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IRC:119-2015

GUIDELINES
FOR
TRAFFIC SAFETY BARRIERS

INDIAN ROADS CONGRESS
2015

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Published by:

INDIAN ROADS CONGRESS

Kama Koti Marg,
Sector-6, R.K. Puram,
New Delhi-110 022

January, 2015

Price : ₹ 300/-
(Plus Packing & Postage)

IRC:119-2015

First Published : January, 2015

Printed by India Offset Press, Delhi- 110 064

1000 Copies

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GUIDELINES FOR TRAFFIC SAFETY BARRIERS

1 INTRODUCTION

Traffic Safety Barriers, also known as Crash Barriers, are provided on high speed highways to prevent accidents when vehicles lose control and run off the road. Especially dangerous are road sections with sharp curves, approaches to bridges with restricted roadway, high embankments, hazardous obstacles such as poles, trees and bridge structural elements. Experience has shown that if suitably designed and properly located, it is possible to redirect the vehicle nearly parallel to the direction of the barrier, contain within tolerable limits the forces experienced by the vehicle occupants, minimize the severity of the accident and reduce the damage to property. In view of the highly cost-effective safety provided by these devices, they are being extensively used on modern high speed highways. The present guidelines have been prepared taking note of the best international practices.

The Road Safety and Design Committee (H-7) deliberated on the draft in a series of meetings. The H-7 Committee finally approved the draft document in its meeting held on 25th March, 2014 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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Honorary Treasurer, Indian Roads Congress	(Das, S.N.), Director General (Road Development), Ministry of Road Transport & Highways
Secretary General, Indian Roads Congress	

The Highways Specifications & Standards Committee (HSS) approved the draft document in its meeting held on 9th August, 2014. The Executive Committee in its meeting held on 18th August, 2014 approved the same document for placing it before the Council. The Council in its 203rd meeting held at New Delhi on 19th and 20th August, 2014 approved the draft "Guidelines for Traffic Safety Barriers" for publishing.

For preparing this document, literature published by Organisations like American Associations of State Highways and Transportation Officials, (AASHTO) has been consulted. Indian Roads Congress acknowledges with thanks the kind permission given by AASHTO to use some of their Figures and Annexures of this document.

2 TYPE OF TRAFFIC SAFETY BARRIERS

Two general types of Traffic Safety Barriers are commonly met with, viz:

1. Road Edge Barrier (also known as Roadside Barriers)
2. Median Barriers

Road Edge Barriers are those placed at the edge of the road (**Fig. 1**), whereas Median Barriers are those placed in the median of a divided carriageway (**Fig. 2**).

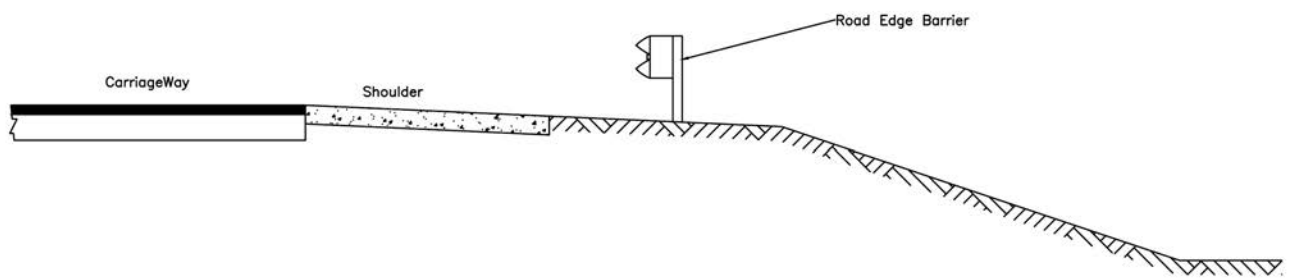


Fig. 1 Road Edge Barrier

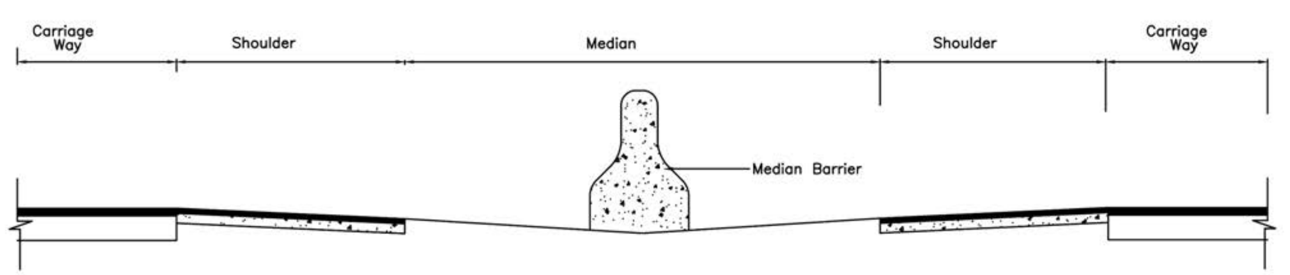


Fig. 2 Median Barrier

Road edge barriers usually consist of metal or concrete beams mounted 30-60 cm above the ground on strong posts of wood, concrete or steel. These posts are either driven into the ground to a depth of about 110 cm or inserted into holes which are then back filled. This serves the purpose of absorbing energy as the posts move in the ground upon impact. Wire ropes (Cables) attached to posts by means of spring brackets also are in use.

