the surrounding areas are difficult to quantify. In light of this, it becomes imperative to pursue policies that minimise transportation costs for the individual road links and the network as a whole using the limited financial resources efficiently. The extensiveness and diversity in road networks create opportunities to explore the wide range of traffic calming techniques and also consider trade-offs between one another to improve any situation.

1.6 In city and metropolitan regions, roads should be designed to restrict the passenger vehicles speeds at 50 km/h and those of trucks and commercial vehicles at 40 km/h. This will ensure that the traffic moves smoothly with less acceleration and deceleration at average speeds between 20 and 30 kmph.

1.7 Vehicle speed is one of the critical factors associated with road accidents because higher speeds reduce the time available to avoid collisions and makes the impacts in collisions more severe. Research studies from around the world demonstrate conclusively that the frequency and severity of accidents usually reduce with reduction in average speed. A decrease in average speed of 1 km/h will typically result in a 3 per cent decrease in fatal accident frequency. Variation in speed between vehicles within the traffic stream is another factor that contributes to accident occurrence. **Table 1.1** and **Fig. 1.1** establishes the importance of speed management in accident severities (Elvik, Christensen, & Amundsen, 2004).

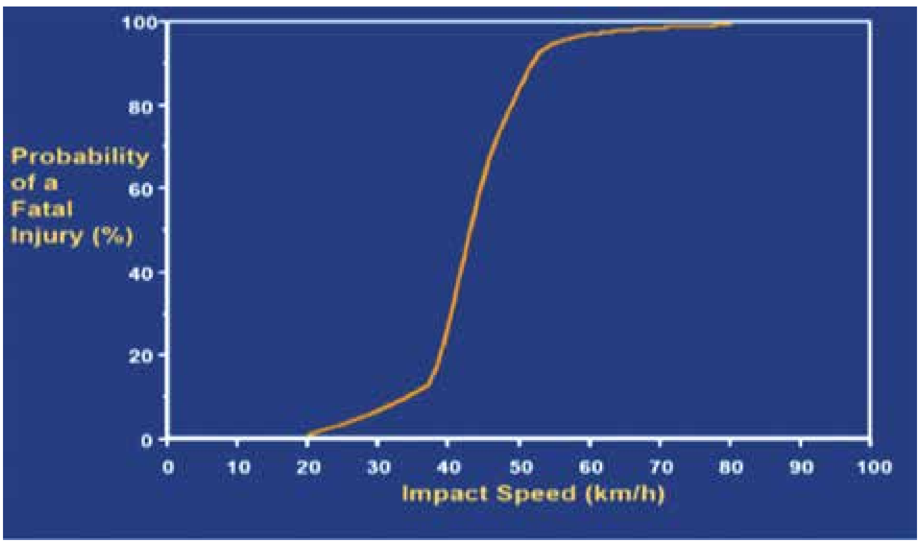


Fig. 1.1 Probability of Fatal Injury for Pedestrian by the Speed of the Car on Impact

Table 1.1 Effect of Death and Injuries by Change in Mean Speed

Change in	**Change in Mean Speed**					
	Speed Reduction			**Speed Increase**		
	-10%	**-5%**	**-1%**	**+1%**	**+5%**	**+10%**
Deaths	-38%	-21%	-4%	+5%	+25%	+54%
Serious Injuries	-27%	-14%	-3%	+3%	+16%	+33%
Other injuries	-15%	-7%	-1%	+2%	+8%	+15%
Property damage crashes	-10%	-5%	-10%	+1%	+5%	+10%

1.8 Given the wide differences in traffic patterns in different countries, it is recommended that clear and unambiguous instructions should be communicated to ensure that the design is appropriate for the local conditions. Two main principles for speed reducing measures have been discussed.

I. Visual measures - Speed limit signs, painted strips across the road, zebra crossing, stop marking on the road surface (visual brakes), three dimensional markings, road surface patterns and plants etc.

II. Physical measures.

It is common experience that visual measures like speed limit signs alone may not suffice to control driving speeds but has significant effects when combined with physical measures.

1.9 The goals and objectives for traffic calming are standard for most countries. Safety is a key objective for virtually all traffic calming schemes, not only in terms of reducing accidents, but also to reduce the degree of danger felt by people using the streets. In recent years, concerns over the environmental and public health effects of traffic have increased considerably leading to an additional objective of minimizing environmental impacts. Reducing the speed and volume of traffic can contribute to a better local environment, but it may often be possible, through imaginative design and the use of appropriate materials (Rehman, et al., 2009).

1.10 This document aims to provide key information about Traffic Calming techniques for urban areas, State Highways, National Highways and rural roads. Chapter 2 lays down the understanding of various traffic calming techniques, followed by a detailed description of various techniques in urban areas in Chapter 3 and rural areas (highways) in Chapter 4.

Table 1.2 Traffic in India vs Traffic in Developed Countries

	Feature	India	Developed Countries
1.	Modal mix of traffic in urban areas	Two-wheelers, three-wheelers and non-motorised traffic comprise a much larger share in urban traffic	Cars are the dominant mode
2.	Modal mix on intercity roads	Trucks, buses and cars constitute a larger share on most highways. Presence of tractors and non-motorised traffic (varies from road to road). Large variation in speeds.	Cars are the dominant mode and there are no tractors and non-motorised traffic. Therefore, little variation in speeds.
3.	Highways passing through townships.	Almost all intercity roads pass through townships and villages. Therefore, all intercity traffic must interact with local traffic when passing through these areas.	Extensive network of limited access highways ensures that most long-distance traffic uses the same. Traffic on intercity roads passing through townships is generally not long distance traffic and hence has slightly different characteristics and needs.

	Feature	India	Developed Countries
4.	Vehicle characteristics	The suspension systems of vehicles and their sizes vary greatly. Therefore, horizontal Traffic Calming measures like lane narrowing and staggering would have to be re-explored to deal with narrow vehicles. Vertical measures like humps (speed breakers) would affect cars, motorcycles, trucks and buses differently.	Since the vast majority of vehicles are cars and even larger vehicles, horizontal measures are effective. Vertical measures must be tailored to cars, buses and trucks, where two-wheelers is not a major issue.
5.	Traffic segregation	Very little segregation of traffic. Traffic Calming measures should target segregation as one of the major goals.	A large proportion of roads in Europe now have segregation of traffic, especially the provision of bicycle lanes thereby making the Traffic Calming measures easier to implement.

2 TRAFFIC CALMING

The central theme of Traffic Calming is to reduce the adverse impact of motor vehicles on built up areas. The techniques usually involve reducing vehicle speeds, providing more space for pedestrians and cyclists, and improving the local environment.

Road engineering aims to bringing the design of the road in accordance with the desired speeds of the vehicles plying on them, constitute the guiding principles of Speed Management by Design or Traffic Calming.

The basic principle of Traffic Calming remains universal, that is to lower the vehicle speeds in order to reduce accidents, pollution and enhance livability of surrounding areas. Vehicles travelling at speeds below 30 km/h can co-exist with pedestrians in relative safety. Measures such as road narrowing, roundabouts and road humps, reduce the negative effects of motor vehicle use, and alter driver behavior and improve conditions for non-motorized street users.

2.1 Necessity of Traffic Calming

Studies have shown that traffic calming can reduce accident levels by up to 40 per cent, and have a significant impact on reducing the severity of accidents, economic loss and air pollution .“The main advantage of traffic calming is that it is self-enforcing and does not normally require any complication traffic control devices and is usually highly cost-effective; achieving benefits with a value far greater than the costs.

2.2 Classification of Traffic Calming Techniques

The classification of traffic calming techniques proposed is shown in **Fig. 2.1**.

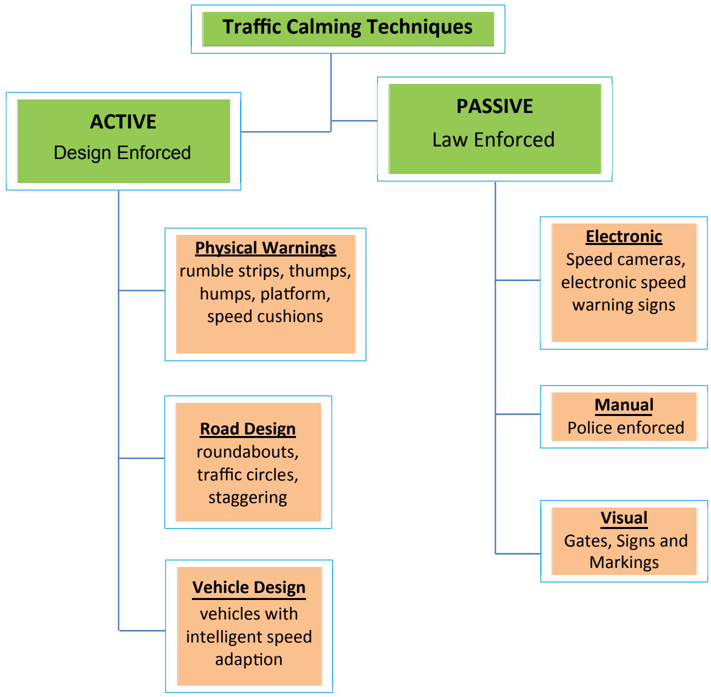


Fig. 2.1 Classification of Traffic Calming Techniques

2.3 Active or Design Enforced

Pro-active or design enforced approaches are highly effective since these can achieve almost 100 per cent success rates in managing speed on the road with relatively low level of capital expenditure. The roads and vehicles can be designed to achieve a desired response to road and speed classification and volume recommendations. The appropriate design can address the driver by influencing the driving behavior. Such approaches should be the preferred method in most cases given their high levels of effectiveness with low investments.

A very high percentage of road accidents are attributable to human error. Changing human behavior of drivers and other road users is a slow process and a significant challenge. Several attempts and experiments at influencing road user behavior have yielded less than satisfactory results. The limitations of the human ability remain evident given the range of behavioral issues and weaknesses - motivation, attention, emotion, observation, prediction, knowledge and skills that prevent the human from being an ideal traffic participant. In this context, the strategies should focus on adapting the transportation system to suit the people who use them, so that they are led to behave safely, rather than nudging people adapt to the system failing which there are serious consequences such as permanent mutilation or fatalities. More precisely, the three basic elements of the system - infrastructure, road user and the vehicle should be adapted to each other. The endeavor should be that the infrastructure and the vehicle parts of the system should adapt well to the limitations of human ability through proper design.

2.3.1 *Physical Warnings*

Traffic calming on road infrastructure can be physical measure to curtail the speed forcing drivers to slow down to the desired speed.

Table 2.1 Types of Physical Warnings

Intent of TC technique/ intervention	Method	Successful Examples
Physical signal to driver	Influences driver behavior by means of jerks and vibrations to the vehicle	Road humps, rumble strips, raised crossings, plat-form junctions raised at pavement level, speed tables and ramps
Psychological signal to driver	Directly affecting his risk perception by visual or audio means	Carriageway width constrictions, chicanes, corner blips, planted central reservations, bends in the traffic route etc.

The common factor that effect of psychological signal to the driver get reduce over time, as the drivers get used to the measures as part of their routine travel habits.

2.3.2 *Lane Narrowing*

Lane narrowing can reduce the speed of cars but its effect is minimal for two wheelers. Also, in the case of bicycle lanes, there are more chances of the lane being encroached upon by the motorized vehicle due to a constricted carriageway. The narrowing should be indicated using lane marking or texture change or colour change or by kerb markers. Lane narrowing is shown in **Fig. 2.2** and **2.3**.

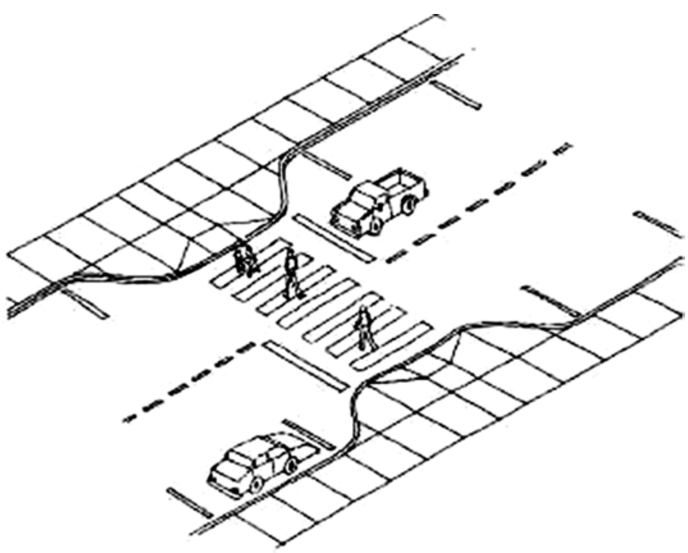


Fig. 2.2 Lane Narrowing

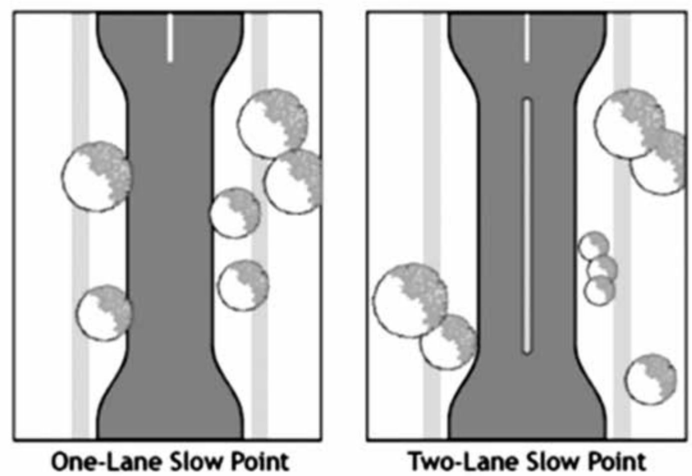


Fig. 2.3 Lane Narrowing

2.3.3 *Speed Breakers/Humps*

Speed breakers are commonly used to reduce speeds and help in maintaining efficient traffic flows by reducing speed differences among the road users. However, the design and type of the speed breaker is critical. The degree of the effect of the humps in terms of speed reduction depends upon the profile, height, gradient, length and the material used in the design. Their sight indicates to the driver about the impending inconvenience in the form of a jerk and vertical deflection and the driver understands higher speed would cause inconvenience to them, thus there would be a general tendency to slow down. Their key advantage is that they can be easily placed at identified locations.

2.3.3.1 Circular Humps

The profile of this hump is circular as shown in **Fig. 2.4**. The radius and chord length can be varied to different passing speed.

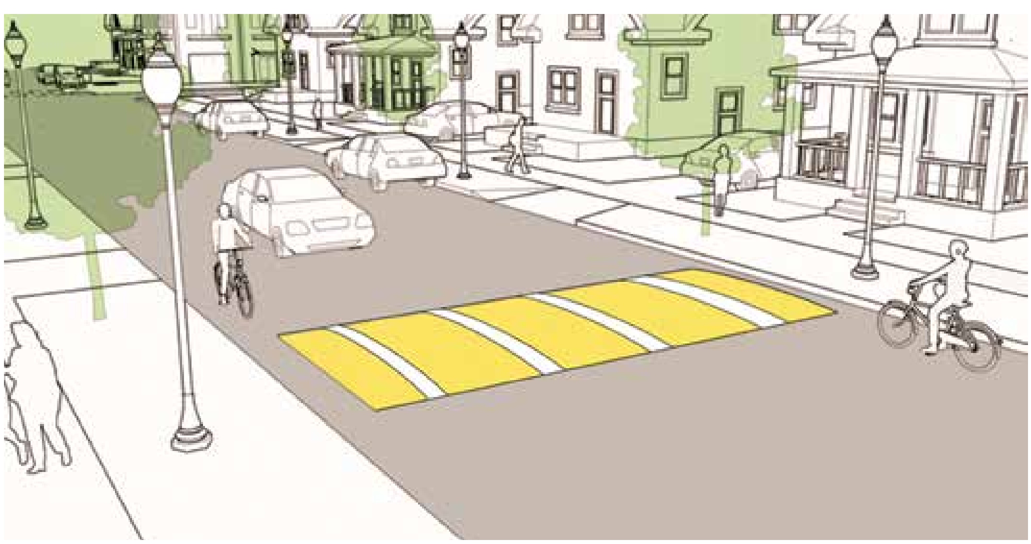


Fig. 2.4 Circular Hump – Shape of a Circular Arc

2.3.3.2 Trapezoidal Humps

The trapezoidal humps have a slightly raised flat section of a carriageway with ramps on both sides as shown in **Fig. 2.5**. These can be used in connection with pedestrian crossings. If installed correctly, the discomfort is moderate for cars, whereas lorries and buses must pass very slowly.

Fig. 2.5 Trapezoidal Hump – Flat Top with Tapered Sides

2.3.3.3 Rumble Strip

Rumble strips are provided at places where speed control is unavoidable in highways and arterial roads. Properly designed rumble strips can be provided on NHs and State Highways. The rumble strip can be cast in situ with cement concrete or premix bituminous materials. Rumble strip may be provided across the entire width of carriageway and paved shoulders (if any). Raised section should be 20 to 30 mm high, 200-300 mm wide and spaced about one meter centre to centre of roughly 6 numbers at one location as shown in **Fig. 2.6**. These are placed across the entire carriageway including the shoulder. Proper workmanship must be exercised to achieve the required height. On approaches to narrow bridge, rumble strips can be used in shoulder to force the driver to slow down and drive on restricted width of pavement in approaches, where shoulder gets terminated or in some case shoulder space is converted to raised footpath etc. In accident prone locations, where accidents have occurred due to departure of vehicles from shoulder on to side slope of embankment, rumble strip can be used on such a shoulder side also.

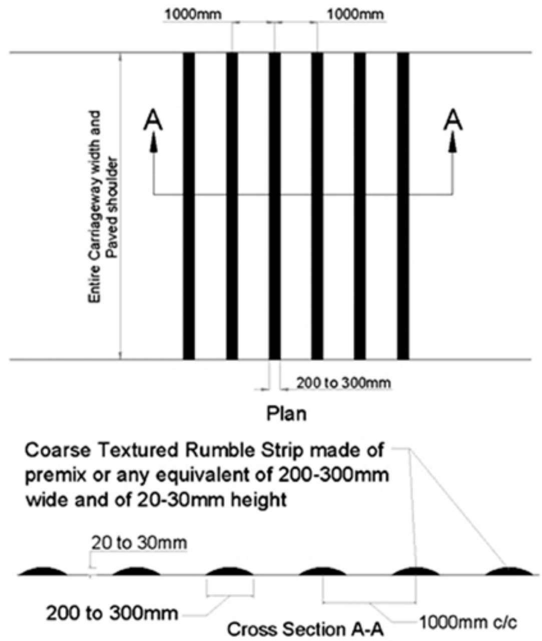


Fig. 2.6 Rumble Strip (Not to Scale)

2.3.3.4 Transverse Bar Markings

Transverse bar marking made of thermoplastic markings is another treatment to alert and to reduce the speed. Number of sets of transverse bar markings on approach to hazardous location depending upon the speed. Each set comprises of 6 bars, 200 to 300 mm wide 600 mm apart of 5 mm high and of 300 mm wide 1000 mm apart of 15 mm high as shown respectively in **Figs. 2.7** and **2.8**.

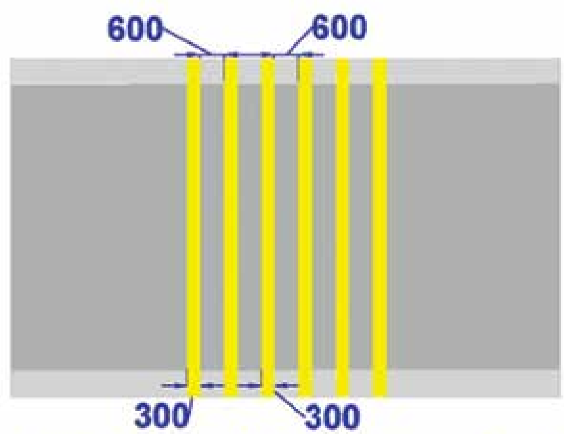
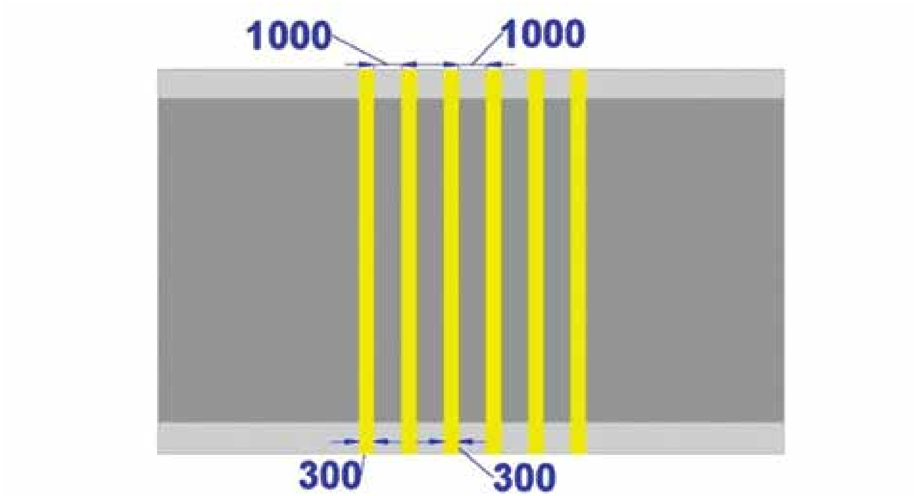


Fig. 2.7 Bars with Height of 5 mm & Gap Width of 600 mm



Thermoplastic Marking of 300 mm wide and 15 mm height, at 1000 mm apart (one set is of 6 Strips). 15 mm height is achieved through six applications of thermoplastic, applied at an interval not less than 1 hour after the previous layer gets solidified. Alternatively, made of Mastic Asphalt or any equivalent material which would provide 15 mm high

Fig. 2.8 Bars with Height of 15 mm & Gap Width of 1000 mm

2.3.3.5 Speed Table (Raised Crossings)

Speed Table, which is the raised crossing, extends the full width of the carriageway between the kerbs and extends over a longer length of road than humps. The surface should be of a different material to the carriageway and footpath. Speed Table is more suitable than road humps when the measures are implemented on bus routes. In a corridor having considerable buses, the length of the Speed Table should be sufficient to accommodate the full wheelbase of the bus to reduce passenger discomfort to a minimum.

Fig. 2.9 Speed Table

2.3.3.6 Raised Crossings

Raised crossings are used to resolve conflicts between different kinds of traffic i.e. cars and other motor vehicles, cyclists and pedestrians and are predominantly used at minor junctions, property access, and entry and exit to service roads and would provide comfort, convenience and safety to all users.

Fig. 2.10 Intersection Treatment for Major to Minor Roads (European Settings)

2.3.4 *Raised Intersections*

Raised intersections are used to bring all users to a common speed limit without affecting the cyclists too much. They can be mainly used on junctions where the intervention does not affect the movement of high volume through traffic.

Fig. 2.11 Intersection Treatment at a Minor Crossing

2.3.5 *Textured Pavements*

Textured pavements are effective for reducing speed of small cars, but are to be combined with other measures to be effective for buses and other large sized cars.

Fig. 2.12 Textured Paving over Raised Crossings

2.3.6 *Roundabouts*

Roundabout is a junction type to reduce the speed of traffic while passing through junction. The central island and deflecting islands are designed in such a way that traffic has to be deflected to reduce the speed before entering circulatory carriageway. In the roundabout high speed conflicts can be avoided, as shown in **Fig. 2.13**. The IRC:65 "Guidelines for Planning and Design of Roundabouts" is recommended for design of roundabout.