Median Barriers of the rigid type are popularly known as the New Jersey concrete barrier, because of its origin and popular usage in that State in USA. Other types are the double-faced steel beams on posts and cable (wire).

Depending upon their mode of performance, traffic safety barriers can be classified generally as:

1. Flexible [e.g., Cable (wire) type barriers]
2. Semi-rigid [e.g., Steel beam type barriers]
3. Rigid [e.g., Concrete barriers]

The major difference among the various types is the amount of deflection that takes place in the barrier when it is hit. The flexible system is the most yielding type. Cable (wire) type barriers fall under this category. This system facilitates containment of the vehicle and also redirects it. It deflects considerably on being hit and thus requires considerable lateral clearance from fixed objects. The wire rope barrier has the minimum impact severity on the occupants of the vehicle. The semi-rigid system offers requisite resistance to control the deflection of the longitudinal member to an acceptable limit and the errant vehicle is redirected along the travel path. Steel beam barriers belong to this category. Rigid barriers do not deflect on impact, and cause the maximum severity of impact amongst the three types. The installation of a rigid system should be considered where small angles of impact are expected, such as along narrow medians or shoulders which could be expected in urban situations. As the system suffers little or no damage on impact, it requires the least maintenance effort. **Fig. 3** shows the three types.

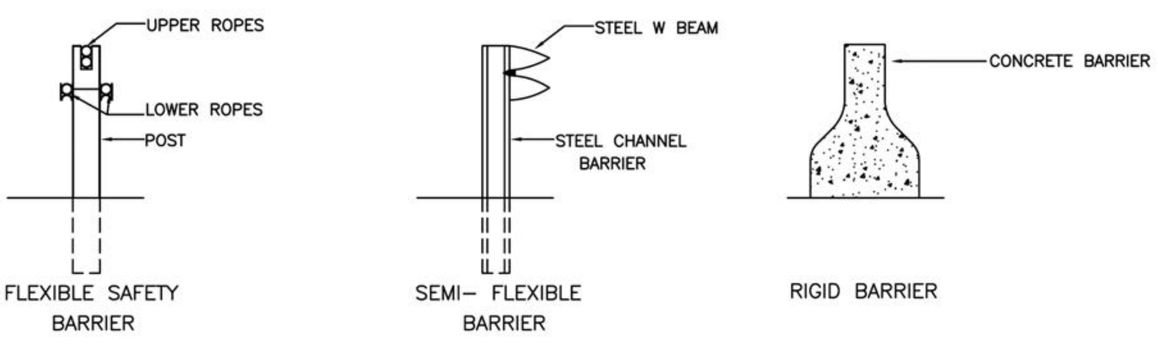


Fig. 3 Types of Safety Barriers

3 REQUIREMENTS OF A TRAFFIC SAFETY BARRIER

A traffic safety barrier must meet the following requirements:

1. The space available behind the barrier must be adequate to permit the full deflection of the barrier.

2. The barrier system must contain and redirect the vehicle at design conditions, not allowing it to penetrate or vault over the barrier.
3. It must not cause sudden acceleration or spin of the vehicle.
4. The vehicle must remain upright during and after the impact and there should not be any loose elements which can penetrate the vehicle.
5. After impact, the final stopping position of the errant vehicle must intrude only minimally into the adjacent traffic lanes.
6. It must provide good visual guide to the road users.
7. It must not entail heavy maintenance expenditure.
8. It must be possible to terminate the system properly.
9. It must involve reasonably low initial cost, maintenance cost and accident cost to the motorist.
10. It must have an aesthetically pleasing appearance.
11. There must be documented evidence of barrier's performance in the field.
12. Though in the past, roadside barriers were developed, tested and installed for vehicles with masses upto 2,000 kg, it is now being increasingly recognized that the barrier systems should be capable of redirecting larger vehicles such as buses and trucks.

4 ROAD EDGE BARRIERS

4.1 Definition

A road edge barrier, also known as roadside barrier, is a longitudinal system used to shield vehicles from hazards on the edge of a road.

4.2 Locations Where Generally Provided

Road Edge barriers are generally provided at the following locations:

1. Embankments with high fills and steep slopes
2. Near roadside obstacles
3. Bridge rail ends
4. At specific locations for ensuring safety of bystanders, pedestrians and cyclists.
5. Dangerous ditches
6. Steep grades
7. Accident Black Spots
8. Hill Roads
9. Grade separator structures

4.3 Warrants for Provision

4.3.1 *Barriers on Road Embankments*

The warrants for the installation of road edge barriers on road embankments are governed by the height and slope of the embankment. These are given in **Fig. 4**. It may be noted that barrier is not warranted for embankment slope of 3:1 or flatter. For Expressways, it is necessary to provide roadside safety barriers on embankments where the recoverable slope upto a distance of clear zone applicable for the design speed is not available (see **Fig. 5**).

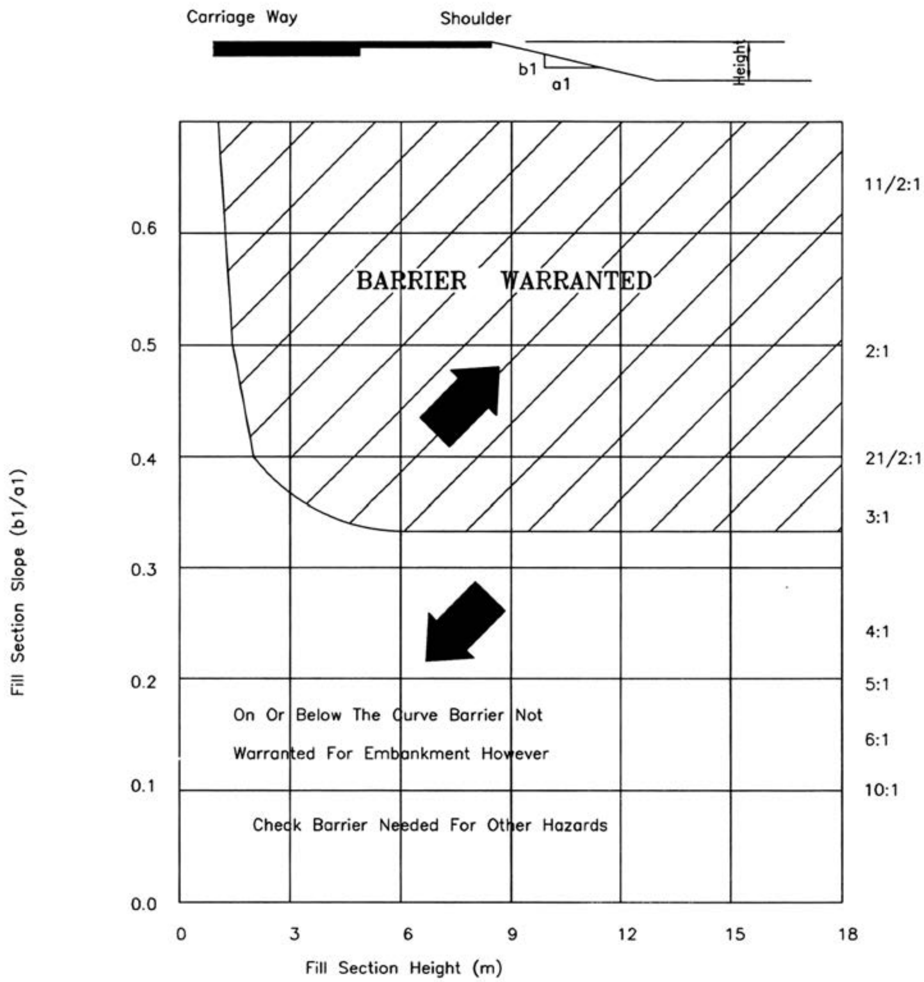


Fig. 4 Warrants for Fill Section Embankments

4.3.2 *Barriers for Shielding Roadside Objects*

A clear, unobstructed, flat roadside is highly desirable. When these conditions cannot be met, barriers are needed. The roadside obstacles are classified as non-traversable hazards and fixed objects. Some typical examples of non-traversable hazards' (**Table 2**) are: rough rock cuts, streams or permanent bodies of water (more than 0.6 m in depth) etc. Similarly some typical examples of 'fixed objects' (**Table 1**) are: sign posts, traffic signal posts, trees with diameter greater than 15 cm etc. The removal of these hazards should be the first alternative to be considered. If it is not feasible or possible to remove or relocate a hazard, then a barrier may be necessary. However, a barrier should be installed only if it is clear that the barrier offers the least hazard potential. **Fig. 6** shows the suggested criteria for determining the clear zone on fill and cut sections for three different vehicle-operating speeds for unrounded shoulder-slope corner. Non-transversable hazards or fixed objects should be removed, relocated or shielded by a barrier if they are within the indicated minimum clear zone width. A "Clear Zone" is 'that roadside border area, starting at the edge of the carriageway, available for safe use by errant vehicles'. Establishment of a minimum width clear zone implies that rigid objects and certain other hazards with clearances less than the minimum width should be removed, relocated to an inaccessible position or outside the minimum clear zone, remodelled to make safely traversable or breakaway or shielded. **Fig. 6** shows the clear zone width, speed and slope criteria.