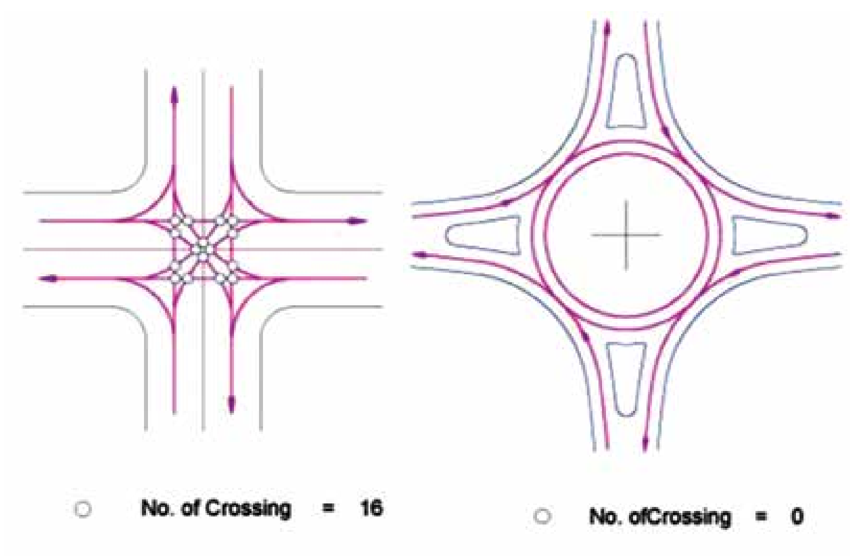


Fig. 2.13 Conflicts in Cross Road Vs Roundabout

2.3.7 *Mini Roundabout*

In the absence of space to accommodate a normal roundabout, mini roundabouts is an alternative to bring about speed reduction.

Fig. 2.14 Mini Roundabouts can be Useful in Slow Speed Urban Environments

Fig. 2.15 Mini Roundabout in IIT Delhi

2.4 Other Measures

There are other measures, which are used internationally are staggering, chicanes, chokers and realigned intersections etc.

2.4.1 *Staggering*

Staggering is one of the few traffic calming techniques which can produce a very predictable effect on traffic speeds depending on the vehicle type. It is done by horizontal deviation of vehicles on the road, restricting them to known turning radii, which would be different speeds for different vehicle types. Hence, the sharper the bend, the slower would be the speed. The maximum achievable speed can be defined based on the geometry of deviation.

The angled kerb blisters which create a horizontal deflection is sufficient to slow vehicles to travel comparable to speed at hump (i.e. 20-25 km/hr at the device). The device operates differently for single lane and two lane devices as shown **Figs. 2.16** and **2.17**.

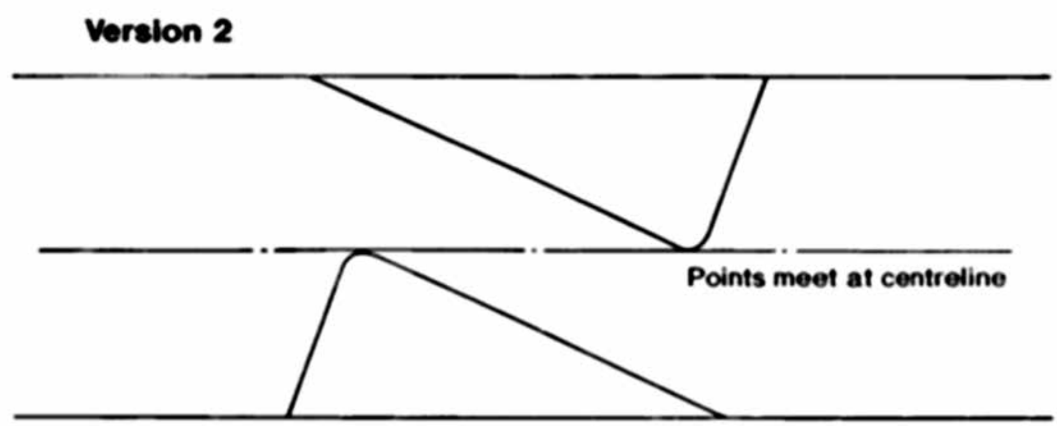


Fig. 2.16 Staggering - One Lane

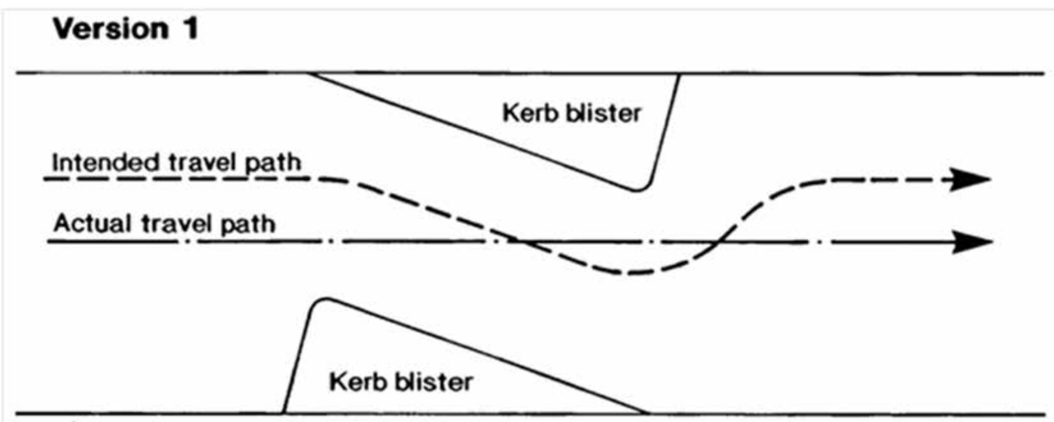


Fig. 2.17 Staggering - Two Lanes

The advantages and disadvantages of staggering is given in **Table 2.2**

Table 2.2 Staggering - Advantages and Disadvantages

Advantages	Disadvantages
• Single lane device restricts speed to about 25 km/hr, eliminates heavy vehicles. Two lane device restricts speed to 40 km/hr, can accommodate buses • can be landscaped • can accommodate parking bays • accommodates cyclists at the kerb	• not recommended as an isolated device • single lane devices restrict speed off large emergency vehicles • single lane devices not suitable for collector streets

2.4.2 *Chicane*

The chicane is another design for staggering whereby to reduce the speed.

Fig. 2.18 Chicane is Another Design Element Used for Staggering

2.4.3 *Realigned Intersection*

Realigning of intersection such as converting skedded crossing into staggered intersection is a way to slow down the speed of cross road traffic as shown in **Fig. 2.19** Chokers and chicane are other options available for reducing speed, reducing the traffic way.

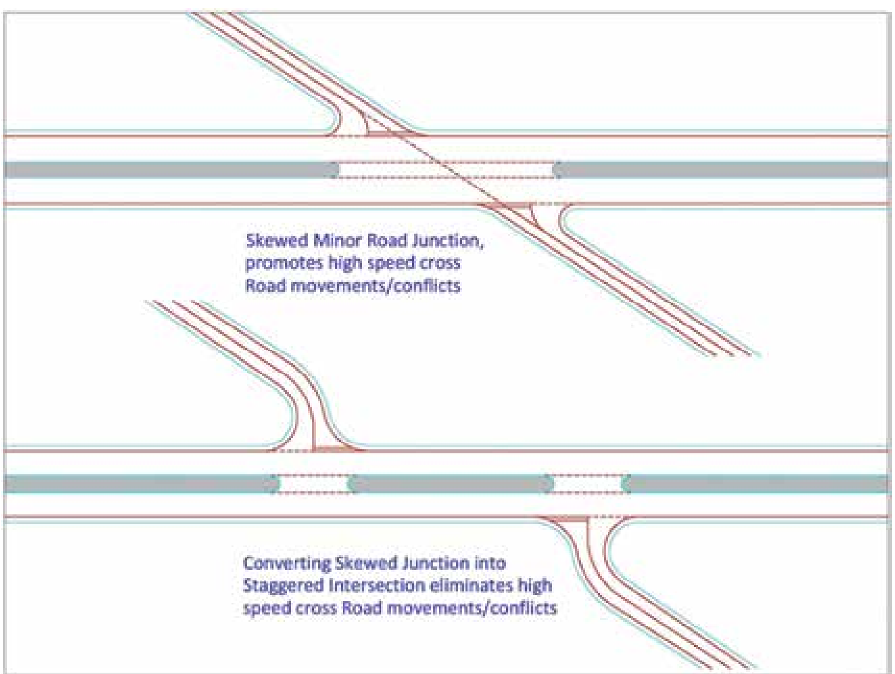


Fig. 2.19 Staggering of Side Roads

2.5 Effectiveness of Traffic Calming Measures

The effectiveness of Traffic Calming measures can be appreciated in **Table 2.3**

Table 2.3 Objectives and Impacts of Traffic Calming Measures

S. No.	Objectives of Traffic Calming Measure	Impact of Traffic Calming Measures
1	Reducing the difference in speed between vehicles and at different points along the same road.	Reduces the disturbances in traffic flow and thereby increases the average speed of all vehicles.
2	Reinforcing the road hierarchy	Slowing down vehicles significantly on access roads, moderately on secondary roads and much less on main roads.
3	Reducing the number of accidents	Reduces the number and severity of traffic jams that are caused by accidents.
4	Reduction in noise, air pollution and aesthetics	Traffic calming generally reduces traffic noise. Speed reductions from 50 to 30 km/h typically reduce noise levels by 4-5 decibels or more in certain circumstances.
5	Increases neighbourhood interaction and crime prevention	Helps make public streets lively and friendly, encourages community interaction, and attracts customers to commercial areas. Discourages extreme anti-social behaviour. Neighbourhoods that are more difficult to drive through (narrow streets, few straight through streets) have significantly less crime than those that are more permeable.

2.6 Passive or Law enforced

Passive measures include speed cameras and electronically displayed speed warning signs and the restrictions enforced by police manually for certain traffic movements, and also visual measures like gates, signs and markings, whereby law can be enforced for those who are violating the instructions and crossing the limits set therein.

2.7 Visual Warnings or Pre-Warnings

Pre-warnings are applied to ensure that drivers become aware of the subsequent speed reducers or changing road speed classification. The pre-warning is not in itself intended to be physically speed reducing but should motivate the drivers to ease the pressure and reduce speed. Pre-warnings will normally be applied on traffic roads before stretches of speed control and can be used for all traffic flows.

2.7.1 *Signs*

Road sign warns and informs the drivers about the nature of the road stretch that they are approaching and about the local speed limit or recommended speed for that road stretch. The road signs may be supplemented by planting, other measures like gates and in certain cases physical warning like rumble strips.

Among other things, road speed classification signs, speed zone signs as well other warning signs, should be designed to consider the reaction time and visible distance at design speeds in the zone that they driving, so that the drivers as well the vehicle can react accordingly before entering the defined zone. IRC:67 for "Code of Practice for Road Signs" should be followed for recommended road signs in India.

Fig. 2.20 Stop Sign

2.7.2 *Feedback Signs*

Increasing number of road accidents in India due to over-speeding and the limitation of the current speed limit signs in India has created the need for a smart speed limiting solution. Driver Feedback Sign (DFS) are designed to display real-time feedback about the speed of the vehicle to the driver. It measures the speed of the vehicle by using a radar and displays the real-time speed of the vehicle on a LED display. These signs have a high impact polycarbonate face and can be programmed to flash when motorists exceed the speed limit. Driver Feedback Signs present the driver with a highly visible display in the daytime or night-time and under all-weather conditions. DFS with its better sign visibility alerts motorists when they are over speeding and helps protect pedestrians and other vulnerable road users. It can be very effectively used on city roads near schools, hospitals and residential areas to warn speeding motorists to slow down. The idea is to warn speeding vehicles continuously and inculcate a culture of driving within suggested speed limits.

Fig. 2.21 Driver Feedback Signs

2.7.3 *Markings*

Road marking also influence driver behavior and markings will invariably catch the attention of drivers. An optimum number of information marked on roads that driver can take action in appropriate time. With a traffic calming project, one should always consider whether the same information can be conveyed through a sensible design of other traffic control measures in addition to signs and marking. Road marking shall be the essential part of traffic calming measures. IRC:35 "Code of Practice for Road Marking" should be followed for pavement marking.

2.7.4 *Gates*

Gates are used as traffic calming to indicate the transition from one traffic environment to another. It is primarily to mark the change to a lower desired speed. Gates can be used on roads such as at the approach to a town or an old town area, or on local roads at the entrance of the local traffic zone.

Gate on a traffic road must function visually by means of planting, change of road surface, portals and lighting and also by slightly narrowing the carriageway. At the entrance to a local traffic zone, humps and reduction of the trafficable width can be considered. Designers should establish location of gates, which, to some degree, resemble the speed reducing measures in the area. For example, gates for a village and town shall be located in such a way that restriction would be applied for a reasonable length and can bring forth compliance.

Fig. 2.22 Entry Gate to Harvington Village near Evesham in Worcestershire, England

The effect of gates in reducing speed depends on their design and on their context. The effect is greatest if they are given a distinctive design; both visual and speed reducing techniques in them.

2.7.5 *3-Dimensional Marking on Roads*

The 3-dimensional marking provided on road gives an impression to approaching driver which in-turn has an effect on speed. It is highly effective initial period of installation, but effect is likely to reduce as drivers are accustomed to know the location after a period of time but will be highly effective for first comers. Invariably, it would serve as altering measures to fast approaching traffic to know the location of hazardous location.

3 TRAFFIC CALMING MEASURES IN URBAN AREAS

Traffic calming can help create more attractive urban environments. Commercial areas along higher-speed streets tend to be unattractive, as much land is used for parking, and settlement patterns have no clear form. Traffic calming projects can even reduce the amount of land devoted to streets and parking, which in turn can increase green-space and reduce impervious surfaces, resulting environmental and financial benefits. Traffic calming schemes generally incorporate a wide range of measures designed to complement each other in both speed reduction and environmental terms. Schemes are designed to be self-enforcing, although the effectiveness of this varies according to the measures employed. The principle techniques used fall into four areas:

- Vertical Deflections
- Horizontal Deflections
- Road Narrowing
- Central Islands

The effects of these measures may be reinforced by a range of supporting measures.

3.1 Vertical Deflections

Vertical shifts in the carriageway are the most effective and reliable of the speed reduction measures. Some of the techniques available to achieve this include:

- Speed Breaker
- Speed Bumps
- Speed Table
- Uneven Road Surface and Stone Set Pavement

3.1.1 *Speed Breaker/Road Hump*

Speed breaker may be of several varieties, the rounded and flat topped being the most common. The latter are particularly suitable in providing crossing places for pedestrians. The width of humps may be restricted to allow the longitudinal drainage. Speed breaker are not recommended on bus routes because of the discomfort caused to passengers.

3.1.1.1 Circular Hump

The profile of circular shaped hump is based on the shape of a circular arc with a radius varying from 11 m to 113 m and a chord length varying from 3.0 m to 9.5 m to achieve desired speed of 20 km/h to 50 km/h. Circular shaped humps with rises less than assumed 10 cm will result in higher speeds than those mentioned. Rises that are higher than 10 cm may cause damage to vehicles. For roads with bus traffic, the table indicates the speeds at which buses can reasonably pass the individual humps. If buses must be able to pass at 40 km/h, the radius of the hump must be 180m and chord length 12 m. **Fig. 3.1** gives the geometrical details of Road Hump.

Table 3.1 Recommended Radii and Chord Lengths, Circular Humps (Assumed Rise = 10 cm)

Desired Speed	Radius	Chord Length	Bus Speed During Passage
20 km/h	11 m	3.0 m	5 km/h
25 km/h	15 m	3.5 m	10 km/h
30 km/h	20 m	4.0 m	15 km/h
35 km/h	31 m	5.0 m	20 km/h
40 km/h	53 m	6.5 m	25 km/h
45 km/h	80 m	8.0 m	30 km/h
50 km/h	113 m	9.5 m	35 km/h

3.1.1.2 Trapezoidal Humps

A hump, which constitutes a 50 to 100 mm raised, flat section of a carriageway with ramps on both sides is called a trapezoidal hump. If designed correctly, the discomfort is moderate for cars, whereas lorries and buses must pass very slowly. **Fig. 3.2** gives geometric details of trapezoidal hump for various speed and also the speeds at which the buses may reasonably pass the individual humps. If buses must be able to pass at speeds of 35 and 40 km/h respectively, ramp lengths must be 3.3 and 4.0 m, and gradients 3.0 and 2.5 per cent respectively

Table 3.2 Recommended Ramp Lengths and Gradients, for Trapezoidal Humps)

Desired Speed	Length of Ramp	Gradient	Bus Speed During Passage
20 km/h	0.7 m	14.0%	-
25 km/h	0.8 m	12.5%	5 km/h
30 km/h	1.0 m	10.0%	10 km/h
35 km/h	1.3 m	7.5 %	15 km/h
40 km/h	1.7 m	6.0%	20 km/h
45 km/h	2.0 m	5.0%	25 km/h
50 km/h	2.5 m	4.0 %	30 km/h

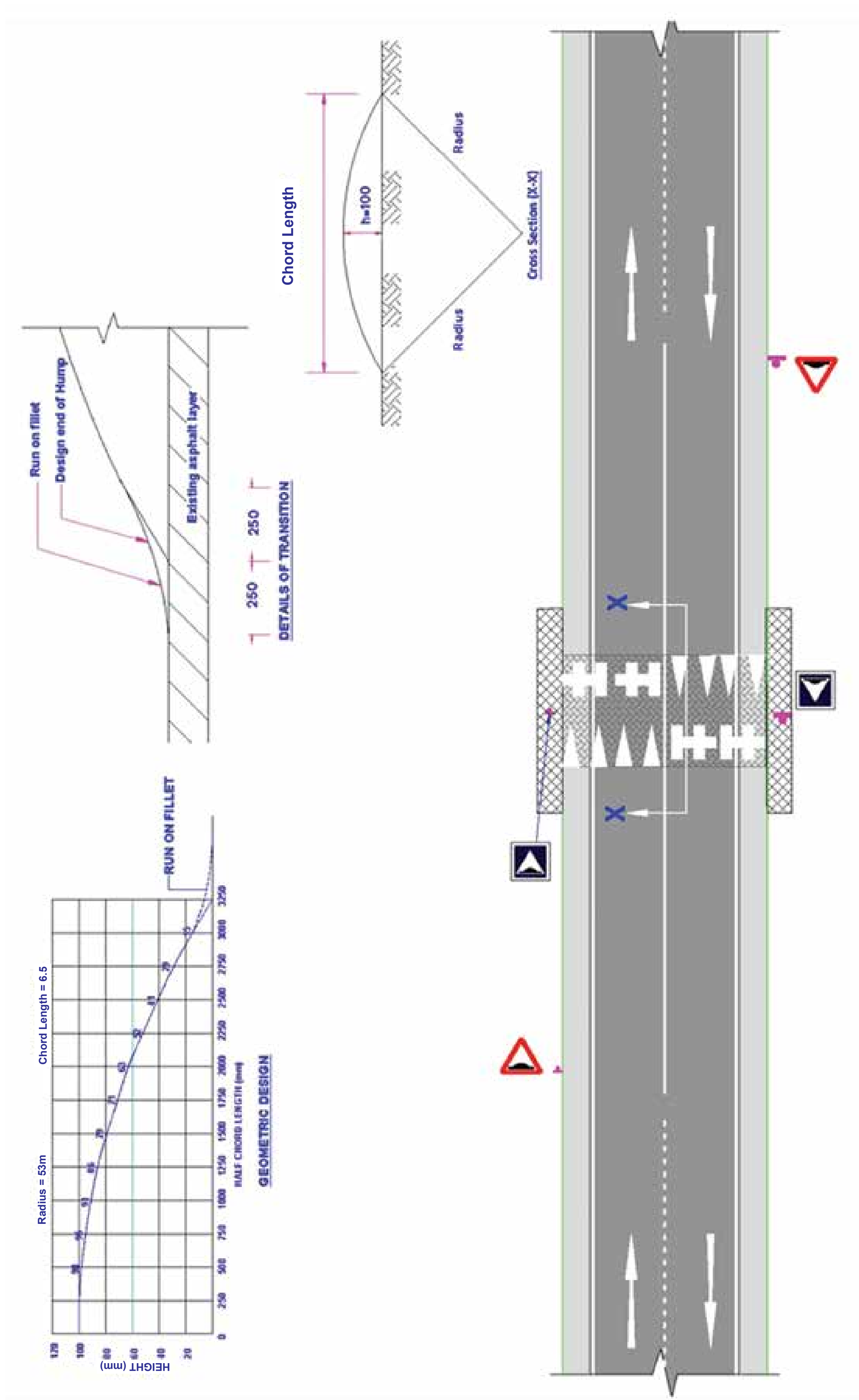


Fig. 3.1 Geometric Details of Circular Road Hump

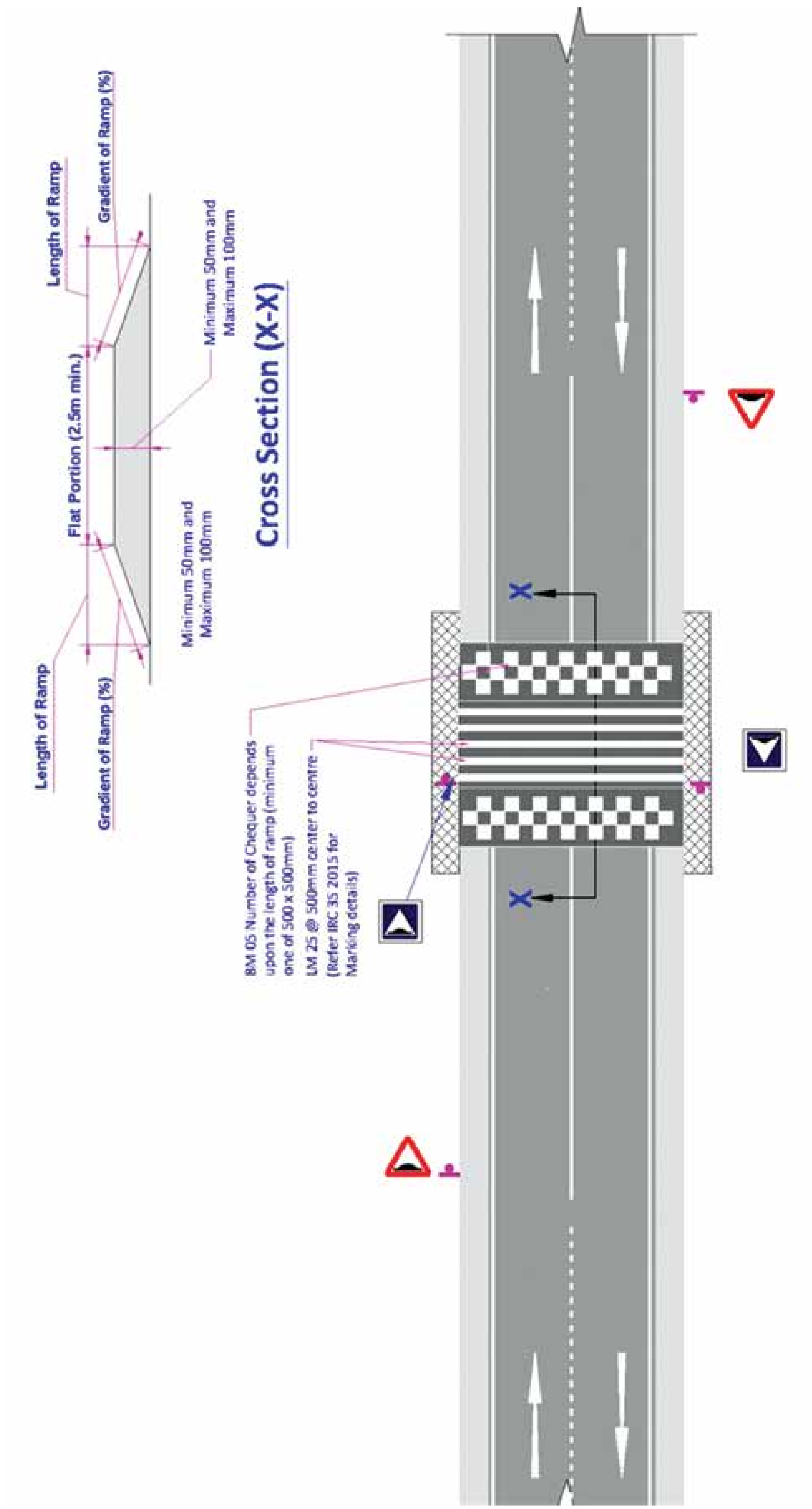


Fig. 3.2 Geometric Details of Trapezoidal Road Hump

3.1.2 *Speed Bumps*

Precast, ready to install bumps are available and are being fixed on the road. These bumps can be nailed to the pavement. In high speed environment, these bumps prove to be traffic hazard. Once the bumps get damaged by repeated striking of traffic movement, the nail remains on the pavement and prove to be damaging the tyres of vehicle. Therefore, its usage is recommended for local and collector streets.