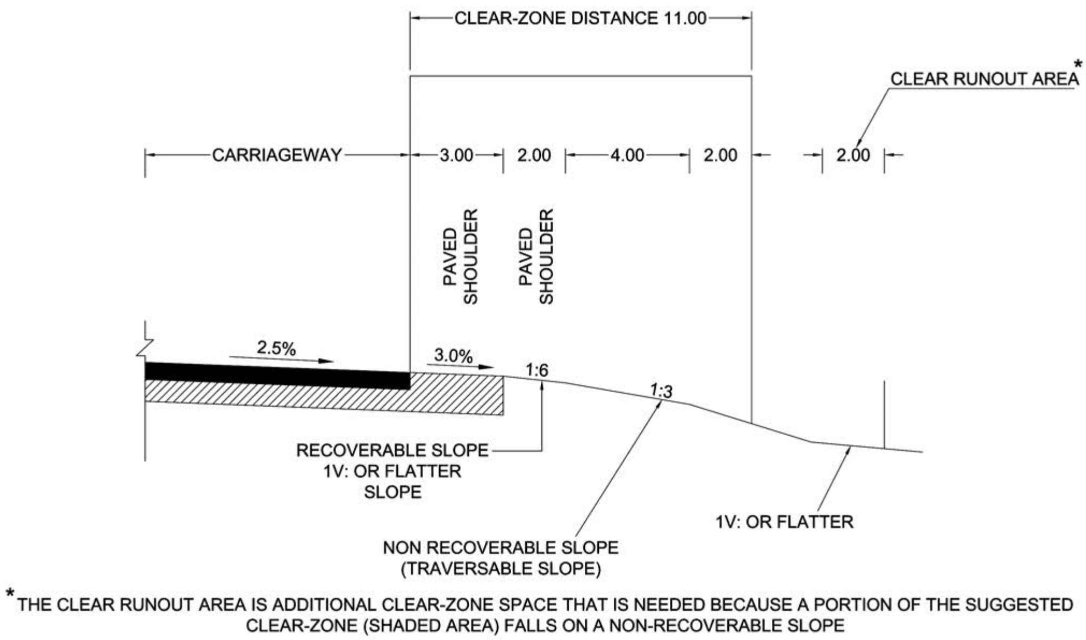


Fig. 5 Clear Zone

The warrants for typical non-traversable hazards and for fixed objects are given in **Tables 1 and 2** respectively.

Table 1 Warrants for Non-Traversable Hazards

Non-Traversable Hazard within Clear Zone as Determined by Fig. 5	Traffic Barrier Required	
	Yes *	No
Rough rock cuts	X	
Large boulders	X	
Streams or permanent bodies of water less than 0.6 m in depth		X
Streams or permanent bodies of water more than 0.6 m in depth	X	
Shoulder drop-off with slope steeper than 1:1 and		
● Height greater than 0.6 m	X	
● Height less than 0.6 m		x

* *All roadside obstacles within the clear zone should be removed if possible, otherwise provide barrier protection.*

Table 2 Warrants for Barriers for Fixed Objects

Fixed Objects within Clear Zone as Determined by Fig. 5	Traffic Barrier Required	
	Yes *	No
Sign, traffic signal, and luminaire supports Breakaway or yielding design with linear impulse		
Less than 4895 N – sec		x
Greater than 4895 N – sec	X	
Concrete base extending 15 cm or more above ground	x	
Fixed sign bridge supports	X	
Bridge piers and abutments at underpass	X	
Retaining walls and culverts	X	
Trees with diameter greater than 15 cm	X	
Wood poles or posts with area greater than 320 sq cm	X	

Notes : *(1) Fixed objects should be removed or relocated so that a barrier is unnecessary if practical.*

(2) Breakaway or yielding design is desirable regardless of distance from carriageway.

Large sign supports are formidable obstacles and require protective treatment. Where continuous guard-rail is not available, sections of barrier should be introduced in front of the supports, the length in advance of a sign being not less than 25 m and preferably 40 m. The approach end should be flared and anchored. The barrier should normally extend 25 m or more beyond the sign support when not anchored, and at least 8 m when anchored. The off-set between the face of the barrier and the support should not be less than 0.6 m, or if the support has a concrete base, it should not be less than 0.5 m.

Protection against collision with lighting columns is difficult, because the columns are numerous and are located relatively close to the road edge. Where continuous barrier is not justified, columns may be installed without protection, if they are lightweight and are set atleast 0.75 or 0.9 m beyond the edge of the useable shoulders. Where barriers are provided, the lighting columns should be set not less than 0.5 m, and preferably 0.6 m behind the face of the barrier. Short sections of barriers are not recommended at each lighting column as a general practice.

4.3.3 *Bridge Rail Ends, Transitions and End Treatments*

Fig. 7 summarises the warrants for an approach barrier to a bridge. The criteria for clear zone requirements given in **Fig. 6** apply here also. If an approach barrier is warranted, adequate transition section between the approach barrier and the bridge railing is needed. If the end of the approach barrier terminates within the clear zone, a crash worthy end treatment is also warranted.

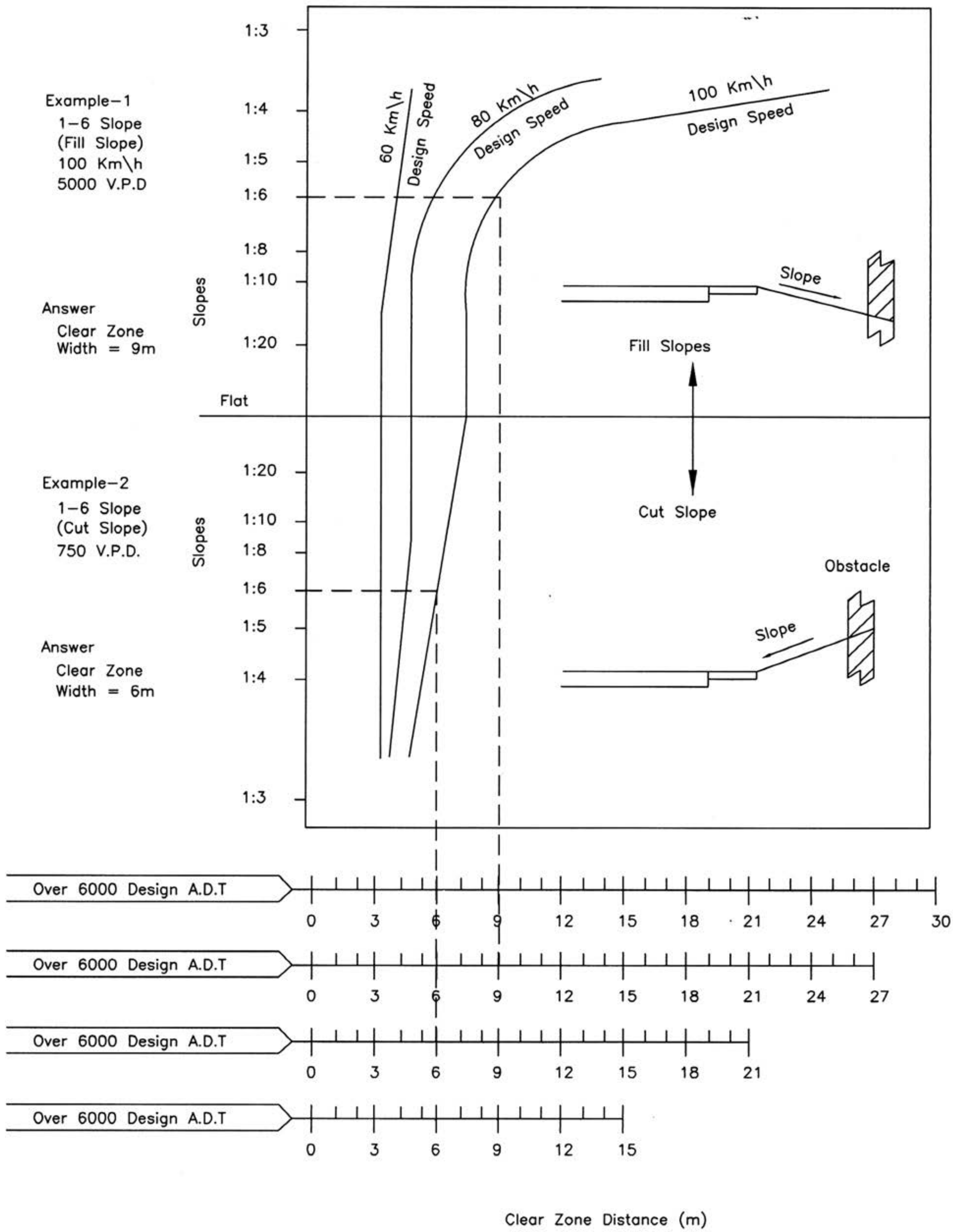


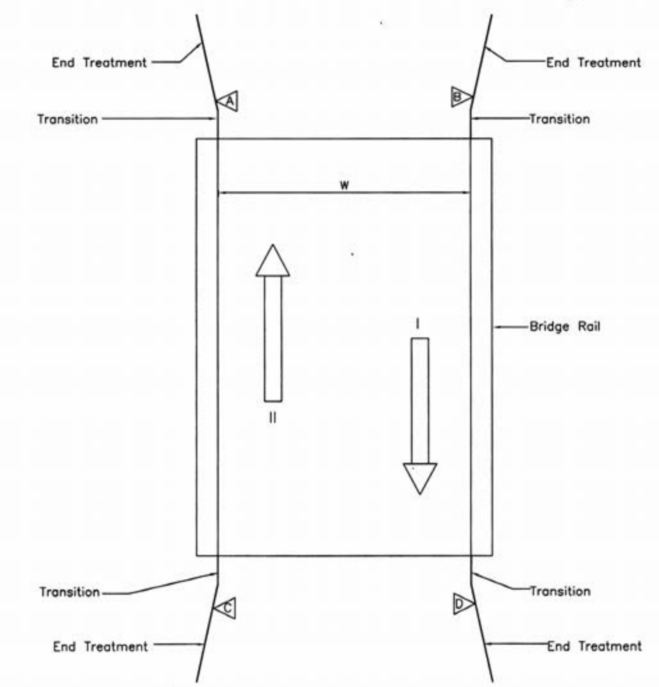
Fig. 6 Clear Zone Distance Curves
(Source: Ref. 1)

4.3.4 *Barriers for the Protection of Bystanders, Pedestrians and Cyclists*

An area of concern in highway safety is the "innocent bystander". In most such cases, the conventional criteria presented earlier cannot be used to establish barrier needs. For example, a major street, highway or expressway may adjoin a school yard, but the boundaries are beyond the clear zone. Conventional criteria would not require that a barrier be installed. However, if there is any reasonable probability of an errant vehicle encroaching on the school yard, a barrier would be warranted. If possible, a barrier could be placed near the school boundary to minimise the hazard. Special consideration should also be given to business and/or residences which are near the right-of-way. For protecting cyclists and pedestrians, when sidewalks and cycle tracks are near the carriageway of high speed facilities, safety barriers may be provided.

4.3.5 *Barriers for Protection from Ditches*

Ditches near the carriageway can be a significant hazard, if their cross-section cannot be easily traversed by an errant vehicle. Preferred ditch cross-sections are shown in the shaded area in **Figs. 8 to 10**. If the cross-section is outside the shaded area, barriers are warranted.