Fig. 3.3 Road Bump in Narrow Residential Street

Fig. 3.4 Road Bump Available in Indian Market

Fig. 3.5 Road Bump in Wide Residential Street

(Gap in the Bump shown in fig. is a Traffic Hazard)

3.1.3 *Speed Table/Raised Pedestrian Crossing*

In a road section having substantial pedestrian crossing, raised pedestrian crossing called Speed Table is a solution, where vertical deflection can be achieved to reduce traffic speed and flat topped portion for pedestrian to cross. **Fig. 3.6** gives the geometrical details of a Speed Table.

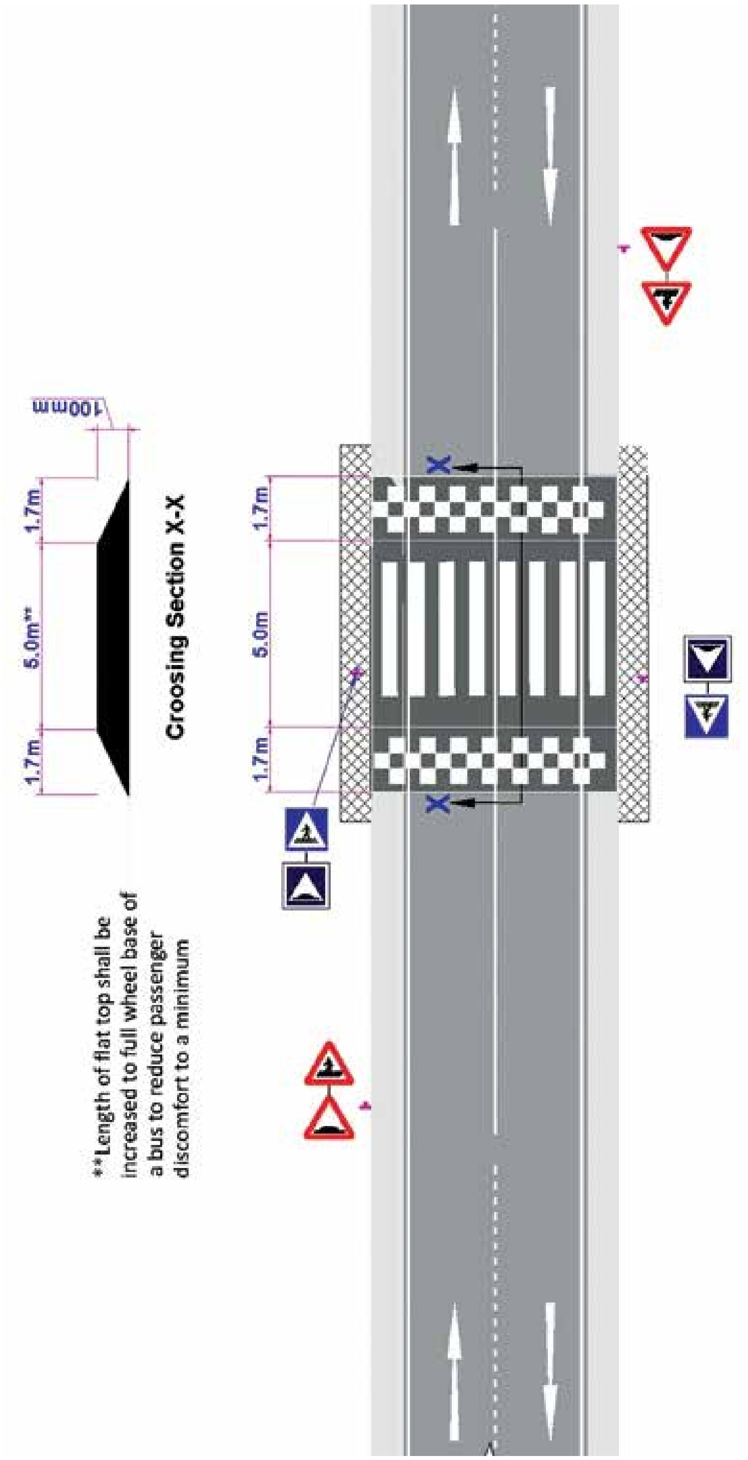


Fig. 3.6 Geometric Details of Speed Table/Raised Pedestrian Crossing

3.1.4 *Uneven Road Surface and Stone Set Pavement*

Uneven road surface or stone set pavement as shown in **Fig. 3.7** is another way of reducing speed. By changing the surface texture, speed get reduced due to discomfort. The kind of accidents generally occur with speed breakers and speed humps with vertical shift generally do not occur that with uneven road surface or that with stone set pavement.

Fig. 3.7 Uneven Road Surface in IIT Delhi

3.2 Horizontal Deflections

Horizontal shifts in the carriageway are less effective than vertical ones in achieving reductions in speed, however their impact is significantly increased when used in combination with a vertical shift. Horizontal shifts are generally gained through chicanes. The speed reducing impact of chicanes is reduced if the measure has to allow for the passage of Heavy Good Vehicles (HGVs), wherein the wider carriageway catered for HGV allows car drivers to take a “racing line”. The use of stone sets or similar treatment can be useful in allowing the passage of large vehicles while discouraging cars. Chicanes significantly reduce parking spaces and should therefore be avoided if spaces are at a premium. Additionally, they should not be dependent upon parked cars for their effect. Horizontal deflection by chicane shall always be provided with hazardous markings and retro-reflective hazard markers to make the chicane conspicuous at all time as shown in **Fig. 3.8**

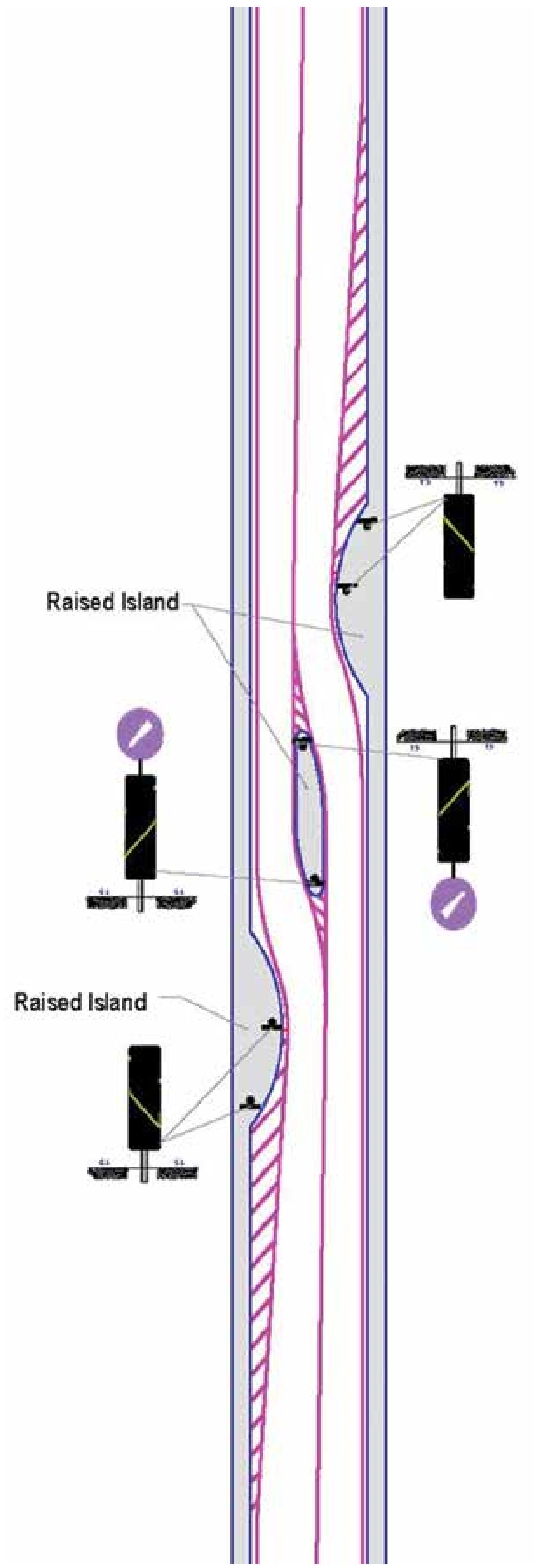


Fig. 3.8 Chicane Island to Deflect the Traffic

3.3 Road Narrowing

Road narrowing may be considered as another supportive measure to vertical deflections. Although it cannot be considered as a speed reducing device; it acts as a reminder or encouragement to drive slowly or calmly. Narrowing the carriageway at specific locations, for example in combination with speed tables, is an effective way of combining measures to increase their effect. The extra space created by road narrowing is generally used to provide widened footpath.

3.4 Central Islands

Providing Central Island in a undivided carriageway in an urban street is an effective measure, which would not only reduce the speed, but serve as refuge space for pedestrian. However, care shall be exercised to provided reasonably bigger and wider island at centre to place a hazard marker sign and shall be protected with marking.

Fig. 3.9 Road Narrowing from Center

3.5 Supporting Measures

A number of supporting measures are commonly used to back up the speed reducing techniques. The use of different surface materials, the planting of trees and the use of street furniture falls into this category. However, as independent measures they generally have little effect on traffic speeds.

Fig. 3.10 Use of Different Surface Material in Rural Haryana

3.6 Traffic Calming at Road Junctions

3.6.1 *Vertical Deflections*

Raised junction areas, and flat top road humps are effective speed reducing measures at junctions. Treatment of junction corners by the use of an uneven road surface is useful for slowing down turning traffic, particularly HGVs, however this has no effect on vehicles going straight ahead.

3.6.2 *Changes in Slignment*

This technique involves narrowing the carriageway in the vicinity of a junction so that all moves through the junction have to deviate from a straight-ahead path. This measure is effective in reducing the speed of straight through traffic; however junction priorities may become confused, when the boundaries of the junction are less recognizable.

3.6.3 *Reduction of the Junction Area*

The area of a junction may be reduced by building out the footways. This is carried out on junction corners at crossroads or T-junctions. In addition, the footway may be built out along the straight at a T-junction. In an urban junction having considerable pedestrian crossing, built out can be provided to prevent free left turn as many times, turning traffic generally do not give way for pedestrian to cross.

Fig. 3.11 Junction Area Reduction - European Setting

3.6.4 *Pedestrian Refuge*

The provision of islands on the approaches to a junction has only a limited effect on vehicle speeds. They will however improve the situation for pedestrians by creating a refuge, although by reducing the amount of carriageway they may hinder large vehicles when turning.

3.6.5 *Special Junction Forms*

Roundabouts and mini roundabouts may be useful in reducing traffic speeds at junctions. The latter is suitable when available space is limited, however, if no vertical elements are placed on the island the speed reducing effect will be more limited. A ramped area around a central island allows large vehicles more turning space.

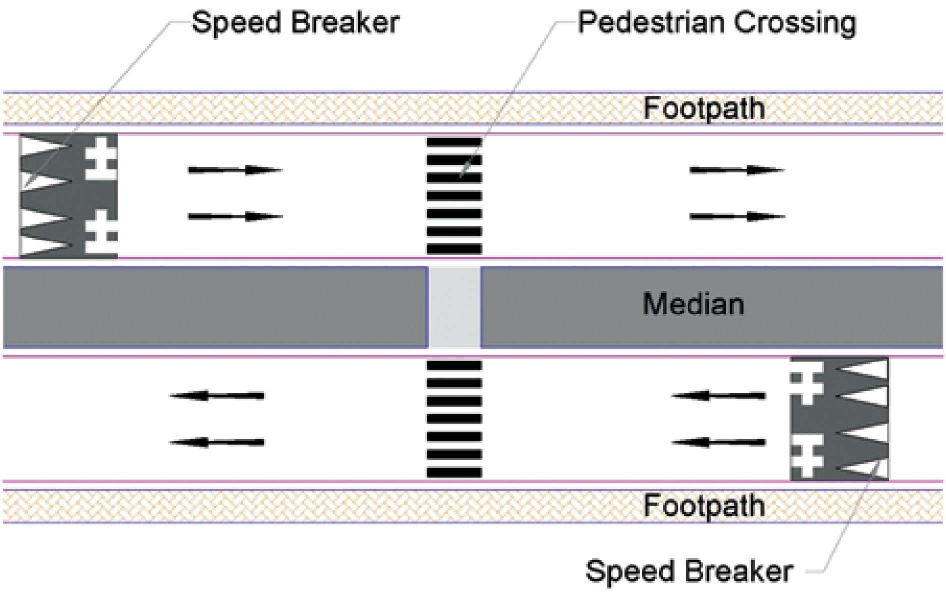


Fig. 3.12 Design to Facilitate Mid-Block Crossing by Pedestrians

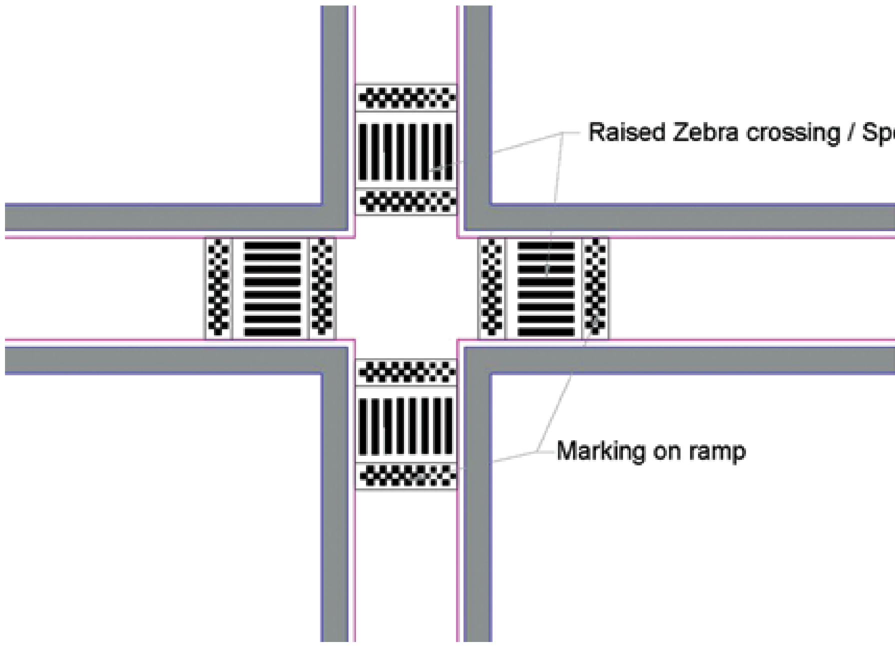


Fig. 3.13 Raised Areas for Pedestrians

3.7 Traffic Calming on Main Roads

In a main road, changes in (surface) level are often regarded as unacceptable, thereby eliminating the use of vertical shifts. Without vertical shift, the potential for achieving slower traffic and reduction in accidents is significantly reduced. Transverse bar marking an alternative in such main road, where vertical deflection might lead to speed breaker hit accidents. **Fig. 3.14** gives alternatives with traverse bar markings of 5 mm and **Fig. 3.15** with transverse bar marking of 15 mm at the boundary of speed zone. Since bar marking with 15 mm demands speed reduction, a set of "SLOW" marking shall be given immediately before markings, at 20 m and 40 m from bar marking.

Approach Speed (Kmph)	Bar Marking (Number of TM08)	Distance (d1, d2, d3 & d4) from Hazard
Upto 50 km	1 set	d1=50,
51 to 65	2 set	D1=50, d2=80
66 to 80 kmph	3 set	D1=50 m, d2=80 m, d3=120 m
81 to 100 kmph	4 set	D1=50, d2=80, d3=120, d4=180 m

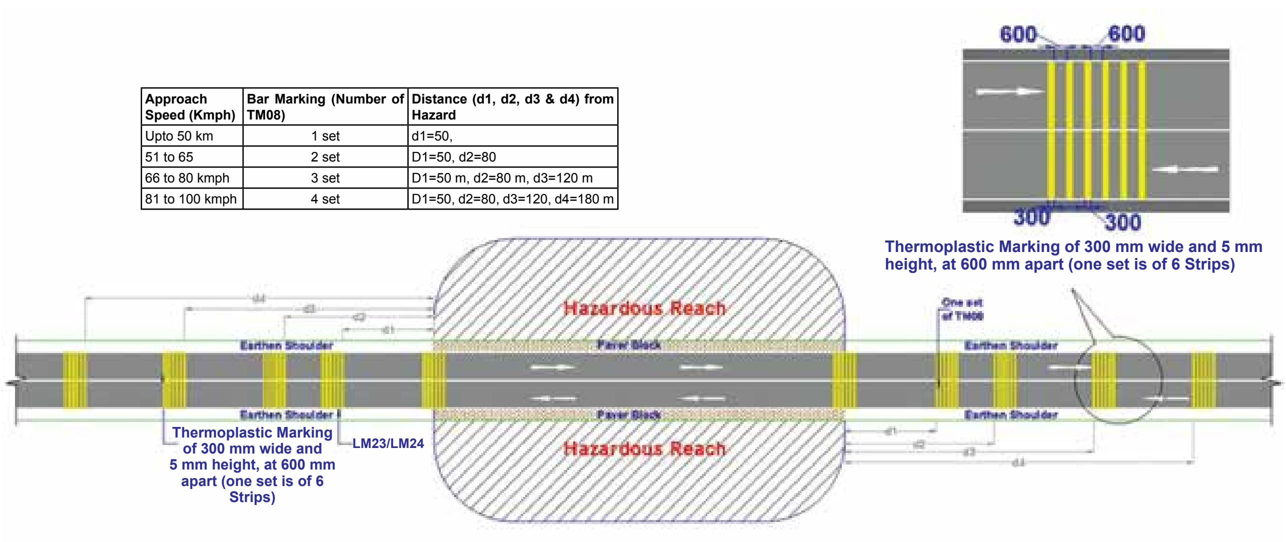
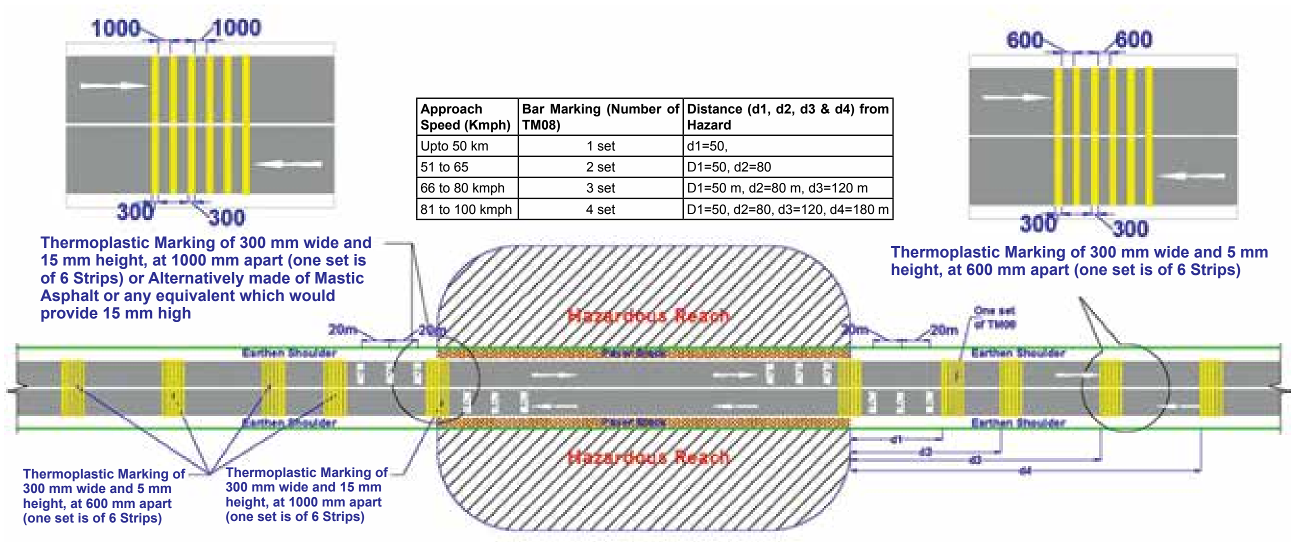


Fig. 3.14 Transverse Bar Marking as an Alerting Measure



Approach Speed (Kmph)	Bar Marking (Number of TM08)	Distance (d1, d2, d3 & d4) from Hazard
Upto 50 km	1 set	d1=50,
51 to 65	2 set	D1=50, d2=80
66 to 80 kmph	3 set	D1=50 m, d2=80 m, d3=120 m
81 to 100 kmph	4 set	D1=50, d2=80, d3=120, d4=180 m

Fig. 3.15 Transverse Bar Marking with Stricter Compliance

Common techniques employed on main roads in urban areas include:

- Road narrowing
- Islands
- Tree planting

Techniques used to control traffic using traffic signals include holding back traffic on a radial to avoid saturating downstream junctions. Applying this technique to a main radial as part of an area wide traffic calming scheme could be used to reduce queuing along the calmed length of road. Physical speed reducing measures would be required to prevent traffic from speeding up once the restraining effect of the congestion was removed. In addition, this technique may increase rat running.

When signaled junctions are relatively close together they may be linked to provide a "green wave" for main traffic movements. This linking may also be used to achieve a "calm" driving speed of 40 km/h. Drivers exceeding the linking speed would hit a red light and would have to wait for the other traffic to catch up. Regular road users would soon realize the benefits of driving at the appropriate linking speed.

3.8 Traffic Management Measures

3.8.1 *Traffic Management on Links*

As a traffic calming measure, road closures and one-way streets are regarded as a last resort as they restrict the choice of routes available for local access traffic. However, they can be very effective in removing through traffic. Problems may arise if turning heads become used as parking areas. If the link is too narrow to allow the construction of a turning head, a road closure would be generally inappropriate.

Several measures are available to create road closures for general traffic while retaining access for buses and/or cyclists. Raised or lowered cushions allow buses to pass unhindered, while the latter will prevent the passage of narrower vehicles.

3.8.2 *Traffic Management at Junctions*

In general, these measures all allow access for cyclists to be retained. Techniques include local road narrowing in the vicinity of the closure, the use of different surface materials, and adequate provision of posts at the closure to prevent motorists driving across the islands.

3.9 Eligibility Criteria and Area of Application

Table 3.3 to **Table 3.6** gives the eligibility criterial and area application of different measures respectively for Urban Arterial, Collector Roads, Residential Roads, High Pedestrian Activity Zones.

Table 3.3 Traffic Calming Techniques for Arterial Roads

Arterial Road (speed limit 50 km/h)	Pedestrian crossing	Left Turns	Intersections
Speed hump Type 1 (parabolic)			
Speed hump Type 2 (flat top)		In the middle to facilitate pedestrian crossing	
Rumble strips	10-20 m before zebra crossing		10-20 m before zebra crossing
Texture change (uncut stones)	10-20 m at zebra crossing		
Raised paint markings (audible markers)			
Paint markings	Before zebra crossing		Before zebra crossing

Table 3.4 Traffic Calming Techniques Collector Roads

Collector Road (speed limit 30 km/h)	Pedestrian crossing	Left Turns	Intersections
Speed hump Type 1 (parabolic)			
Speed hump Type 2 (flat top)	✓		✓
Rumble strips	10-20 m before zebra crossing		
Texture change (uncut stones)	✓		✓

Raised paint markings (audible markers)	✓		✓
Paint markings	✓		✓

Table 3.5 Traffic Calming Techniques Residential Roads

Speed limit <20 km/h	Pedestrian crossing	Left Turns	Intersections
Speed hump Type 1 (parabolic)			
Speed hump Type 2 (flat top)			✓
Rumble strips		✓	
Texture change (uncut stones)	✓	✓	✓
Raised paint markings (audible markers)	✓	✓	✓
Paint markings	✓	✓	✓

Table 3.6 Traffic Calming Techniques High Pedestrian Activity Zones

Speed Limit 10km/h	Pedestrian crossing	Left Turns	Intersections
Speed hump Type 1 (parabolic)			
Speed hump Type 2 (flat top)		To ensure safe pedestrian crossings at left turns.	All four sides for pedestrian crossings
Rumble strips	10-20 m before zebra crossing		
Texture change (uncut stones)	✓	All along the left turn lane except 4-5 m wide plane surface for wheel chairs.	✓
Raised paint markings (audible markers)	10-20 m before zebra crossing	✓	✓
Paint markings	✓	✓	✓

4 TRAFFIC CALMING ON RURAL ROADS (HIGHWAYS)

National and State Highways together carry more than 70 per cent of the total road traffic in India and safety has become a major concern on these roads. This challenge is accentuated when these highway roads pass through villages and towns. The local traffic and activities around the highways slow down the speeds of the through traffic and often cause congestion during the day. However, low levels of local traffic allow the through traffic to move at much higher speeds, thereby create safety hazard for the locals.

In light of this, any intervention aimed at upgrading the NH & SH sections in such areas must balance the seemingly contradictory objectives - safe environment for the vulnerable road users within local communities as well as unhindered and swift movement for through traffic. Towns and villages in these areas are of different sizes and densities (depending the local region) and the local traffic typically comprises of slow moving vehicles like bicycles, animal carts, tractors and pedestrians. The volume and speeds of these modes are at huge variance and have to interact with long distance high speed inter-city traffic. Since the highways are accessible through local roads, intersection create situations for conflicts and accidents.

4.1 Demarcation of Traffic Calming Zones on NH and SH

NH-SH may pass through urban or rural area which demands different treatment due to variation in density and land use patterns as listed below:

4.1.1 *Rural Areas*

Villages are characterized by low density scattered development. Only a few roads intersect or meet the highway. However, if the highway passes through the village, there is bound to have pedestrian movement across and along the highway. The low volume of cross movement does not give enough inducement to the speeding traffic on the highway to slow down. Hence, there is a justification for traffic calming measures in rural areas. Length of the corridor needing traffic calming measure may vary from 100 m to 1 km in case of villages.

4.1.2 *Special Area Zoning*

Areas within a built up areas may require special traffic calming measures for additional safety. Areas near a school or a hospital require absolutely low speeds. School children are more prone to commit mistakes while negotiating with highway traffic. Hence, it is recommended that vehicles should travel at maximum speeds of 25 kmph near schools and 30 km/h near hospitals.

4.1.3 *Urban Areas*

Cities and towns are characterized by high-density built-up area with commercial development along the major roads and highways. There is an official boundary defined by the municipality. However, for the purposes of traffic calming on the section where cross movements on the highway are caused by the density of roadside development, there is a need to define the boundary where the density falls abruptly. There may be several city roads intersecting the highway. Several intersections, both signalized and non-signalized, may be present inside the urban area. The volume of local traffic and the traffic management at intersections itself act as a deterrent to high speeds. Hence they largely contribute to traffic calming by themselves. The most important issue in urban area is to ensure smooth flow of through traffic at an acceptable speed of 30-40 kmph. Often the volume of local traffic and road side activities do not permit this at peak hours and the section becomes very unsafe at night when traffic moves above 70 kmph. This problem exists in small towns also where the urban corridor can be 1-5 kms long. The NH-SH section passing through such urban areas has to be treated like an urban arterial having service roads for local traffic and safe pedestrian crossing including pedestrian refuge areas at every 100-200 m as per the local need to ensure safety of pedestrians.

4.2 Demarcation of Zones for Traffic Calming Measures

The areas where the NH & SH roads pass through the villages typically have a scattered patterns of development and the low and erratic levels of pedestrian crossing movements do not produce enough signals for the approaching vehicles to slow down in time. In order to deal with this, there should be buffer zones with a demarcated boundary and the vehicles should decelerate gradually as they come near the zone. The extent of this zone may vary from 100 m to 1 km depending on the local density and intensity of the land use in the area.

Speed breakers have not proven to be effective in such situations. These have zones of influence of not more than 70-80 m around them and hence are ineffective in maintaining low vehicle speeds in the entire conflict zone. In case these are not well designed, they can seriously damage the vehicles at night especially the ones with lower chassis heights.

The approach would for gradual and informed deceleration of vehicles to safe speeds and then sustaining those speeds through visual and tactile warning signs. The total length wherein potential conflict is high should be kept optimum to command respect from through traffic. On approach at a distance 500 m to 750 m, the transition speed limit sign could be installed, which could be repeated and also with other warning sign as shown in **Fig. 4.1**. The **Table 4.1** gives recommended speed from boundary of speed zone.

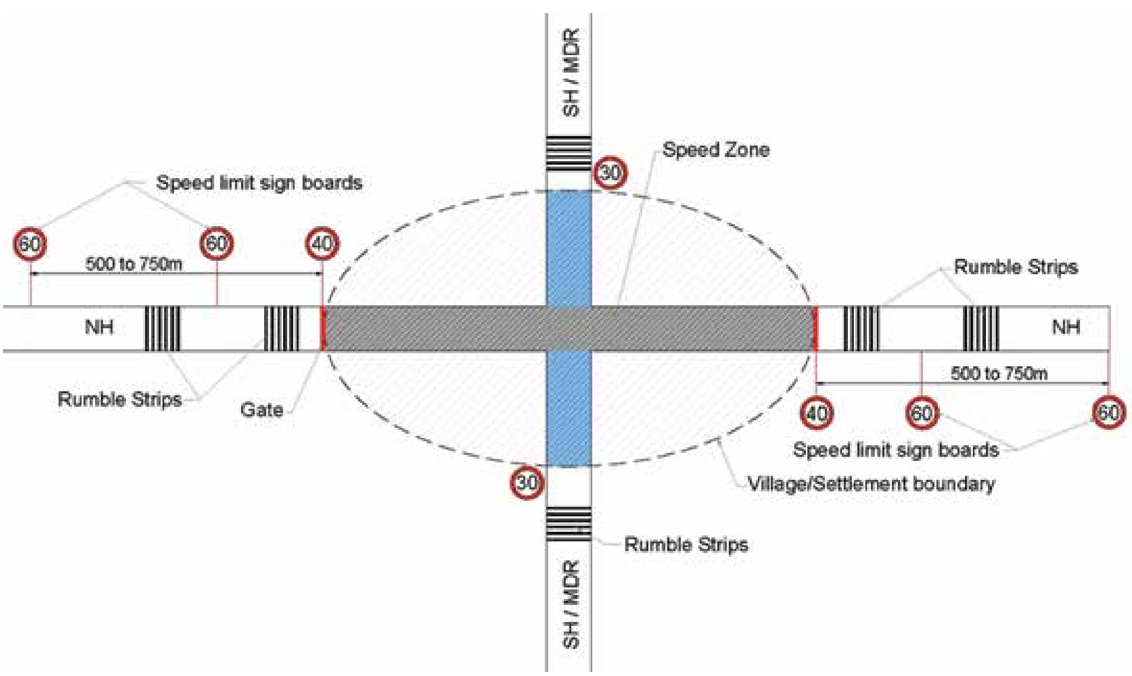


Fig. 4.1 Speed Zones on NH/SH Passing through Village

Table 4.1 Recommended Speed as per Distance from Boundary of Speed Zone

Sl. No.	Length (m)	Recommended Speed (km/h)	
		Heavy vehicles	All other vehicles
1	260 from the boundary	55	60
2	220 from the boundary	45	50
3	180 from the boundary	35	40
4	150 from the boundary	25	30
5	Within boundary	20	25

4.3 Demarcation of Traffic Calming Zones at Road Junctions

In case of minor roads joining the highway, it is not financially feasible to provide a signalised intersection. Often, yellow or red warning lights are not respected by the fast through traffic on low volume roads. Traffic-calming measures offer appropriate solutions for such sections because these are self-enforcing and comparatively cheaper than signalization.

Traffic calming measures at junctions (NH-SH, NH-ODR etc.) should be recommended in the context of appropriate road hierarchy. Smooth flow of traffic should be maintained at a safe speed on the higher category of road. The junctions may be categorized into two different types:

I. T-junctions

II. 4-armed intersections

The status of the minor road vis-à-vis the major road is an important parameter in determining the zone of conflict. The hierarchy of the minor road calls for different traffic calming measures. Three cases are discussed below:

4.3.1 *Case I: NH/SH Meeting NH*

Most of the times this would be a major intersection point with either traffic police or signalization equipments installed to control the traffic flow. The presence of a large volume of traffic itself gives rise to several commercial activities which requires adequate visual and tactile queues for the driver on the highway to slow down. Nevertheless, it is still advisable to treat the minor road with adequate traffic calming measure so that the speed of approach is considerably reduced. The area of influence on the main road needs to be demarcated for appropriate treatment to reduce the speed to acceptable limits.

4.3.2 *Case II: MDR Meeting NH/SH*

Such roads usually connects important villages, village mandis (markets) and other important nodes in the region. Further they are often unmanned and rarely signalised. It is important that traffic-calming measures are installed on the minor road leading to the national highways or the state highway. The major road should also be treated visually to sensitise the drivers about the approaching intersection.

4.3.3 *Case III: ODR Meeting NH/SH*

This junction is more vulnerable to conflicts. Having a low traffic volume on the minor road results in fewer activities at the intersections. Thus such junctions remain inconspicuous from a distance on the major road. Hence, vehicles approaching from the minor road need to slow down to "dead speed" before they can find gaps on the major road. The visibility of the major roads should also be high. This helps the driver to make appropriate decisions on the gaps. The measures to reduce chances of conflict would include visual warning on the major road with rumble strips and pre-warners and speed breakers on the minor roads. Since these crossings could be far more in number than the other two mentioned above, it is not feasible to cause a substantial speed reduction on the major road instead it is important to reduce the speeds of the vehicles on the minor roads and suggest zonal speeds of 45-50 kmph on the major road. This would be enough for the vehicles travelling on the minor road to manoeuvre and find gaps in the traffic stream.

4.3.4 *ODR meets Highway in a T-junction*

In this case the vehicle on the major road is made to gradually decrease its speed to 45-50 km/h before it resumes to a higher speed on the major road.

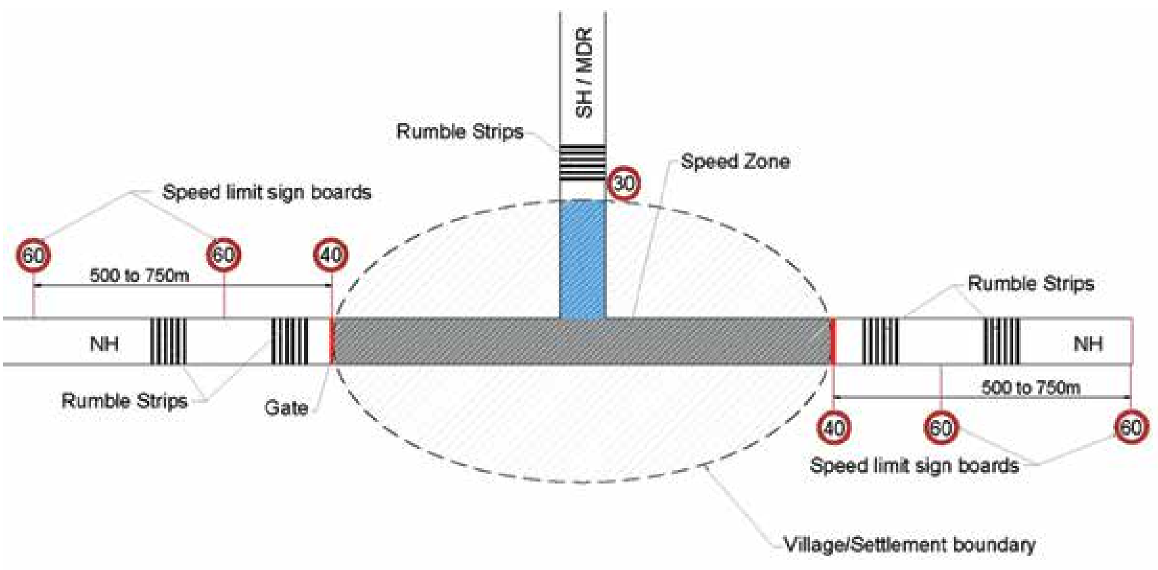


Fig. 4.2 T Junction between NH/SH and MDR

4.4 Checklists for Traffic Calming Treatment

Traffic calming treatment on NH and SH corridors passing through towns and villages is dependent on the following factors:

- Variation in day time and night time traffic volume
- Variation in local traffic activities in day time and night time
- Day time speeds vs night time speeds of vehicular traffic
- Local needs of pedestrian crossings and other activities

Seven different situations can be identified to address the TC requirement on NH and SH corridors.

4.4.1 *Safety Management on Highway Corridors passing through Desolate Areas*

- Apart from providing delineators and paved shoulders, no special treatment needs to be provided to improve safety of straight corridor highway stretches passing through desolate areas. However, at intersections (of these highways) with village roads, visual and physical warning signs in the form of speed limit signs and rumble strips should be provided to drivers in those areas.
- Speed breakers should be provided on intersecting village roads to bring down the vehicular speeds to 30 km/h or below at the intersection.
- In case of undivided highways in junction, splitter and channelizing islands shall be provided with hazard signs and markings. Junctions shall be provided with information sign and markings with road studs. The visibility funnel shall be kept encumbrance free.

4.4.2 *Speed Management on Highways passing through Agricultural Fields*

Vehicular traffic on highways passing through agricultural fields conflicts with crossing of pedestrian, cattle and farm-vehicle traffic.

- Service lanes should be provided on both sides of the highway to segregate this traffic from the traffic on the highway. Warning and speed limit signs should be provided on the highway before each opening in the service lane.
- In case of undivided highways, where space does not permit construction of segregated service lanes, 1 to 1.5 m wide mountable median and a minimum of 1.5 m wide footpath on both sides of the highway may be provided throughout the corridor, to act as refuge for crossing pedestrian and cattle traffic, along with sign posts enforcing a speed limit of 50 km/hr.
- At intersections with minor roads, warning signs should be provided on intersecting roads, indicating, speed limit of 50 km/hr on highway and 30 km/hr on the minor roads along with ‘intersection ahead’ warning signs. Apart from these, physical devices such as rumble strips on highway and speed breakers on the minor roads should be used to warn the driver of the approaching intersection. For visual impact, the intersection may be provided with a change of texture and color. The visibility funnel shall be kept encumbrance free.

4.4.3 *Speed Management on Highways passing through Industrial Areas*

Industrial areas generate a lot of demand for parking of heavy goods vehicles.

- Highways passing through these stretches should be provided with a minimum 6 m wide service lane, segregated from the main carriageway by a footpath/median and/or paved shoulders on both sides of the road.

- In case of undivided highways, mountable median may be provided throughout the corridor with gaps aligned with the openings in the service lane. Highway traffic should be warned in advance of crossing vehicular traffic at these openings in the medians and the service lane. Speed limit and warning sign boards should be provided and also rumble strips and rumble areas. Wherever space constraint does not permit the construction of service lanes, a minimum of 2.5 m wide paved shoulders and 1.5 m wide footpath should be provided on both sides of the highway.
- Raised pedestrian crossings should be provided on highways (along with warning signs for vehicular traffic) wherever high cross pedestrian traffic is expected.

4.4.4 *Traffic Calming Treatment on Highway Corridors passing through Residential/ Commercial Areas*

Residential and commercial areas, generate a lot of demand for cross-pedestrian, cattle and vehicular traffic.

- Highway traffic approaching such an area should be warned, using gates at the entry of the zone, with the name and length of the village/town corridor marked on it. Speed limit signs (40 km/hr) should also be posted at these locations along with rumble strips as a physical warning measure.
- In case of undivided highways, a 1.2 m wide mountable median may be provided throughout the length of the corridor, with gaps wherever required. These gaps at intersections with minor roads or service lane entries should be treated distinctly from the rest of the carriageway. Texture and colour change treatment should be applied (along with flashing beacon where cross traffic is more). To alert drivers of cross traffic at these locations, advance warning signs should be posted along the highway indicating change of speed limit to 30 km/hr. Rumble strips may also be provided on the roads approaching the intersections along with advance warning sign boards indicating ‘rumble strips ahead’.
- In addition, minor roads should be provided with road humps to bring down vehicular speed to 30 km/hr at the intersection, along with advance warning signs indicating ‘road hump ahead’.
- All schools, hospitals and institutional areas along the highway, should be provided with raised pedestrian crossings at every 100-150 m. These crossings should be accompanied by advance warning signs stating ‘speed breaker ahead’, ‘school/hospital area’ and 30 km/hr speed limit.
- In case of high-density corridors where setback from the highway is less than 6 m, traffic calming devices should be used to restrict corridor speed between 30 to 50 km/hr.
- 2.5 m wide continuous paved shoulders should be provided along with minimum 1.5 m wide raised footpaths on both sides of the highway.

4.4.5 *Traffic Calming Treatment of Rail-Road Intersection on Highways*

- Highway traffic approaching a rail-road intersection be warned, visually, using 30 km/hr speed limits signs, 'rail-road crossing ahead' warning sign as well by bright street lighting at the intersection, and physically, using rumble strips and speed breakers on both sides of the crossing.
- In case of undivided highways, a 100 to 200 m long (based on queuing length at the location) mountable median should be provided on both sides of the crossing.
- The gates at the rail road crossing should be provided with a retro-reflective signs along with flashing beacons for better visibility at night.

4.4.6 *Traffic Calming Treatment of Bridges on Highways*

- Highway traffic approaching bridges on highway should be warned through sign posts, indicating 'Bridge Ahead'. Apart from these, advance indication should also be given using signposts and road markings, of 50 km/hr speed limit, and 'no overtaking zone'.
- Rumble strips should be used to physically warn the drivers on approach to the narrow bridges.
- Reflective studs should be used to highlight lane markings on the bridge.

4.4.7 *Traffic Calming Treatment on Hill Roads*

Bends on hill roads may be provided with delineators. A continuous lane marking should be maintained throughout the corridor, using thermoplastic paint as well reflective studs. Signposts indicating corridor speed limit of 30-40 km/h should be provided at regular intervals. Hazardous locations should be provided with advance warning signs.

5 CHECKLISTS

The section below gives set of checklist for following situations.

- Highway Corridor (Divided Carriageway)
- Highway Corridor (Without Central Median)
- Stretches of Highway without Pedestrian Footpaths
- Stretches of Highway without Service Lane
- Road Junctions on Highways
- Rail-road Intersection on Highways
- Bridges on Highways
- Urban Roads
- Hill Roads

The first column lists land use patterns, moving from first row showing low density areas to the last row showing high density areas. Various options for achieving the desired results are listed for each type of area. Suggested measures are indicated along with a figure showing these measures. All traffic signs shall be as per IRC:67 "Code of Practice for Road Signs".

5.1 Highway Corridors

Low

Desolate Agricultural Field

- No treatment

Residential/Commercial Areas (Fig. 5.1)

- Provide gates at both ends when the corridor passing through residential or commercial areas.

Industrial Areas (Fig. 5.2)

- Provide signage in gates showing name of the area and the length of the corridor. If possible, provide service roads.
- Provide a pedestrian friendly surface, that would cause discomfort for through vehicular movement, could of paver block at same level of carriageway.

Residential & Commercial >3 m Setback (Fig. 5.3)

- Provide gates at both ends of the corridor passing through residential or commercial areas. Also, provide signage showing name of the area and the length of the corridor.
- Provide 40 km/h speed limit signs and 70 or 60 km/h as transition speed limit. Provide other warning and informatory sign as necessary.
- Provide warning signs for merging roads and physical traffic calming devices on side roads.
- Provide a pedestrian friendly surface, that would cause discomfort for through vehicular movement, could of paver block at same level of carriageway.

Residential & Commercial <3 m Setback (Fig. 5.4)

- Provide gates at both ends of the corridor passing through residential or commercial areas. Zig zag marking in the congested section. Also, provide signage showing name of the area and the length of the corridor.
- Provide 40 km/h speed limit signs and 70 or 60 km/h as transition speed limit. Provide other warning and informatory sign as necessary.
- Provide psychological traffic calming measures on main corridor.
- Provide warning signs for merging roads and physical traffic calming devices on side roads.
- Provide a pedestrian friendly surface, that would cause discomfort for through vehicular movement, could of paver block at same level of carriageway.

Schools, Hospitals & Institutional Areas (Fig. 5.5)

- Provide gates at both ends of the corridor passing through highly congested Schools, Hospitals & Institutional Areas. Zig zag marking in the congested section. Also, provide signage showing name of the area and the length of the corridor.
- Provide 40 km/h speed limit signs and 70 or 60 km/h as transition speed limit.
- Provide psychological traffic calming measures on main corridor and the last set of bar marking shall be 6 numbers of thermoplastic of 15 mm of height so as curtail the speed.
- Provide warning signs for merging roads and physical traffic calming devices on side roads
- Provide other warning and informatory sign as necessary.
- Provide a pedestrian friendly surface, that would cause discomfort for through vehicular movement, could of paver block at same level of carriageway.