Traffic Direction	Distance Between Bridge Rails –W (m)	Approach Barrier Required At
I And II	≤ 2 x Clear Zone Width	A,B,C,D
I And II	> 2 x Clear Zone Width	C,B
II Only	All Widths	C,D
I Only	All Widths	A,B

Fig. 7 Bridge Approach Barrier Criteria
(Source: Ref. 1)

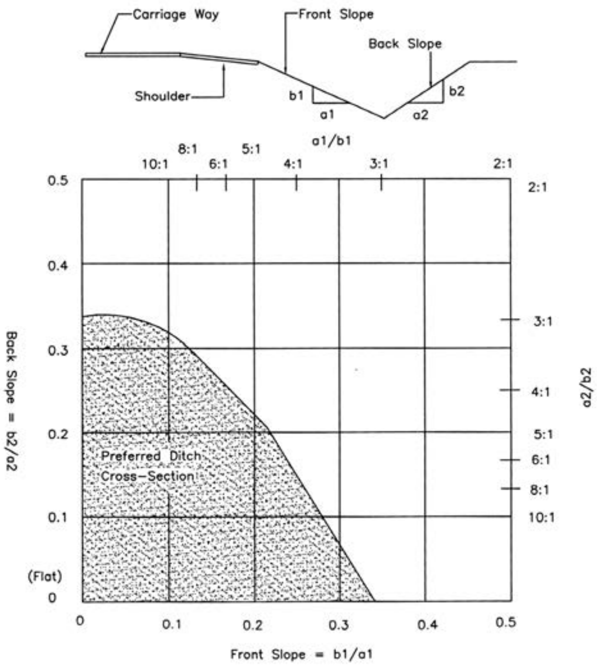


Fig. 8 Preferred Ditch Sections for :
(a) Vee Ditch; or
(b) Round Ditch, Bottom Width < 2.44 m,; or
(c) Trapezoidal Ditch, Bottom Widh < 1.22 m,; or
(d) Rounded Trapezoidal Ditch, Bottom Widh < 1.22 m
(Source: Ref. 1)

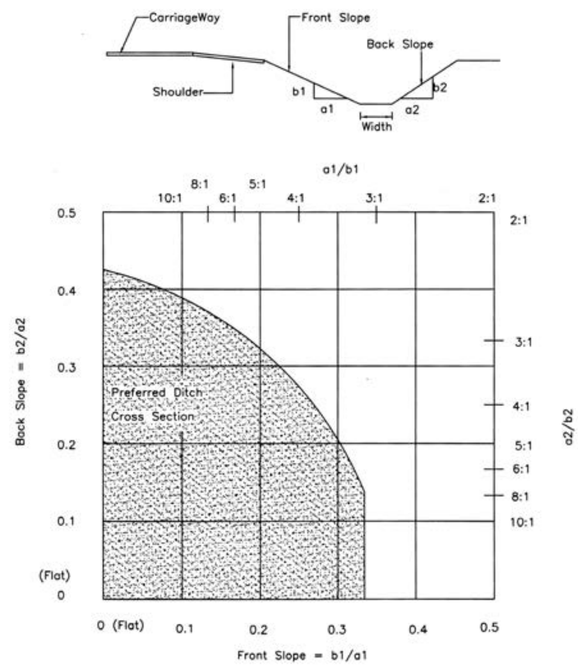


Fig. 9 Preferred Ditch Sections for:
(a) Trapezoidal Ditch, Bottom Width = 1.22 m to 2.44 m; or
(b) Round Ditch, Bottom Width = 2.44 m to 3.66 m
(Source: Ref. 1)

4.3.6 *Steep Grades*

On steep grades, loss of brakes on a vehicle produces a dangerous situation both for the driver of the affected vehicle and also for other drivers. In such situations, special consideration should be given to the installation of a roadside decelerating device. A gravel bed attenuator, starting from the edge of the paved shoulder, comprising of 25 to 50 cm deep bed of graded gravel 6 to 10 mm size (rounded or angular) has shown good promise.

4.3.7 *Safety Barriers at Accident Black Spots*

If the cause of accidents at black spots is the sharp radius of curve or presence of roadside fixed objects like piers, abutments, traffic sign supports, the provision of W-beam safety barriers will protect the vehicles from running off the road or colliding against the fixed objects. On sharp curves, the W-beam barriers should extend to 100 m beyond the beginning and end of the curves. For protection from colliding against fixed objects, the safety barriers length should be sufficient enough to protect the fixed objects from the impact of errant vehicles.

4.4 Selection Guidelines for Edge Barriers

4.4.1 *Main Objective Criteria*

Once established that a roadside barrier is warranted, the most appropriate roadside barrier system is the one that offers the required degree of shielding at the lowest cost.

4.4.2 *Performance Capability*

The selected design should show satisfactory performance, either through crash testing or favourable accident experience within the range of expected conditions. In the Indian context, it is to be borne in mind that locations with poor geometrics, high traffic volumes and/or speeds and a significant volume of heavy truck traffic will warrant a higher performance level or stronger railing system in comparison to the situation where only passenger vehicles are to be considered.