As population density increases

High

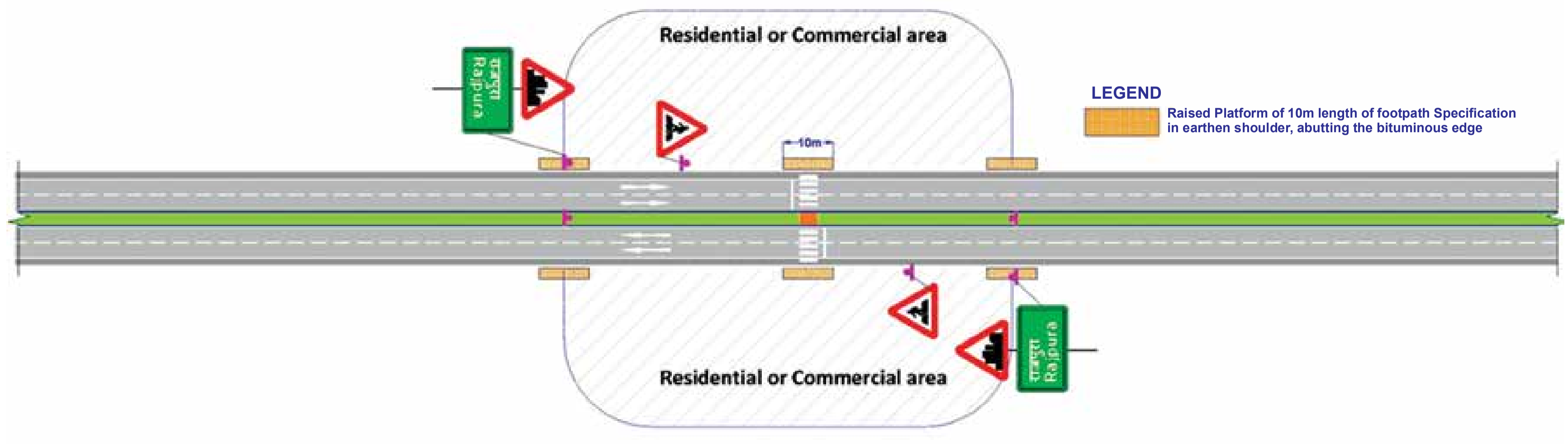


Fig. 5.1 Schematic Diagram for Highway Corridors (a)

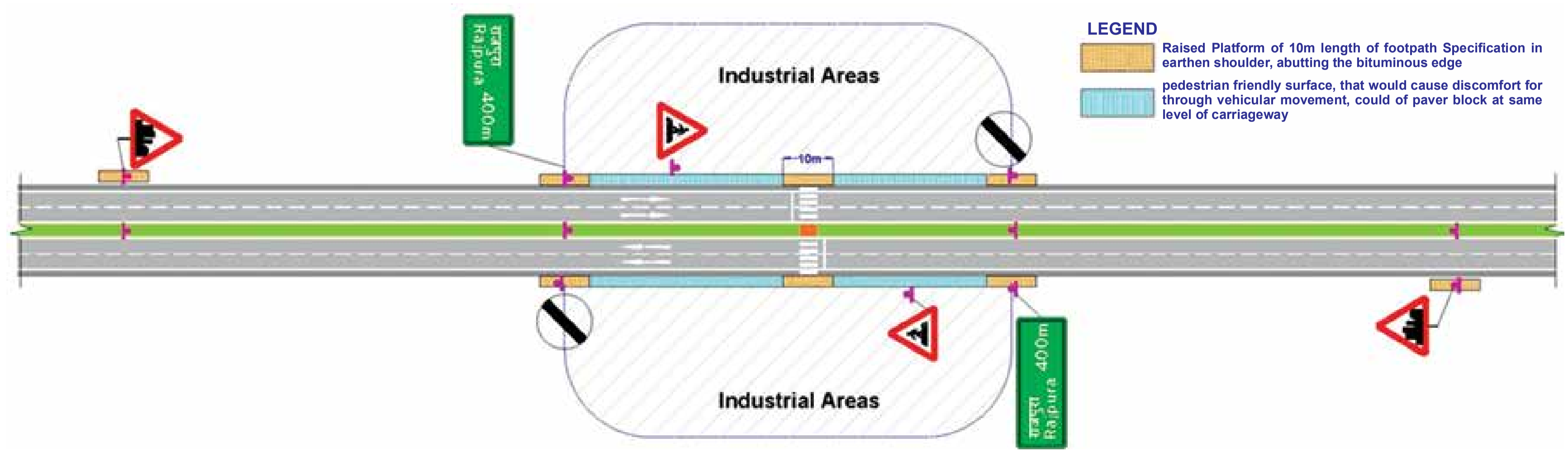


Fig. 5.2 Schematic Diagram for Highway Corridors (b)

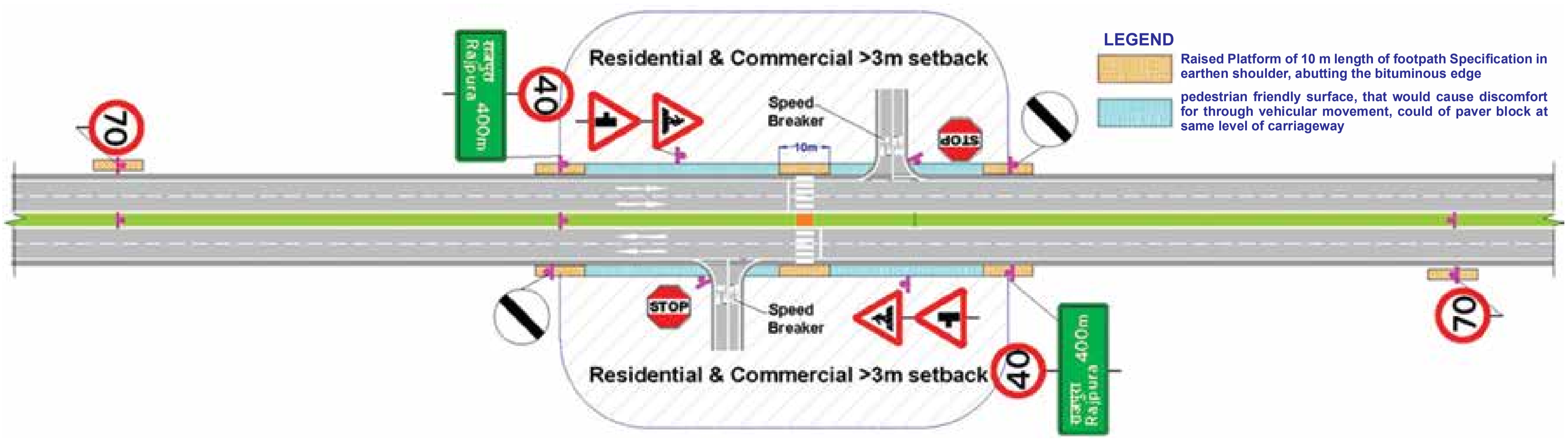


Fig. 5.3 Schematic Diagram for Highway Corridors (c)

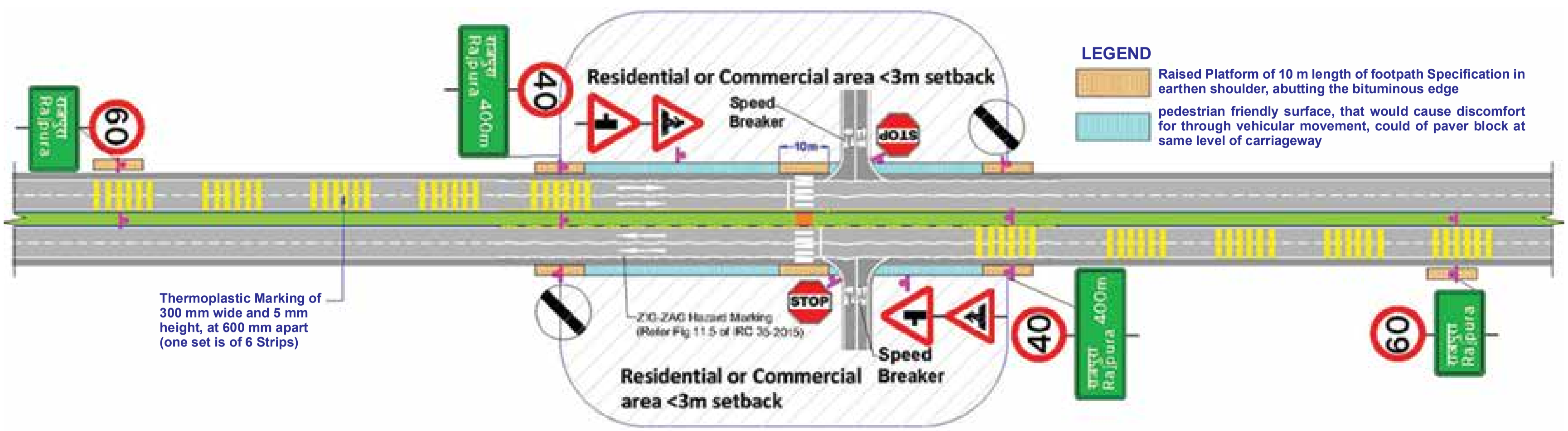


Fig. 5.4 Schematic Diagram for Highway Corridors (d)

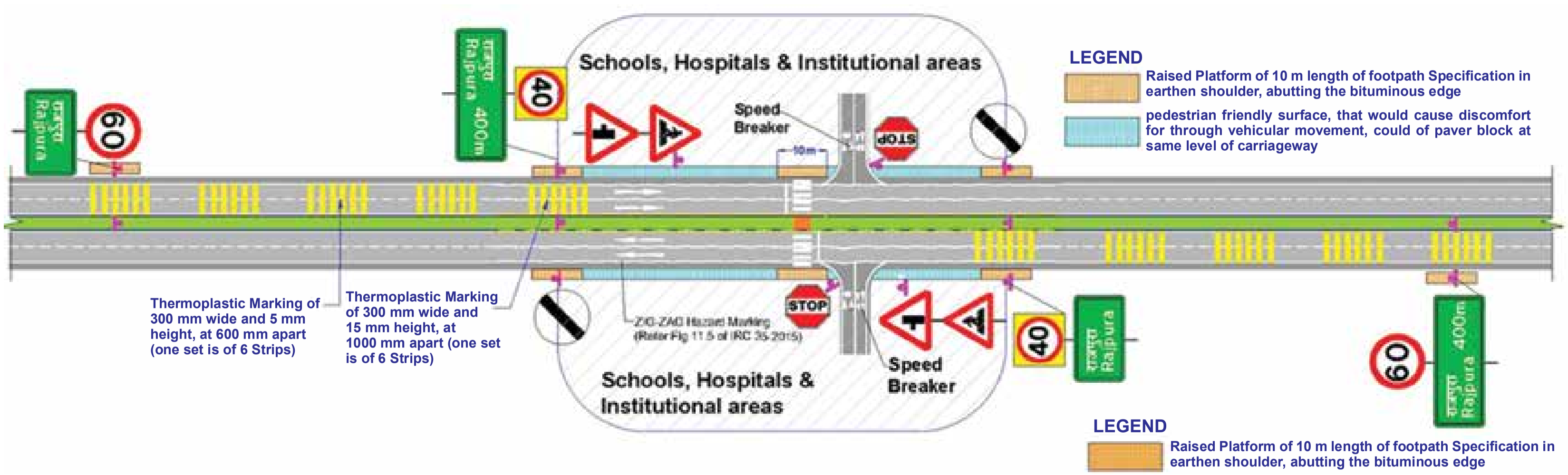


Fig. 5.5 Schematic Diagram for Highway Corridors (e)

5.2 Highway Corridors without Central Medians

Low

As population density increases

Desolate Agricultural Fields
- No treatment.

Villages (Fig. 5.6)
- Paint a 150 mm wide continuous yellow line in the centre of the carriageway preceded by warning centre line.

Industrial Areas (Fig. 5.7)
- Paint a 150 mm wide continuous yellow line in the centre of the carriageway preceded by warning centre line.
- Provide road studs at 6 m intervals, on no-overtaking section and 9 m interval on warning section, on both centre line and edge line.

Residential & Commercial >3 m Setback (Fig. 5.8)
- Provide gates at both ends of the corridor passing through residential or commercial areas.
- Provide signage showing name of the area and the length of the corridor.
- Provide 40 km/h speed limit sign and proceeded by transition speed limit sign.
- Provide speed limit signs, and warning signs for merging roads and physical traffic calming devices.
- Provide other warning and informatory sign as necessary.

Residential & Commercial <3 m Setback (Fig. 5.9)
- Provide gates at both ends of the corridor passing through residential or commercial areas. Zig zag marking in the congested section. Also, provide signage showing name of the area and the length of the corridor.
- Provide 40 km/h speed limit signs and 70 or 60 km/h as transition speed limit.
- Provide psychological traffic calming measures on main corridor.
- Provide other warning and informatory sign as necessary .
- Provide warning signs for merging roads and physical traffic calming devices on side roads.
- Provide a pedestrian friendly surface, that would cause discomfort for through vehicular movement, could of paver block at same level of carriageway.

Schools, Hospitals & Institutional Areas (Fig. 5.10)
- Provide gates at both ends of the corridor passing through highly congested Schools, Hospitals & Institutional Areas. Zig zag marking in the congested section. Also, provide signage showing name of the area and the length of the corridor.
- Provide 40 km/h speed limit signs and 60 km/h as transition speed limit.
- Provide physical traffic calming on main corridor to curtail the speed.
- Provide warning signs for merging roads and physical traffic calming devices on side roads
- Provide other warning and informatory sign as necessary.
- Provide a pedestrian friendly surface, that would cause discomfort for through vehicular movement, could of paver block at same level of carriageway.

High

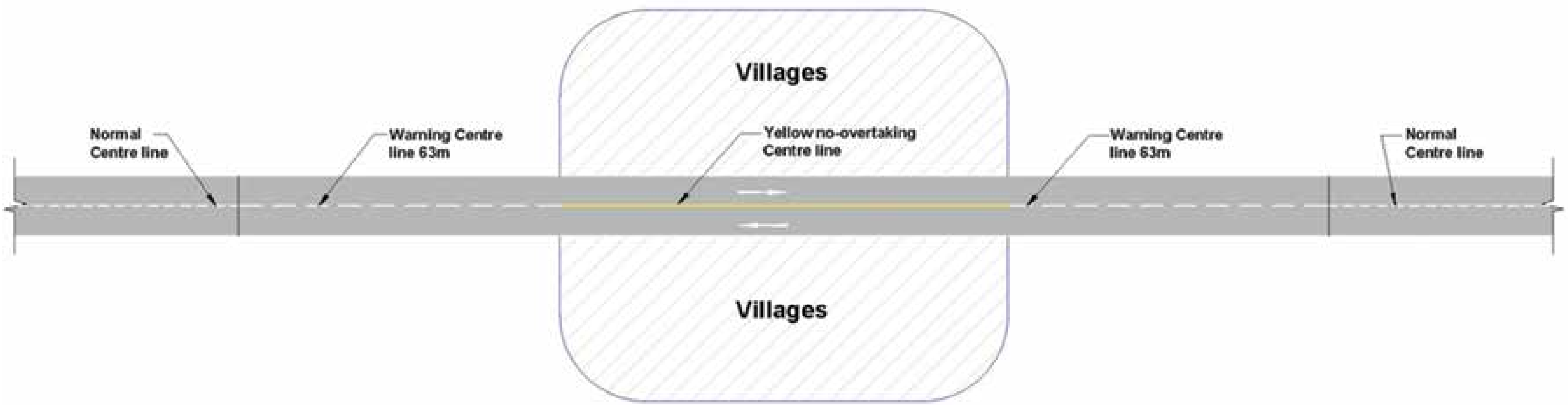


Fig. 5.6 Schematic Diagram for Highway Corridors without Central Medians (a)

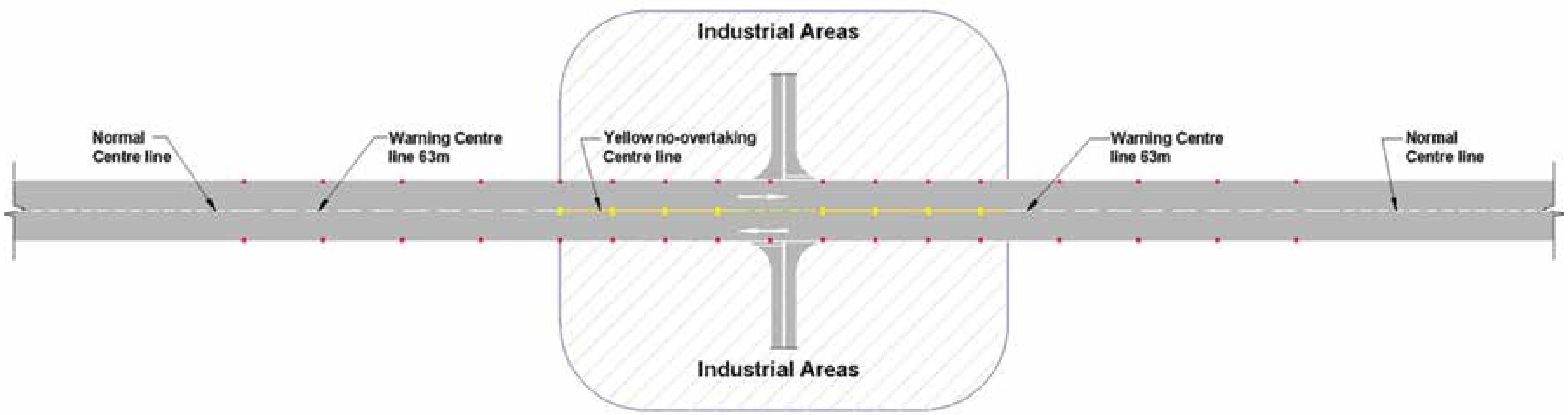


Fig. 5.7 Schematic Diagram for Highway Corridors without Central Medians (b)

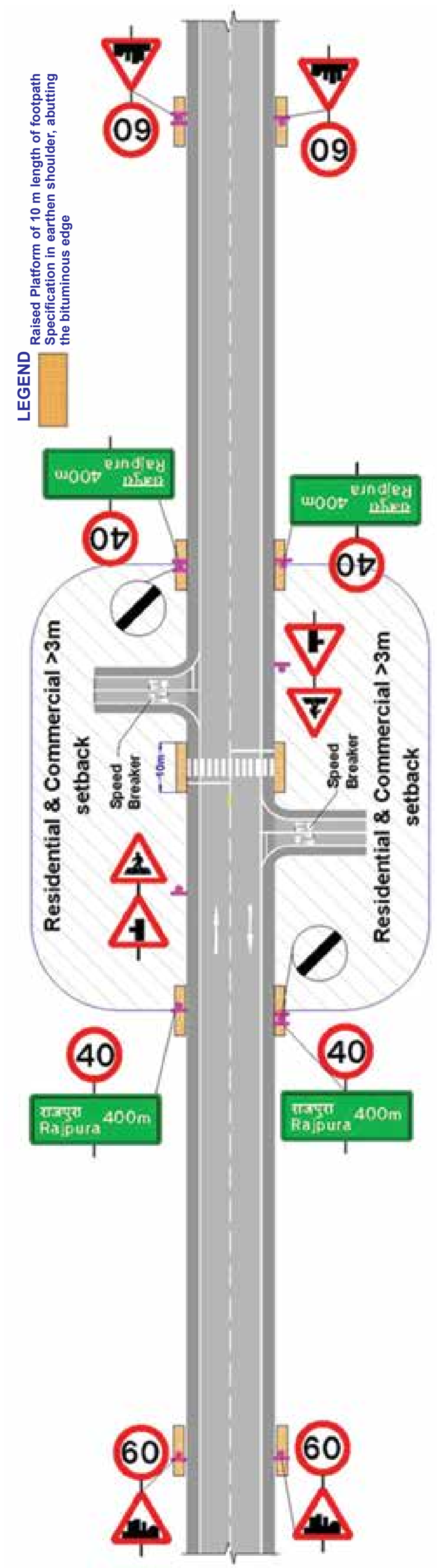


Fig. 5.8 Schematic Diagram for Highway Corridors without Central Medians (c)

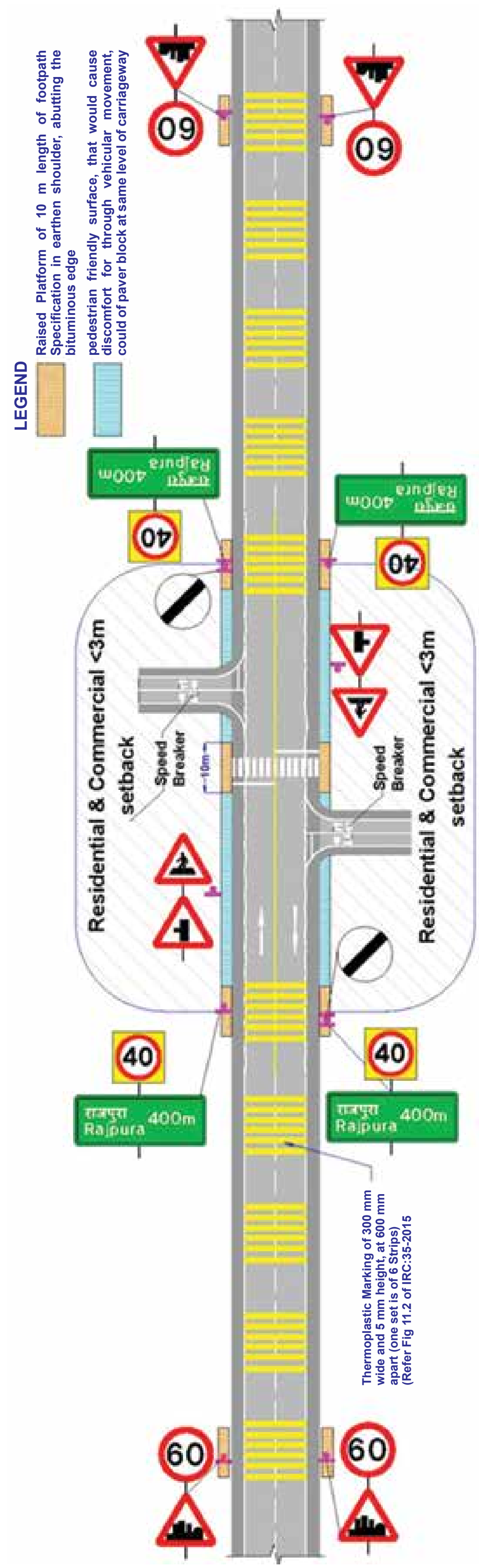


Fig. 5.9 Schematic Diagram for Highway Corridors without Central Medians (d)

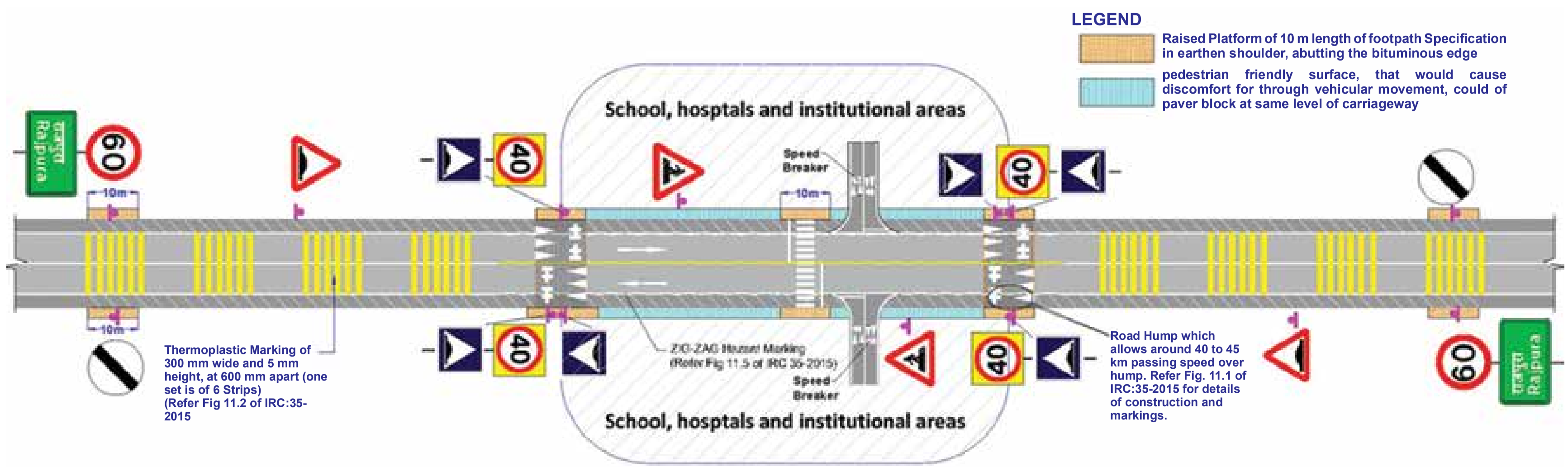


Fig. 5.10 Schematic Diagram for Highway Corridors without Central Medians (e)

5.3 Stretches of Highways without Pedestrian Footpaths

Low

As population density increases

Desolate Agricultural Fields

- No treatment.