4.4.3 *Deflection Characteristics*

Having determined the performance capability, the type of the barrier to be selected will depend on the site characteristics. At sites where the distance between the barrier and the shielded object or terrain feature is large, a flexible barrier which deflects upon impact and imposes lower impact forces on the vehicle and its occupants is to be preferred. However, if the obstacle is immediately adjacent to the barrier, a semi-rigid or rigid barrier system is the only choice.

4.4.4 *Site Conditions*

Where the distance between the barrier and edge of the carriageway is too wide, a flexible barrier is to be preferred over a rigid barrier. Also, if the barrier is to be placed on a slope steeper than 1:10, a flexible type barrier should be used. With narrow grade widths and corresponding narrow shoulders, the post will have to be embedded deeper and a closer post spacing required.

Between the carriageway end and the barrier, the terrain type can greatly affect the barrier's impact performance. Kerbs and roadside slopes are two particular features which need to be considered. Crash tests show that use of any guard-rail/kerb combination where high speed, high angle impacts are likely, should be discouraged; where there are no feasible alternatives, the use of a low kerb (less than 100 mm) or stiffening of the guardrail (to reduce its deflection) usually proves satisfactory. On lower speed roads, a vaulting potential still exists, but the risk of occurrence being lessened, no design change is warranted. Kerb/barrier combinations should be crash tested if extensive use of the combination is envisaged.

4.4.5 *Compatibility*

The fewer the different roadside barrier systems used on new construction and reconstruction of highway projects, the better it, is because the systems in use have proven effective over the years; construction and maintenance personnel are familiar with the systems; parts and inventory requirements are simplified and end treatments can be standardised. If, however, the site characteristics or performance requirements cannot be satisfied with a standard railing, then a non-standard or special barrier design may be resorted to.

4.4.6 *Life Cycle Costs*

In the final selection of the most suitable barrier system, the total costs (initial plus maintenance costs) of alternate barrier systems play a very important role. As is true for most structures, for a high strength barrier, even though the initial cost will be high, the maintenance costs will be low. However, if the strength of a barrier is not upto the mark initially, it will require more of maintenance and, therefore even though the initial cost may be low, the maintenance costs will be high.

4.4.7 *Aesthetics and Environmental Considerations*

Aesthetics are generally not the controlling factors in the final selection of a roadside barrier except that in recreational areas or parks, the barrier which blends well with the surroundings should be selected. However, the selected systems should be crashworthy. Certain types of railing may deteriorate in highly corrosive urban/industrial environments; in such harsh environments, use of galvanised steel and painting with anti-corrosive paints must be resorted to. Also, the possibility of using corrosion resistant materials like aluminium or cement concrete must be explored in such harsh environments. Where solid barriers are used, care must be taken to see that these barriers do not restrict sight distance of motorists.

4.4.8 *Field Experience*

Documented proof of a barrier's field performance is of paramount importance. There is little reason, if at all, to install a barrier for which the performance record is not available. In the Indian context, impact performance and repair cost data must be maintained by the concerned highway agency and made available to engineers responsible for selecting and installing traffic barriers. A format for recording the performance details is enclosed at **Annexure I.**

4.5 Types of Road Edge Barriers

The following types of Road Edge Barriers commonly used in the USA are recommended: -

- i) Blocked out "W" beam type steel barrier
- ii) Blocked out Thrie beam type steel barrier
- iii) Wire rope barrier

4.6 Blocked-out "W" Beam type Steel Barrier

Blocked-out "W" beam type Steel Barrier with steel post is shown in **Fig. 11**. It consists of a steel post and a 3 mm thick "W" beam rail element attached to a steel block, which in turn is attached to the steel post. The barrier is of a semi-rigid type. The steel post and the blocked-out spacer are channel section 75 mm x 150 mm size 5 mm thick. The rail shall be 700 mm above the ground and 1100 mm below the ground, and shall be spaced at 2 m centre to centre. The posts, beam, spacer and fasteners shall be galvanised by the hot dip process.

4.7 Blocked-out Thrie Beam Type Steel Barrier

A Blocked-out Thrie-Beam type steel barrier is shown in **Fig. 12**. This design is costlier than the simple W beam type discussed earlier, but is less prone to damage by vehicle collisions, especially for shallow angle impacts. The post and spacer blocks are of steel channel section 75 mm x 150 mm x 5 mm. The spacing of the posts is 2 m centre to centre. The post is 850 mm above the ground and is driven into the ground to a length of 1150 mm. All the steel components and fasteners are galvanised by the hot dip process.