Villages (Fig. 5.11)

- Provide paved shoulders of 1.5 - 2.5 m width with edge line.
- Yellow centre line preceded by Warning centre line reinforced with road studs.

Industrial Areas (Fig. 5.12)

- Provide 1.5 m wide median for pedestrian refuge with 5.5 m bituminous width on both sides.
- Pedestrian guard rail to streamline pedestrian to designated crossing location.

Residential & Commercial >3 m Setback,

Residential & Commercial <3 m Setback

Schools, Hospitals & Institutional Areas (Fig. 5.13)

- Provide a minimum of 1.5 m - 2 m wide footpath for congested section beyond the bituminous width. Alternatively at location if it causes on street parking and drainage issues, at same level of carriageway.
- Provide 1:8 ramps at the ends of all pedestrian footpaths.
- Provide reflector studs at the beginning of ramp gradient.
- Yellow centre line preceded by warning centre line reinforced with road studs.
- Provide warning and informatory sign as necessary.

High

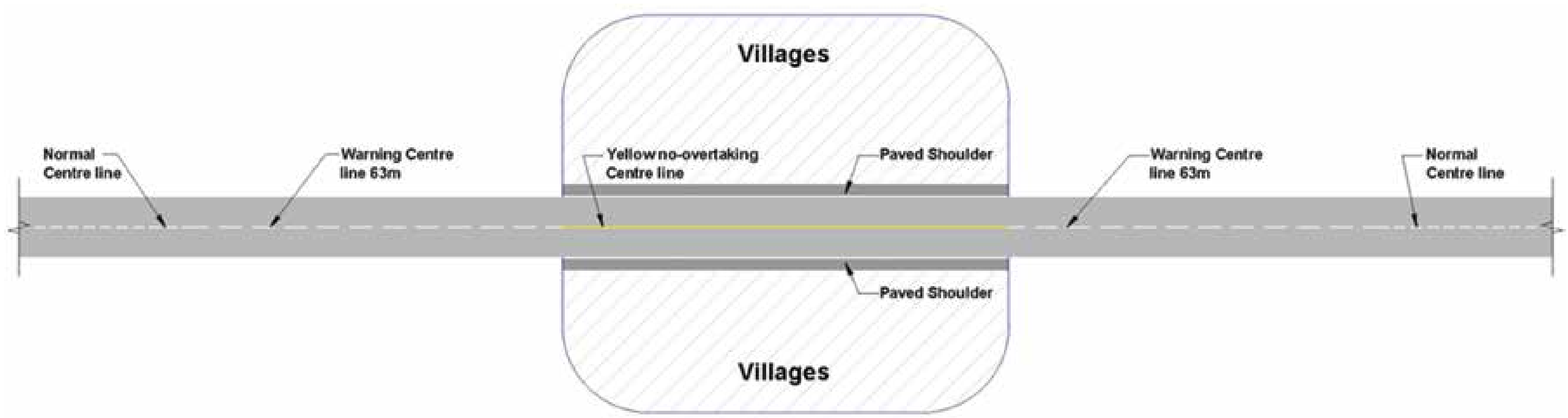


Fig. 5.11 Schematic Diagram - Highways without Pedestrian Footpaths (a)

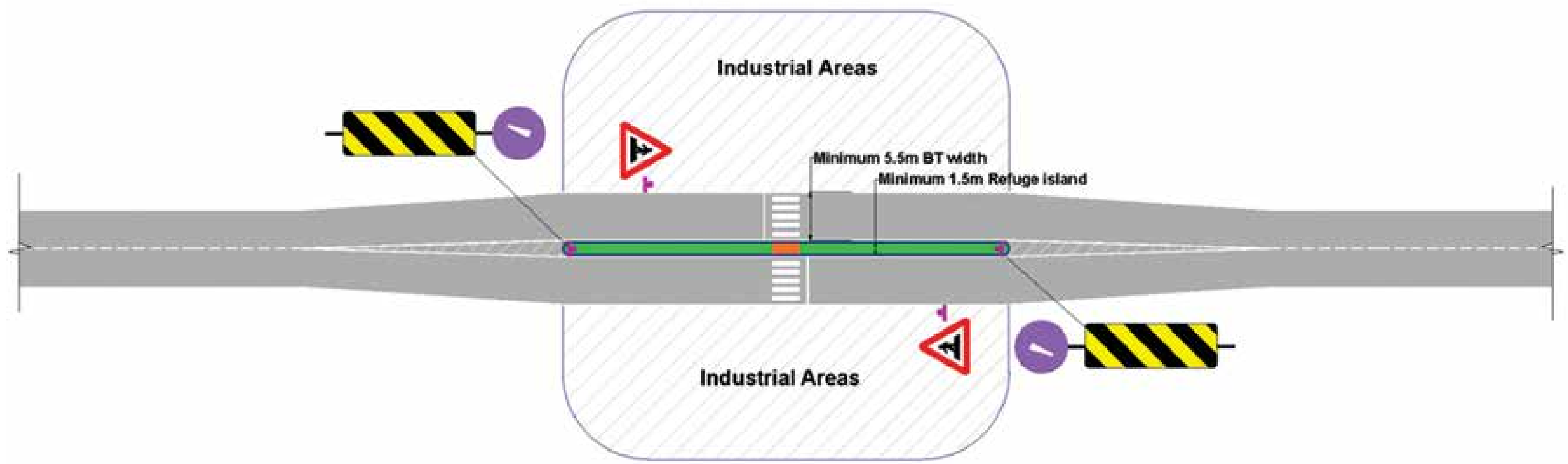


Fig. 5.12 Schematic Diagram - Stretches of Highways without Pedestrian Footpaths (b)

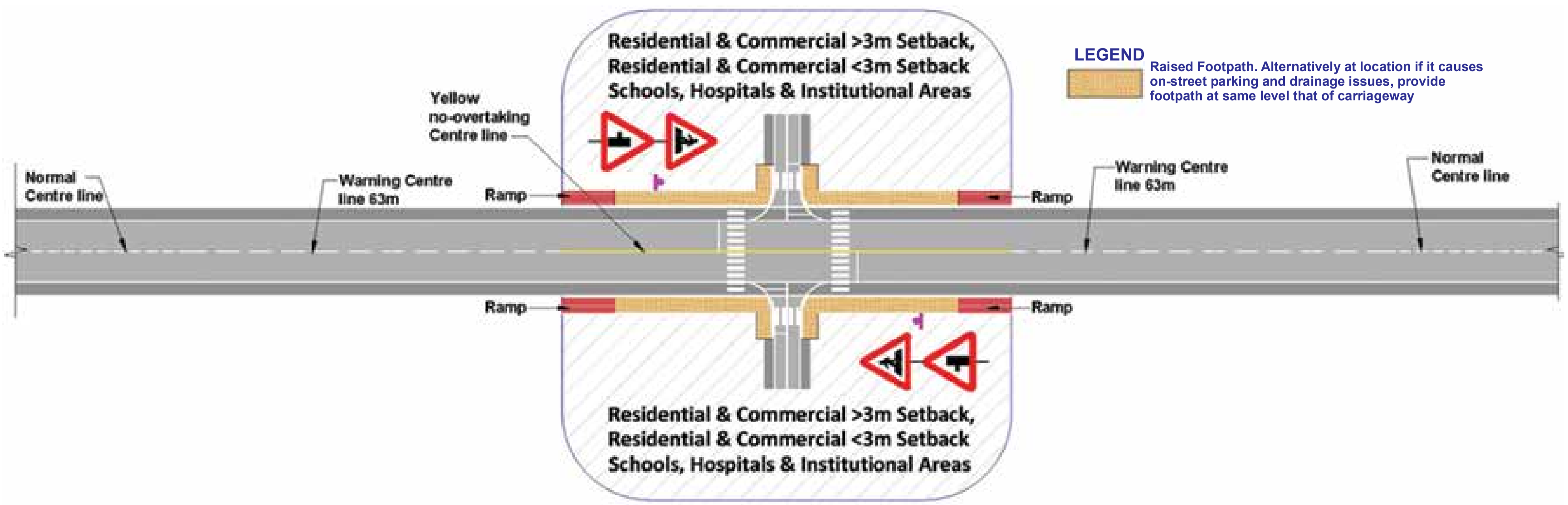


Fig. 5.13 Schematic Diagram - Stretches of Highways without Pedestrian Footpaths (c)

5.4 Stretches of Highways without Service Lanes

Low

As population density increases

Desolate Agricultural Fields
- No treatment.

Villages (Fig. 5.14)
- Paved shoulders of 1.5 - 2.5 m.
- No overtaking centre line preceded by warning centre line, all reinforced with road studs.

Industrial Areas (Fig. 5.15)
- Paved shoulders of 1.5 - 2.5 m.
- No overtaking centre line preceded by warning centre line, all reinforced with road studs.
- Provide pedestrian friendly surface, that would cause discomfort for through vehicular movement, could of paver block at same level of carriageway.

Residential & Commercial >3 m Setback (Fig. 5.16)
- Paved shoulders of 1.5 - 2.5 m.
- No overtaking centre line preceded by warning centre line, all reinforced with road studs.
- Protected parking slots with chicane islands, beyond which footpath and with pedestrian crossing at shortest distance.

Residential & Commercial <3 m Setback (Fig. 5.17)
- Provide a minimum of 6.0 m wide service lane for commercial section of road.
- Use pedestrian footpaths to segregate service lanes from highway and the property wall.
- Provide adequate signs and road markings, clearly demarcating entry and exit points to the service lane.

Schools, Hospitals & Institutional Areas (Fig. 5.18)
- Provide a minimum of 6.0 m wide service lane for section of road having schools, hospital, and institutions.
- Use pedestrian footpaths to segregate service lanes from highway and the property wall.
- Provide adequate signs and road markings, clearly demarcating entry and exit points to the service lane.

High

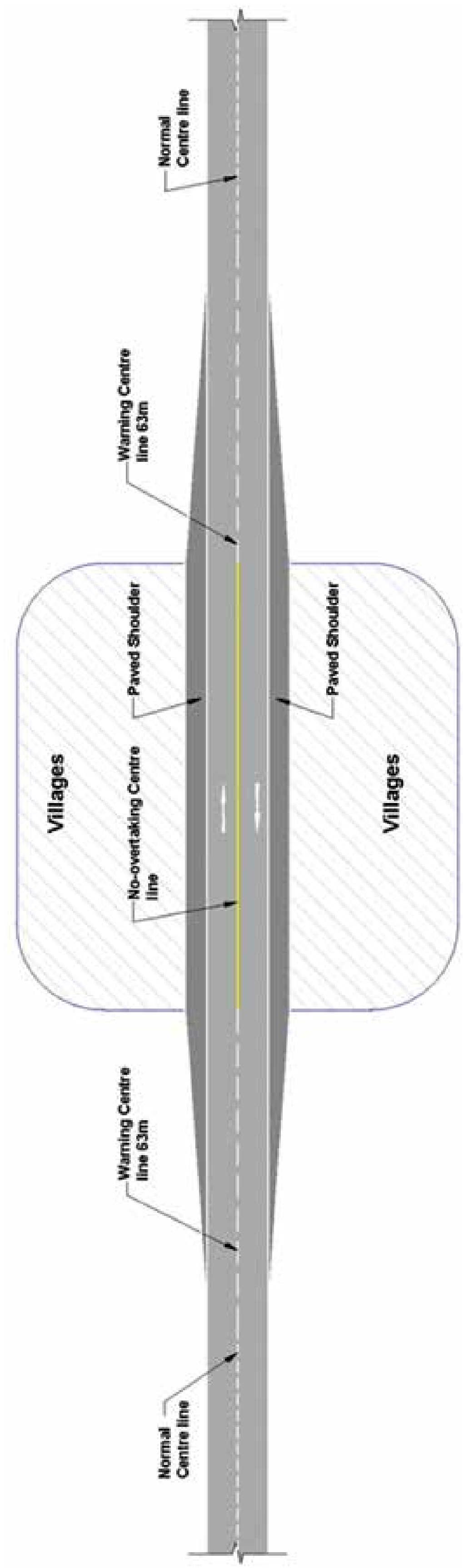


Fig. 5.14 Schematic Diagram - Highways without Service Lanes (a)

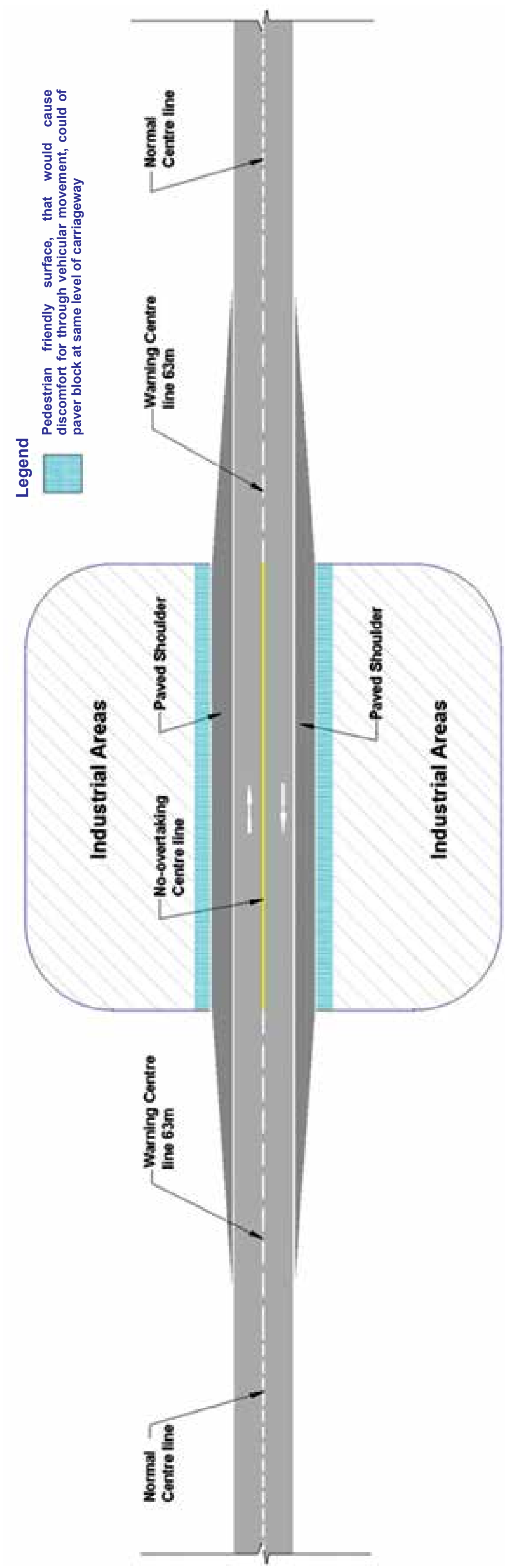


Fig. 5.15 Schematic Diagram - Highways without Service Lanes (b)

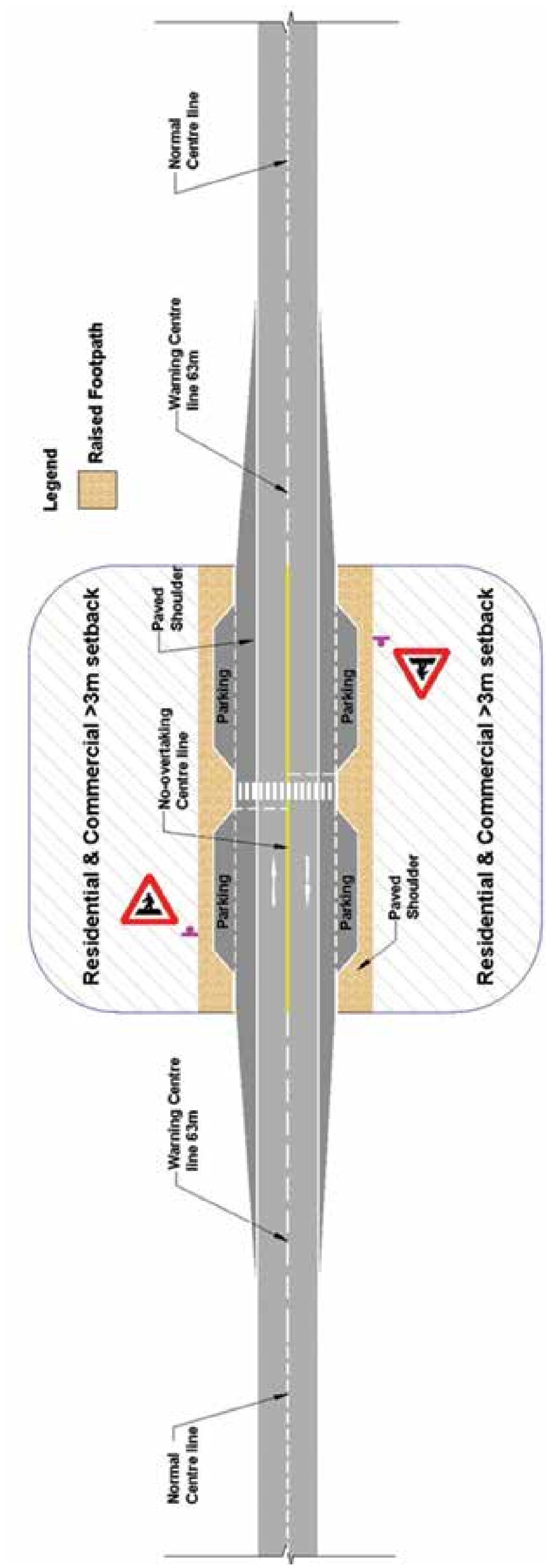


Fig. 5.16 Schematic Diagram - Highways without Service Lanes (c)

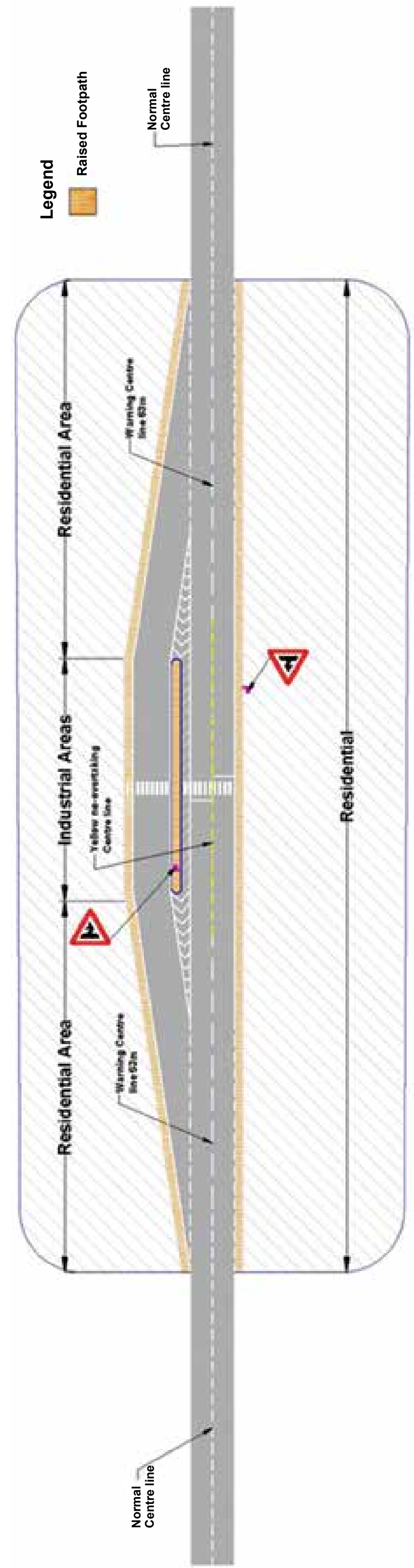


Fig. 5.17 Schematic Diagram - Highways without Service Lanes (d)

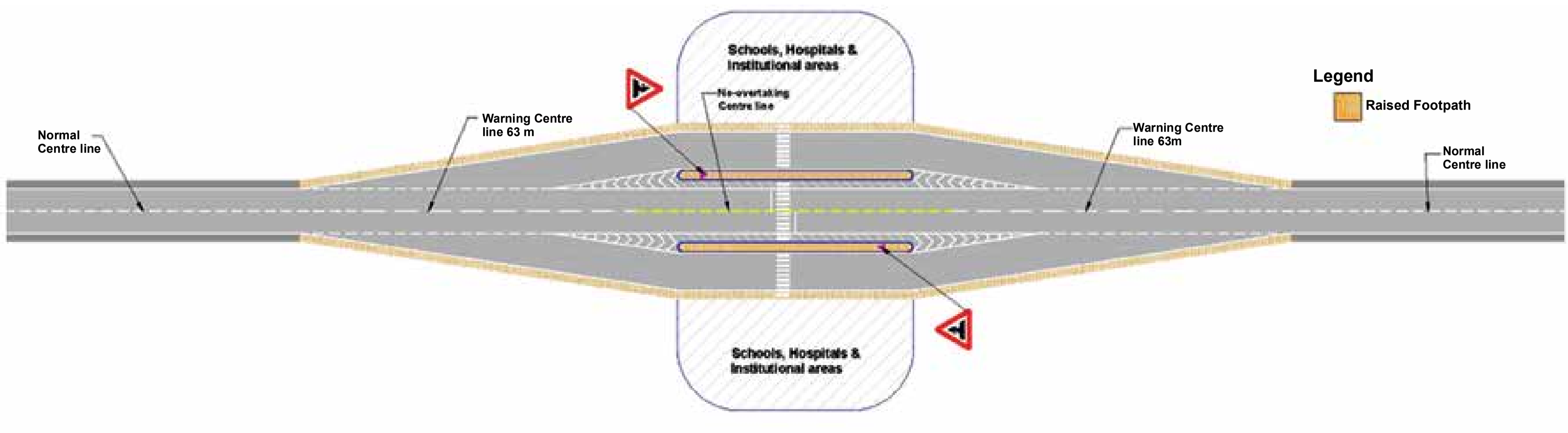


Fig. 5.18 Schematic Diagram - Highways without Service Lanes (e)

5.5 Road Junctions on Highways

Low

As population density increases

High

Desolate Agricultural Fields
- No treatment.

Village Roads/Other District Roads (ODR) (Fig. 5.19)
- Provide warning signs on all intersecting roads.
- Road hump for side road and also STOP sign.
- Prepare side gradient near to flat for at least for a vehicle length where it joins the main road.

Industrial Areas

State Highways (SH) & Major District Roads (MDR) (Fig. 5.20)
- Provide warning signs on all intersecting roads.
- Road hump for side road.
- Provide Texture change and/or color of road surface at the intersection.
- Prepare side gradient near to flat for at least for a vehicle length where it joins the main road.

Residential & Commercial >3 m Setback (Fig. 5.21)
- Provide warning signs on all intersecting roads.
- Road hump for side road.
- Provide Texture change and/or color of road surface at the intersection.
- Provide psychological traffic calming measure on approached to junction crossing.
- Prepare side gradient near to flat for at least for a vehicle length where it joins the main road.

Residential & Commercial <3 m Setback (Fig. 5.22)
- Provide warning signs on all intersecting roads.
- Road hump for side road.
- Provide Texture change and/or color of road surface at the intersection.
- Provide psychological traffic calming measure on approached to junction crossing.
- Provide speed limit sign and also transition speed limit sign.
- Prepare side gradient near to flat for at least for a vehicle length where it joins the main road.

Schools, Hospitals & Institutional Areas (Fig. 5.23)
- Provide warning signs on all intersecting roads.
- Road hump for side road.
- Provide Texture change and/or color of road surface at the intersection.
- Provide psychological traffic calming measures on main corridor and the last set of bar marking shall be 6 numbers of thermoplastic of 15 mm of height so as curtail the speed.
- Provide speed limit sign and also transition speed limit sign.
- Prepare side gradient near to flat for at least for a vehicle length where it joins the main road.

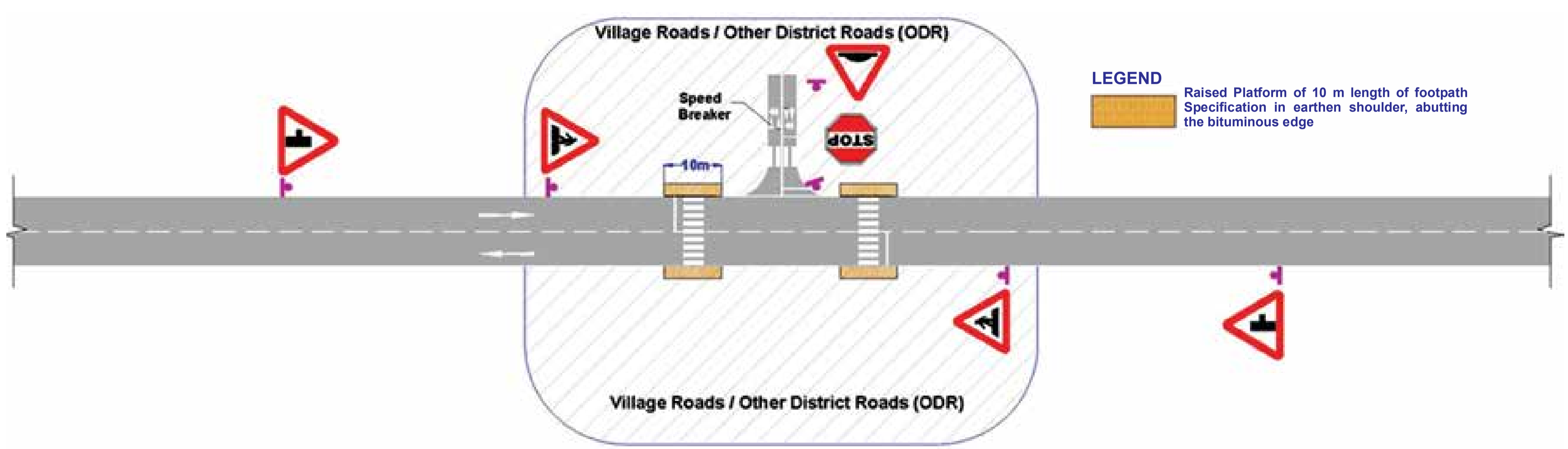


Fig. 5.19 Schematic Diagram - Road Junctions on Highways (a)

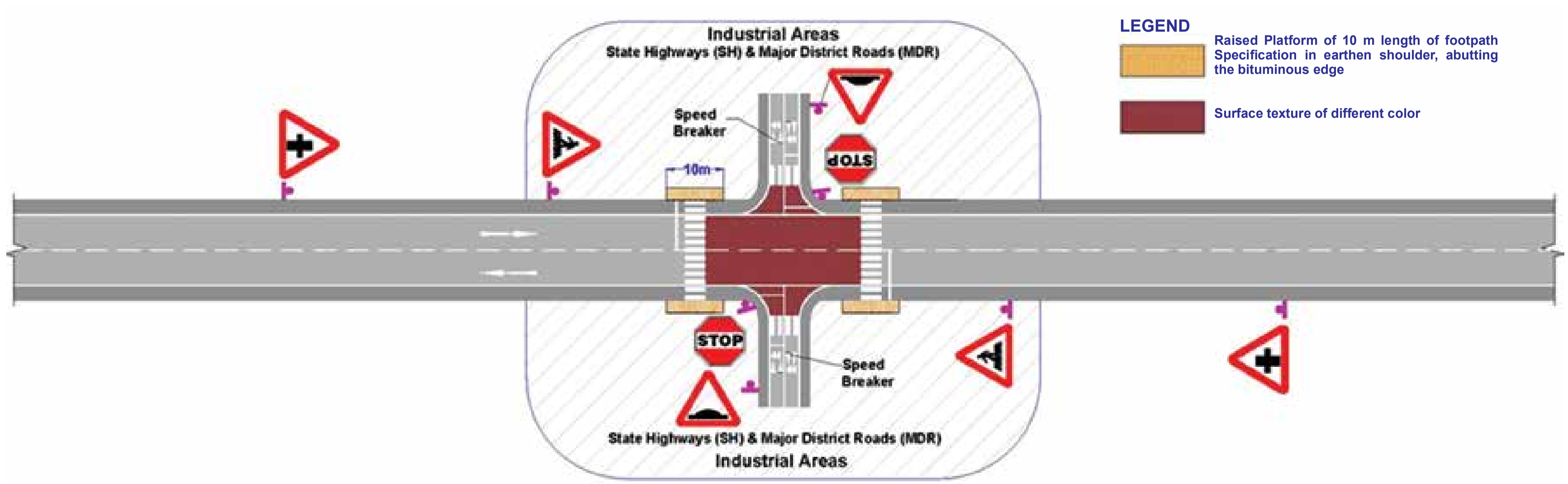


Fig. 5.20 Schematic Diagram - Road Junctions on Highways (b)

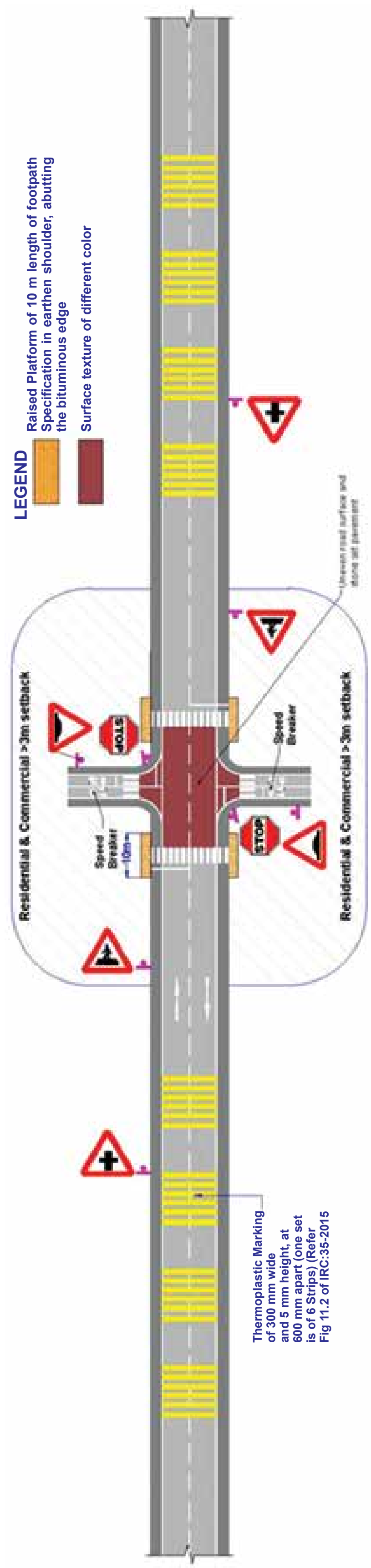


Fig. 5.21 Schematic Diagram - Road Junctions on Highways (c)

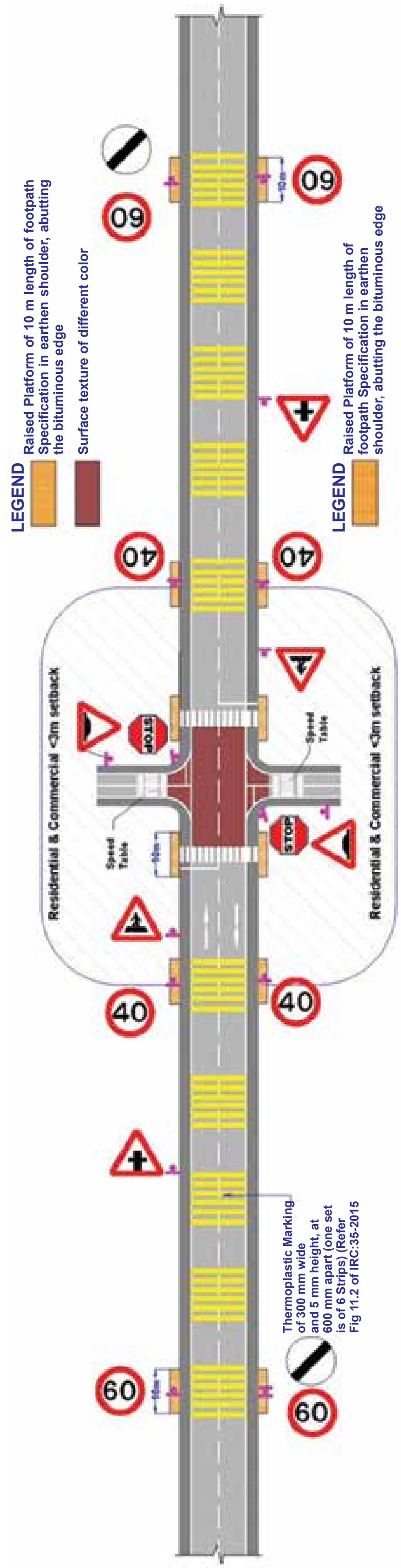


Fig. 5.22 Schematic Diagram - Road Junctions on Highways (d)

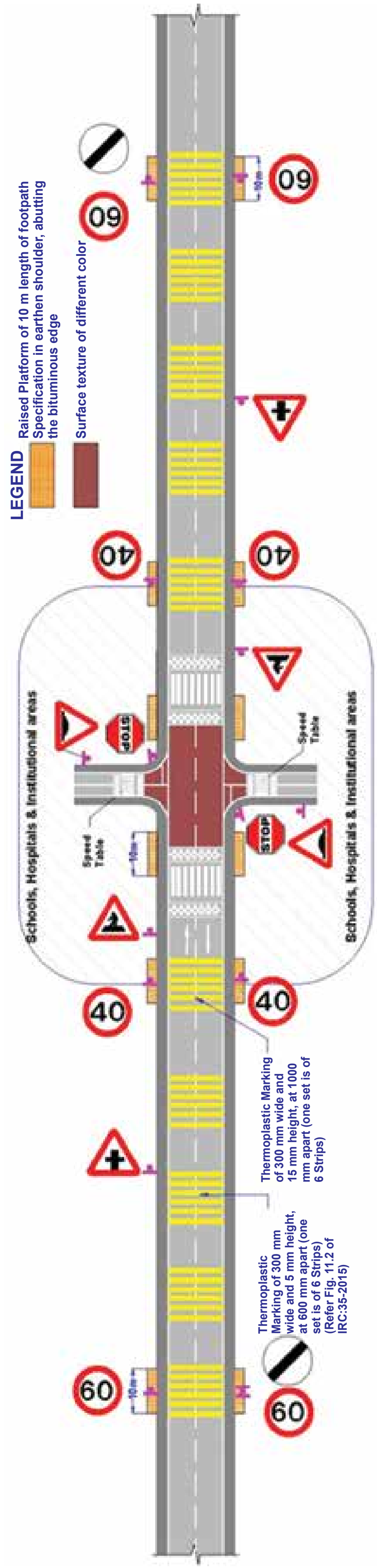
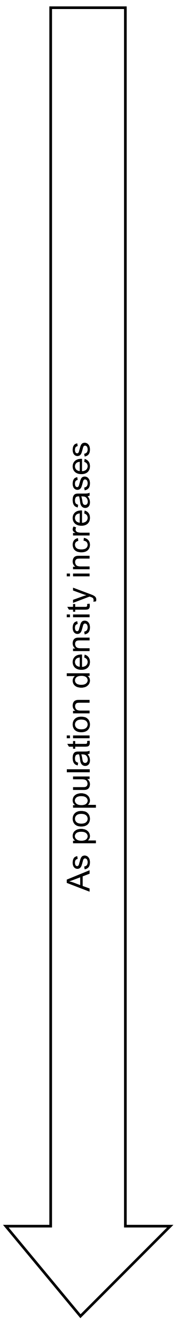


Fig. 5.23 Schematic Diagram - Road Junctions on Highways (e)

5.6 Rail-road Intersections on Highways

Low



High

Desolate Agricultural Fields

Industrial Area & Agricultural Fields (Fig. 5.24)

- Provide warning signs for 'Rail-road crossing ahead' at 250 m and 50 m ahead.
- Reduce vehicular speed to 50 kmph 250 m before the rail-road intersection.
- Provide psychological traffic calming and road hump at 15 m from the Gate of rail line.
- Provide adequate speed limit signs.

Residential & Commercial >3 m Setback

Residential & Commercial <3 m Setback

Schools, Hospitals & Institutional Areas (Fig. 5.25)

- Provide warning signs for 'Rail-road crossing ahead' at 250 m and 50 m ahead.
- Reduce vehicular speed to 50 kmph 250 m before the rail-road intersection.
- Provide psychological traffic calming and road hump at 15 m from the Gate of rail line.
- Provide adequate speed limit signs.
- Provide footpath for 50 m on both side and both approaches

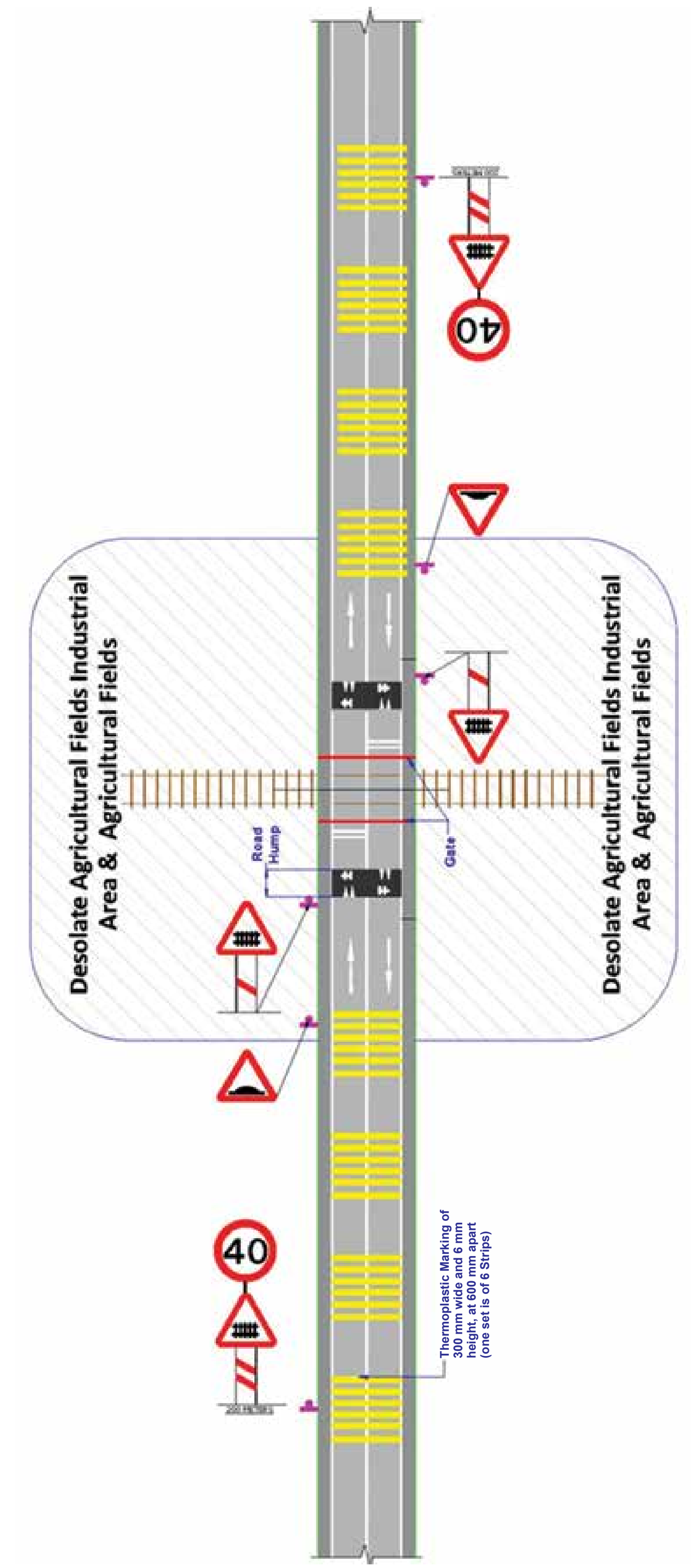


Fig. 5.24 Schematic Diagram - Railroad Intersections on Highways (a)

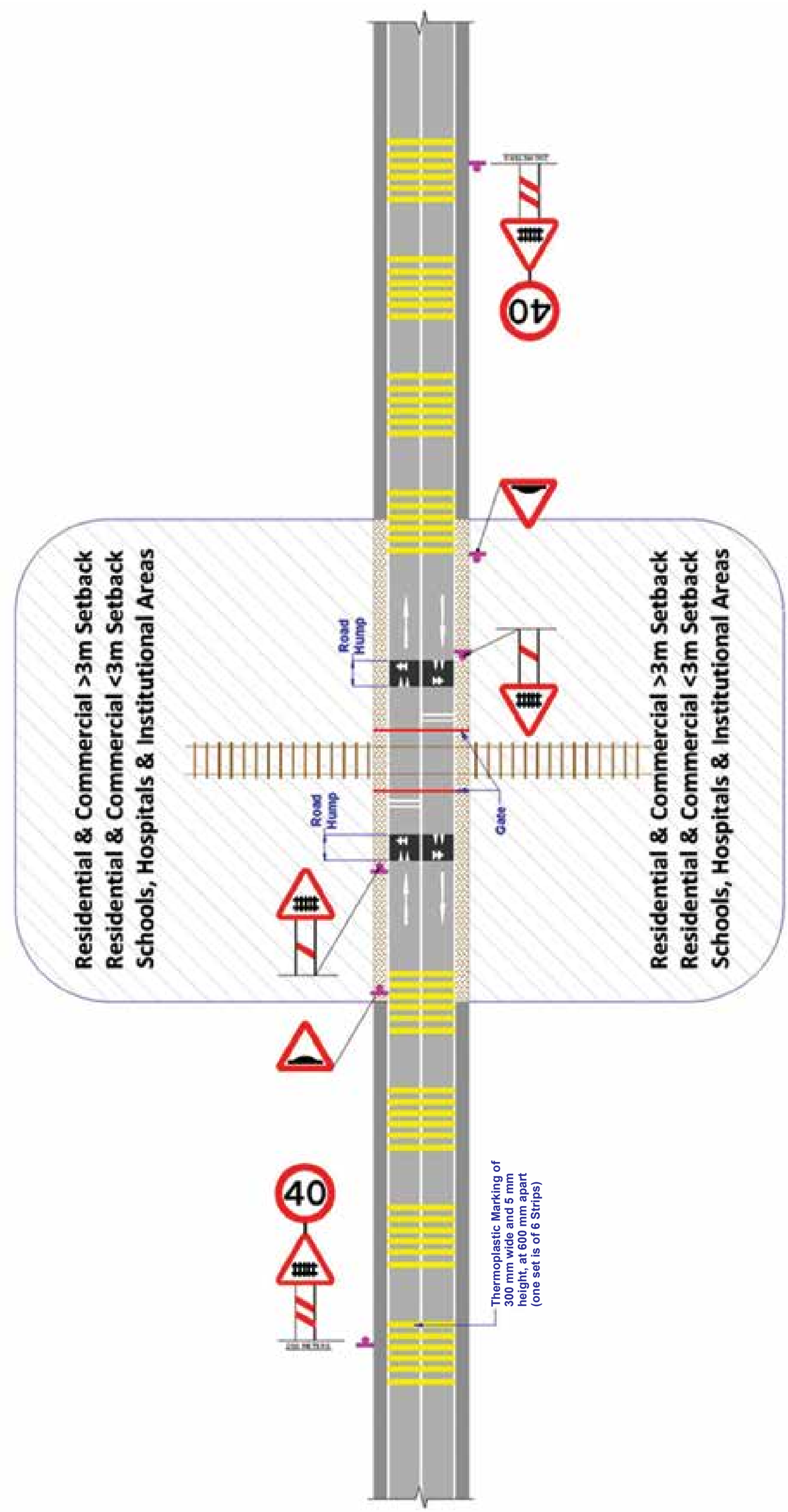


Fig. 5.25 Schematic Diagram - Rail-road Intersections on Highways (b)

5.7 Bridges on Highways

Low

As population density increases

2-Lane Bridges (With No Footpaths) (Fig. 5.26)

- Provide warning signs for 'road narrowing' and speed limit sign.
- Provide 'no overtaking' and speed limit sign.
- Provide rumble strips of 6 mm high.
- Provide ladder hatching to traffic to streamline to BT width of bridge.
- Provide Hazard Marker sign.

4-Lane Bridges (Only Carriageway) (Fig. 5.27)

- Provide warning signs for 'road narrowing' and speed limit sign.
- Provide 'no overtaking' and speed limit sign.
- Provide rumble strips of 6 mm high.
- Provide ladder hatching to traffic to streamline to BT width of bridge.
- Provide Hazard Marker sign.

High

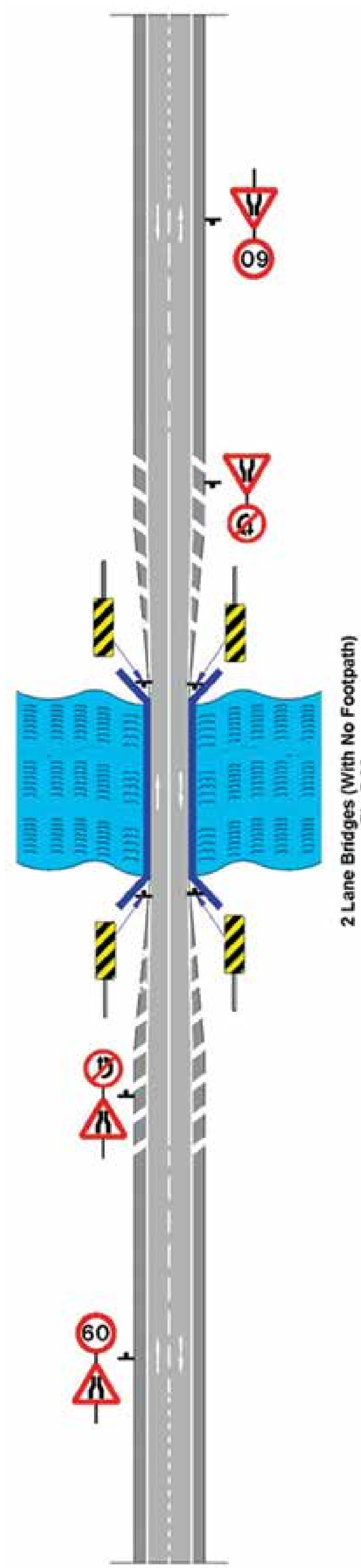


Fig. 5.26 Schematic Diagram - Bridges on Highways (a)

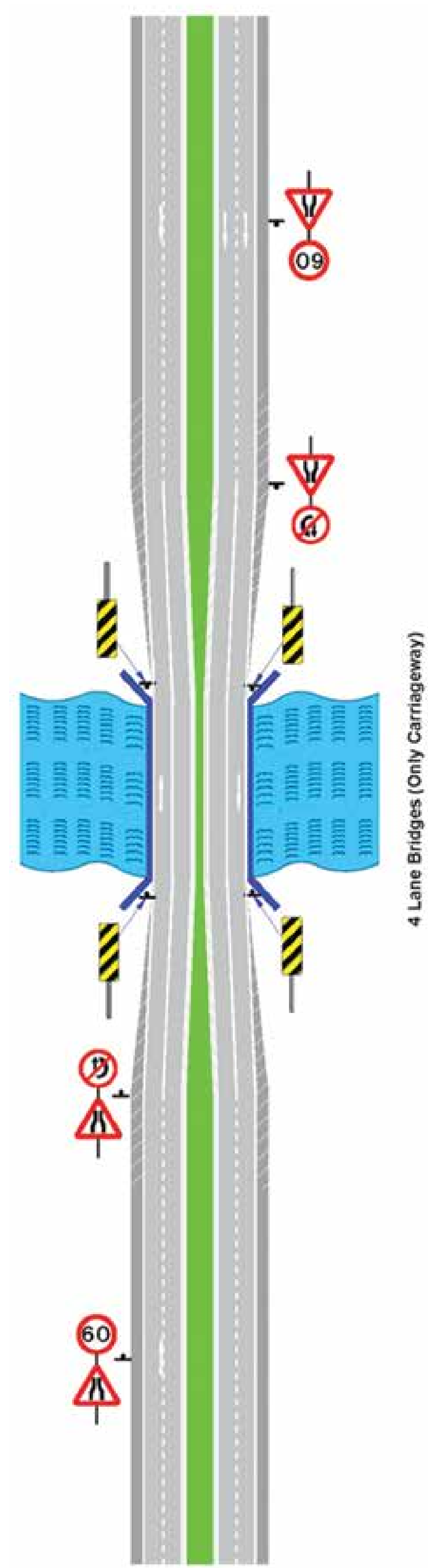
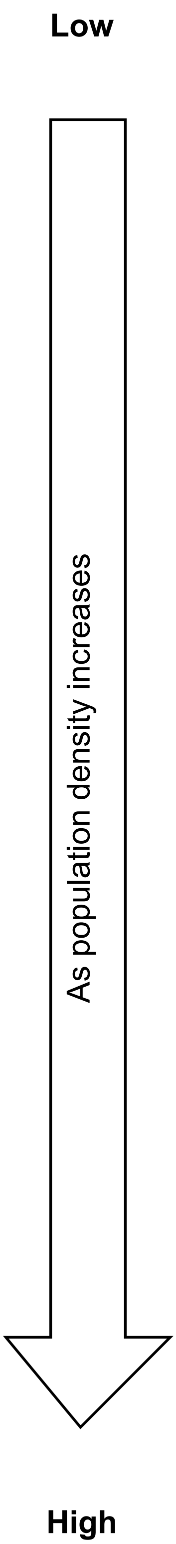


Fig. 5.27 Schematic Diagram - Bridges on Highways (b)

5.8 Urban Roads



Arterial & Sub-Arterial Roads (Fig. 5.28)

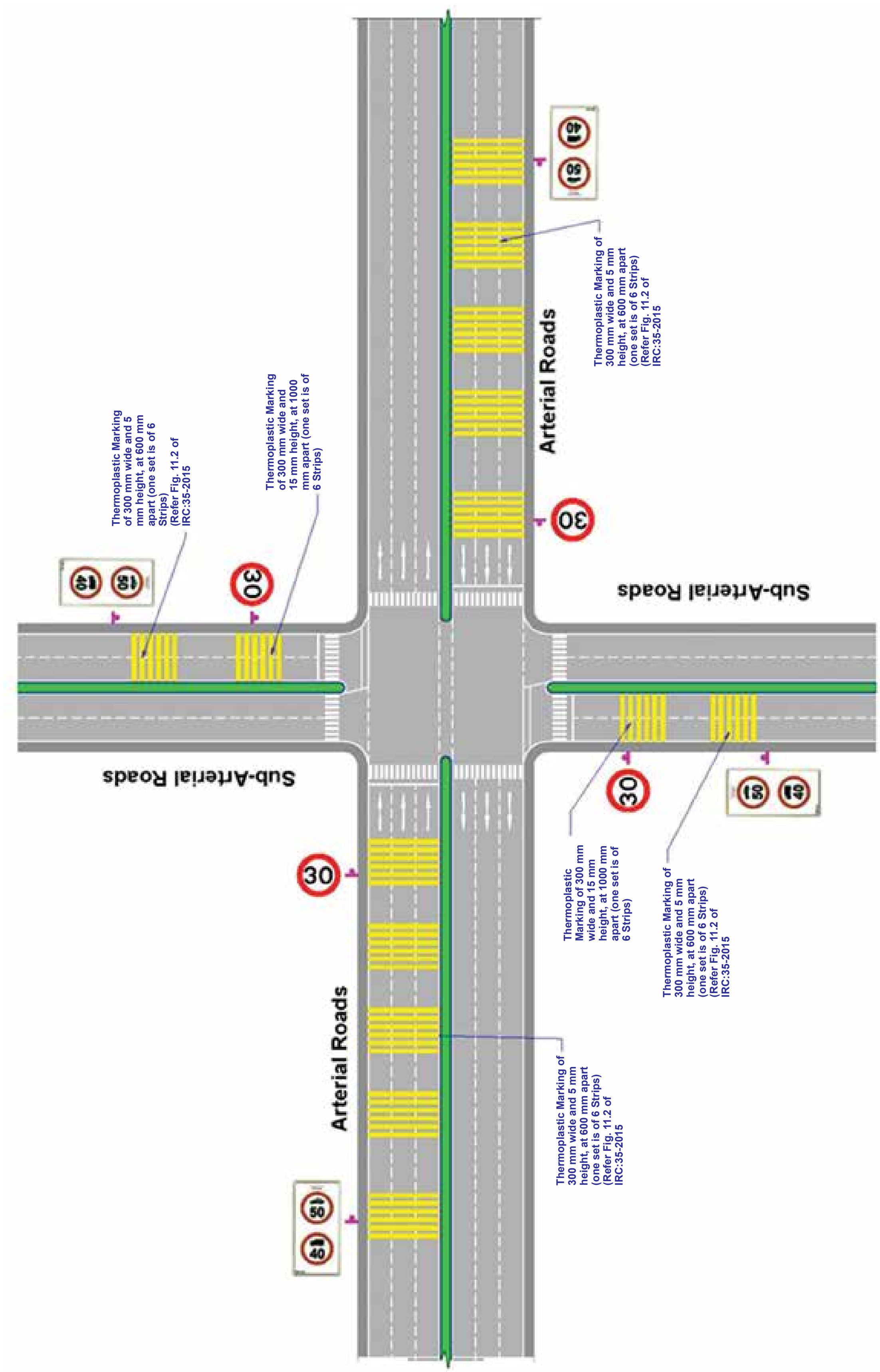
- Restrict vehicular speeds to 50 kmph for cars and 40 km for heavy vehicles.
- Reduce vehicular speeds to 30 kmph from a distance of 100 m from intersections with roads of same hierarchy.
- Provide psychological traffic calming measures on main arterial road.
- Provide psychological traffic calming measures on sub-arterial road and the last set of bar marking shall be 6 numbers of thermoplastic of 15 mm of height so as curtail the speed.

Collector Roads (Fig. 5.29)

- Provide speed breaker 50 m ahead of intersection with arterial or sub arterial roads.
- Provide warning signs for 'speed breakers ahead'.
- Provide Give way signs before intersection with arterial or sub-arterial roads.
- Restrict vehicular speeds to 40 km/h for cars and 30 kmph for heavy vehicles on these roads.

Local Roads (Fig. 5.30)

- Restrict entry of heavy vehicles except school buses.
- Restrict speed of heavy vehicles to 20 km/h and cars to 30 km/h.
- Provide speed breakers after every 200 m interval.



Arterial & Sub-Arterial Roads

Fig. 5.28 Schematic Diagram - Urban Roads (a)

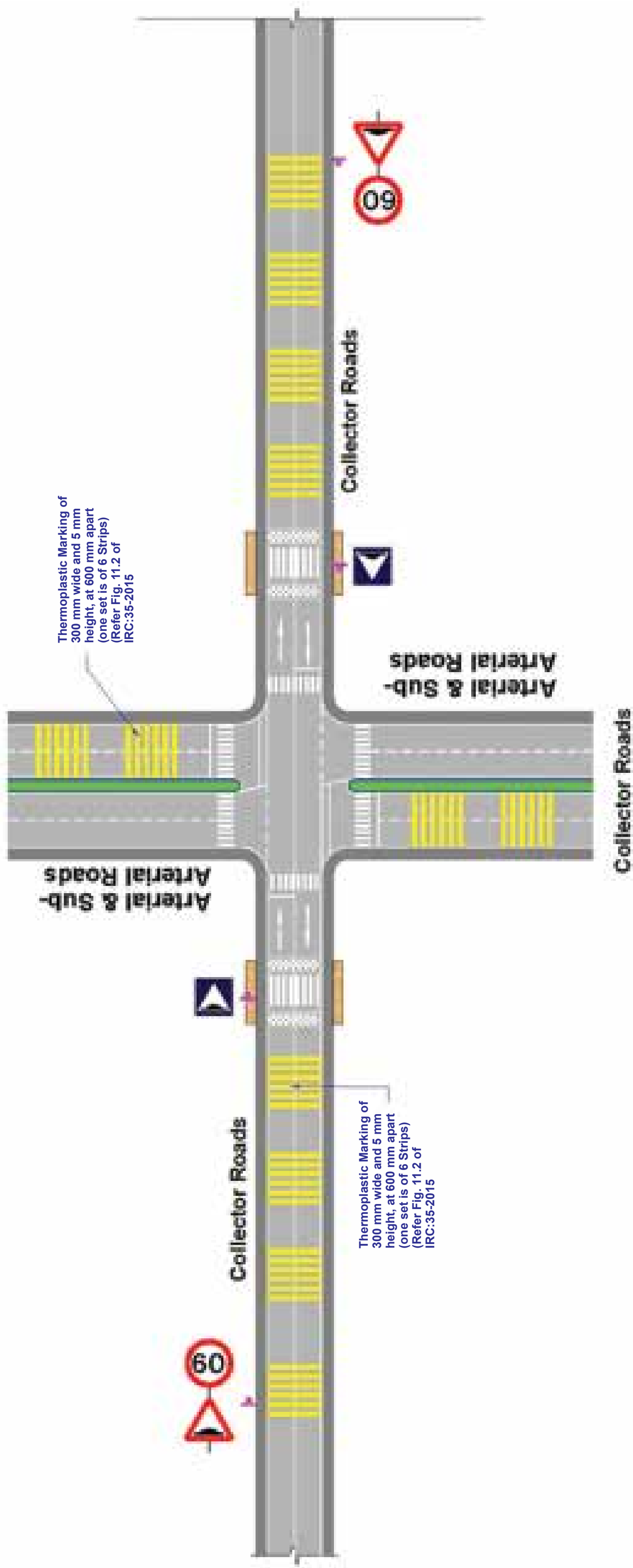


Fig. 5.29 Schematic Diagram - Urban Roads (b)

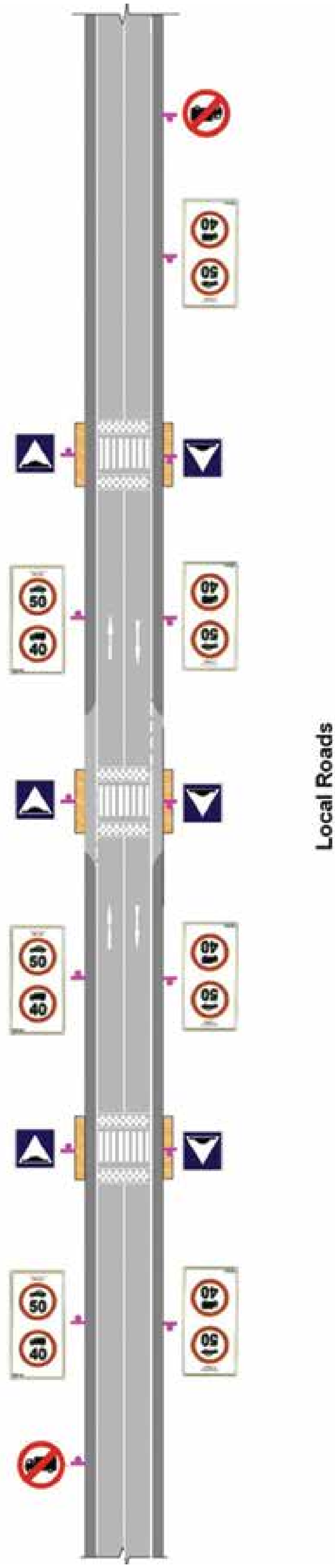


Fig. 5.30 Schematic Diagram - Urban Roads (c)

5.9 Hill Roads

Low

As population density increases

High

Normal Drops or Climbs (Straight Stretch) (Fig. 5.31)

- Post speed limits signs.
- Provide centre and edge line markings with road studs.

Steep Drops/Climbs on Straight Stretches (Fig. 5.32)

- Post adequate speed limit sign posts.
- Provide adequate signage indicating “steep drop/climb ahead”.
- Provide adequate lane markings.

Blind Bends With or Without Steep Drops/Climbs (Fig. 5.33)

- Post adequate speed limit sign posts.
- Provide adequate signage indicating “steep drop/climb ahead”.
- Provide centre line Marking.
- Provide reflector studs on centre line markings.
- Provide psychological rumble strips.
- Provide triple chevron signs indicating the direction of bends.
- Provide convex mirror to see oncoming vehicle.
- Provide adequate crash/deflection barrier.

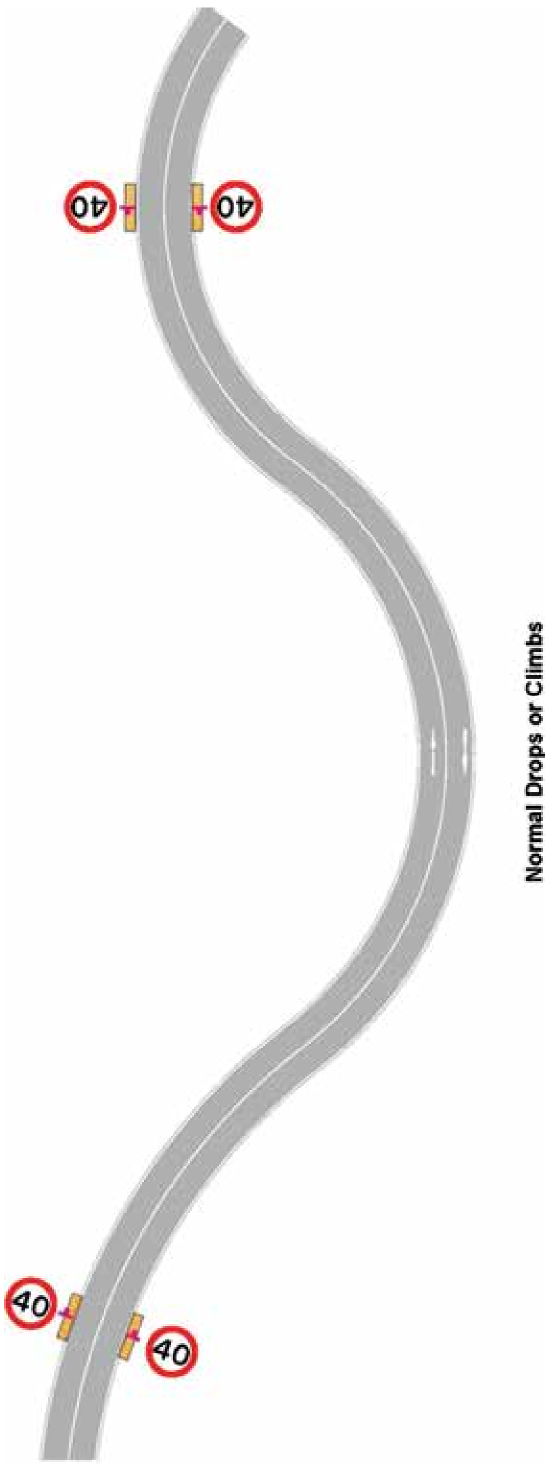


Fig. 5.31 Schematic Diagram - Hill Roads (a)

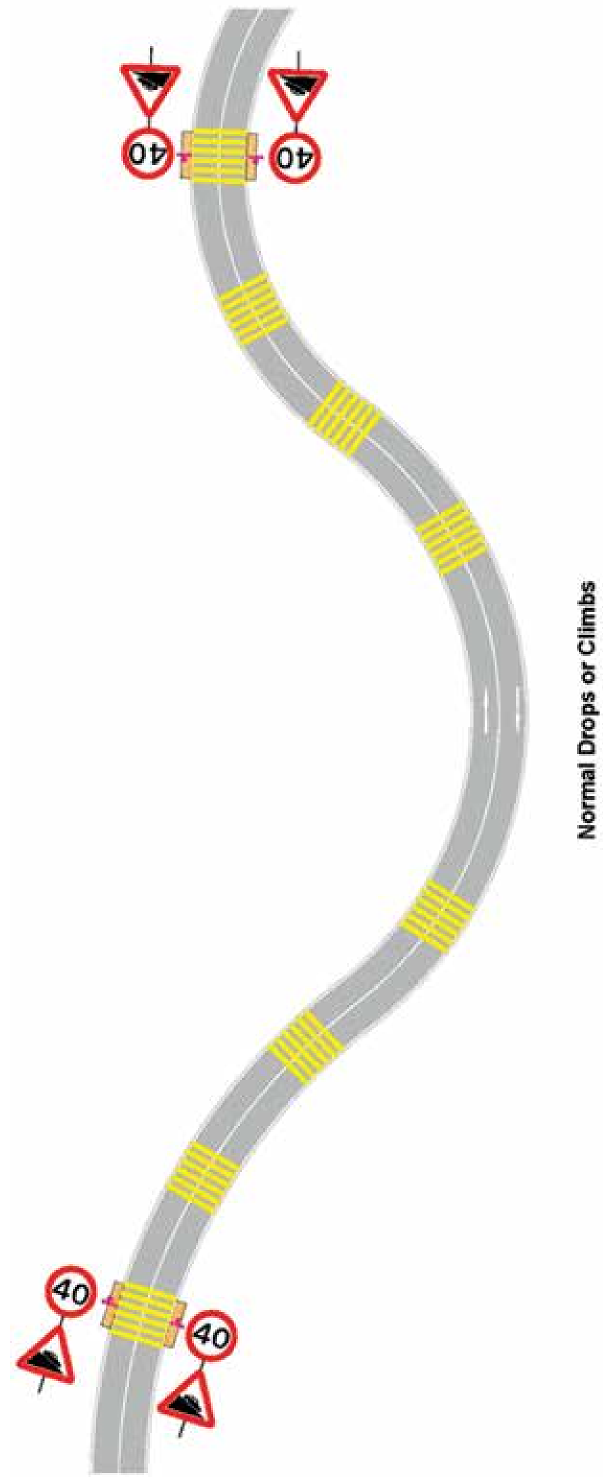
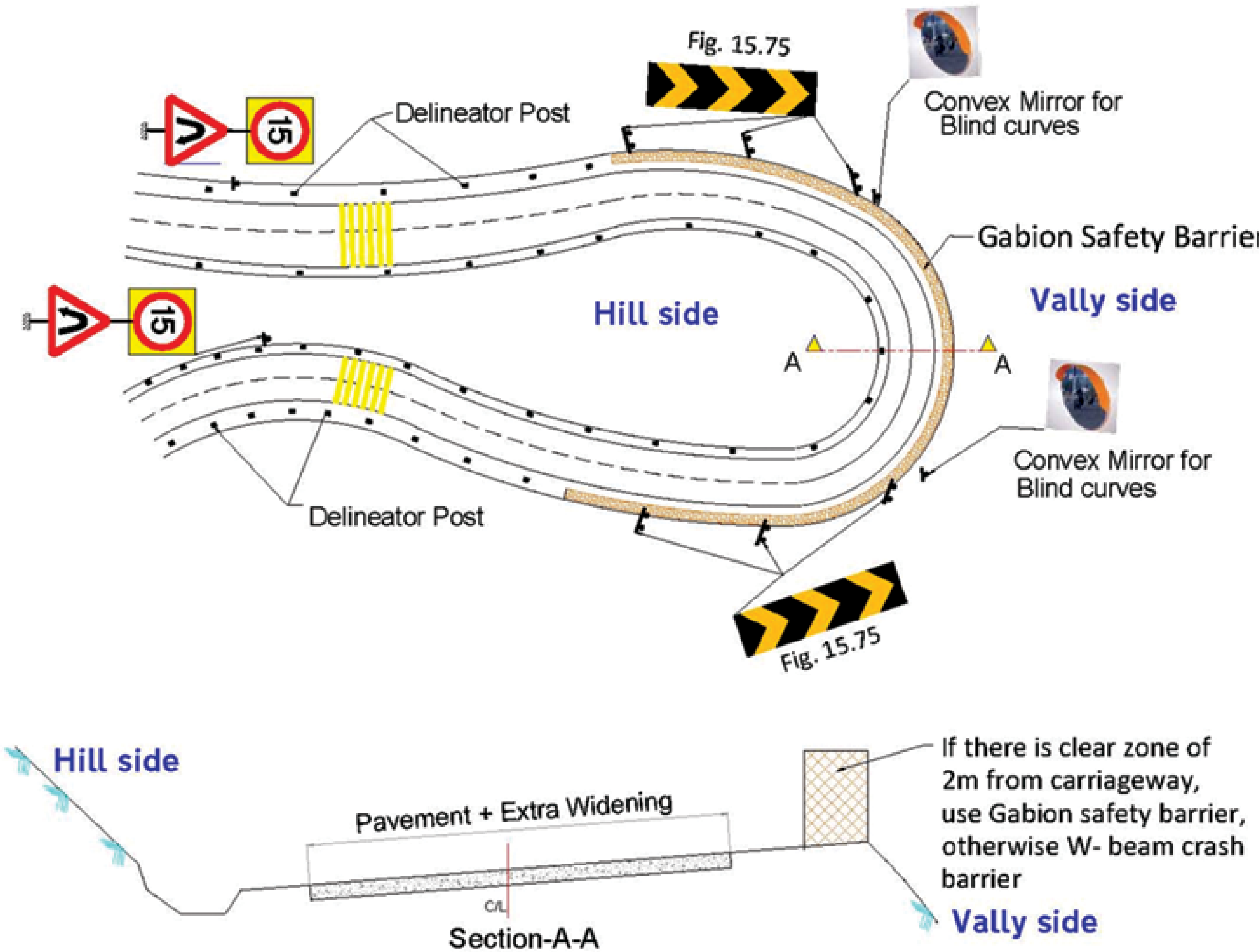


Fig. 5.32 Schematic Diagram - Hill Roads (b)



Hairpin Bend

Fig. 5.33 Schematic Diagram - Hill Roads (c)

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(The Official amendments to this document would be published by the IRC in its periodical, 'Indian Highways' which shall be considered as effective and as part of the Code/Guidelines/Manual, etc. from the date specified therein)