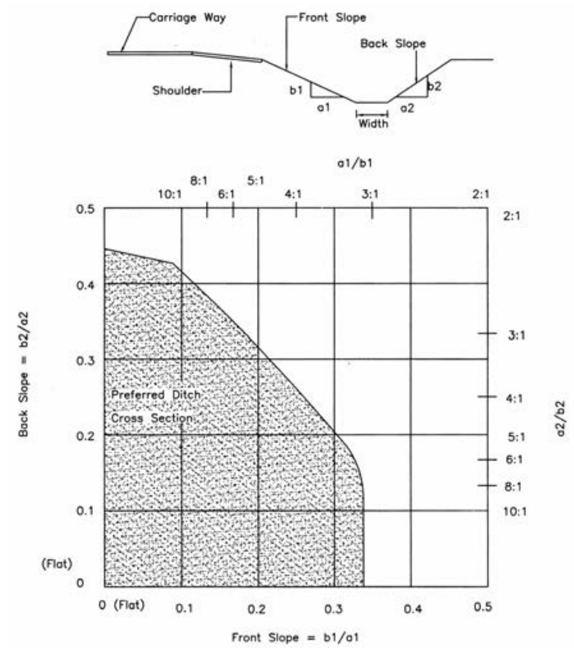


Fig. 10 Preferred Ditch Sections for:
(a) Trapezoidal Ditch, Width > 2.44 m,; or
(b) Round Ditch, Bottom Width > 3.66 m,; or
(c) Round Trapezoidal Ditch, Width > 1.22 m
(Source: Ref. 1)

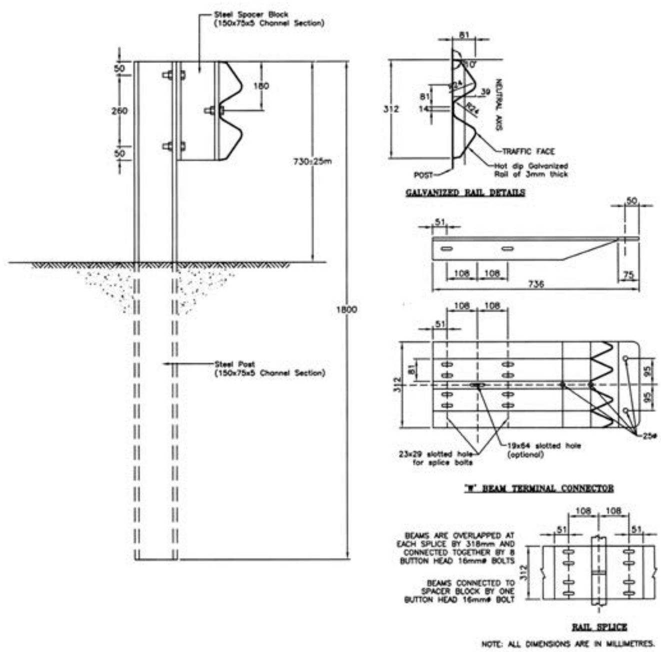


Fig. 11 Typical Details of 'W' Structural Elements

4.8 Advantages of Using Channel Sections vis á vis I-Section

It is interesting to observe that most of the American designs adopt channel sections in preference to I-sections for a variety of reasons. The channel sections make the connections with other components of the barrier system much more convenient than for I-sections. In general, the flat surface area exposed in channel sections is more than what can be made available with I-sections. Under the same load, a channel section will deform more than a corresponding I-section, thus reducing the magnitude of impact on the impacting vehicle. Lastly, channel sections are more economical than I-sections.

4.9 Minimum Length of Safety Barriers and foundation Details

The minimum length of safety barrier shall be 50 m. For barriers at hazardous location 2/3rd of length shall be before the hazard and 1/3rd after hazard. The overall design, length and foundations shall be such that meet the specifications given in **Annexure II**.

4.10 End Treatment for Steel Edge Barriers

An untreated end of the roadside barrier can be hazardous if hit, because the barrier beam can penetrate the passenger compartment and cause the impact vehicle to stop abruptly. End treatments should, therefore, form an integral part of safety barriers. An end treatment should not spear, vault or roll a vehicle for head-on or angled impacts.

The end treatment on approach shall be Modified Eccentric Loader Terminal (MELT) arrangement as shown in **Fig. 13** and departure sides it shall be Trailing Terminal (TT) arrangement shown in **Fig. 14**. Following the same end treatments, **Fig. 15** gives the typical layout of W-beam whether on raised median sides or on depressed/flushed median sides.

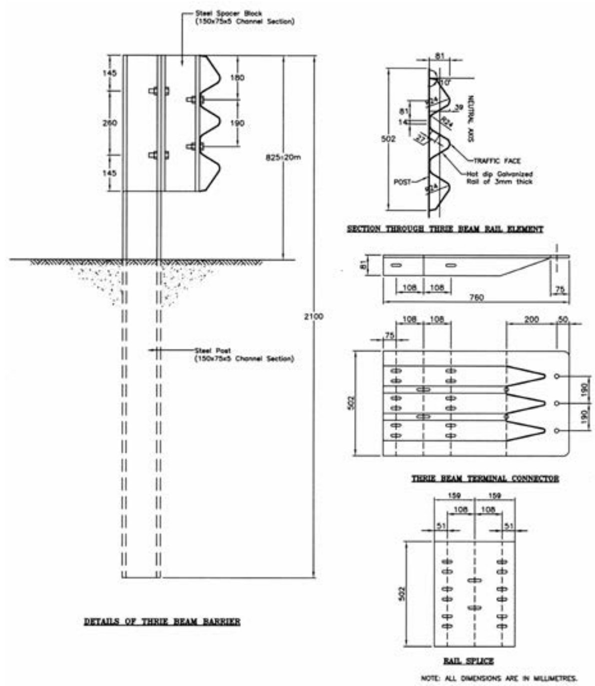


Fig. 12 Typical Details of Thrie Beam Structural Elements

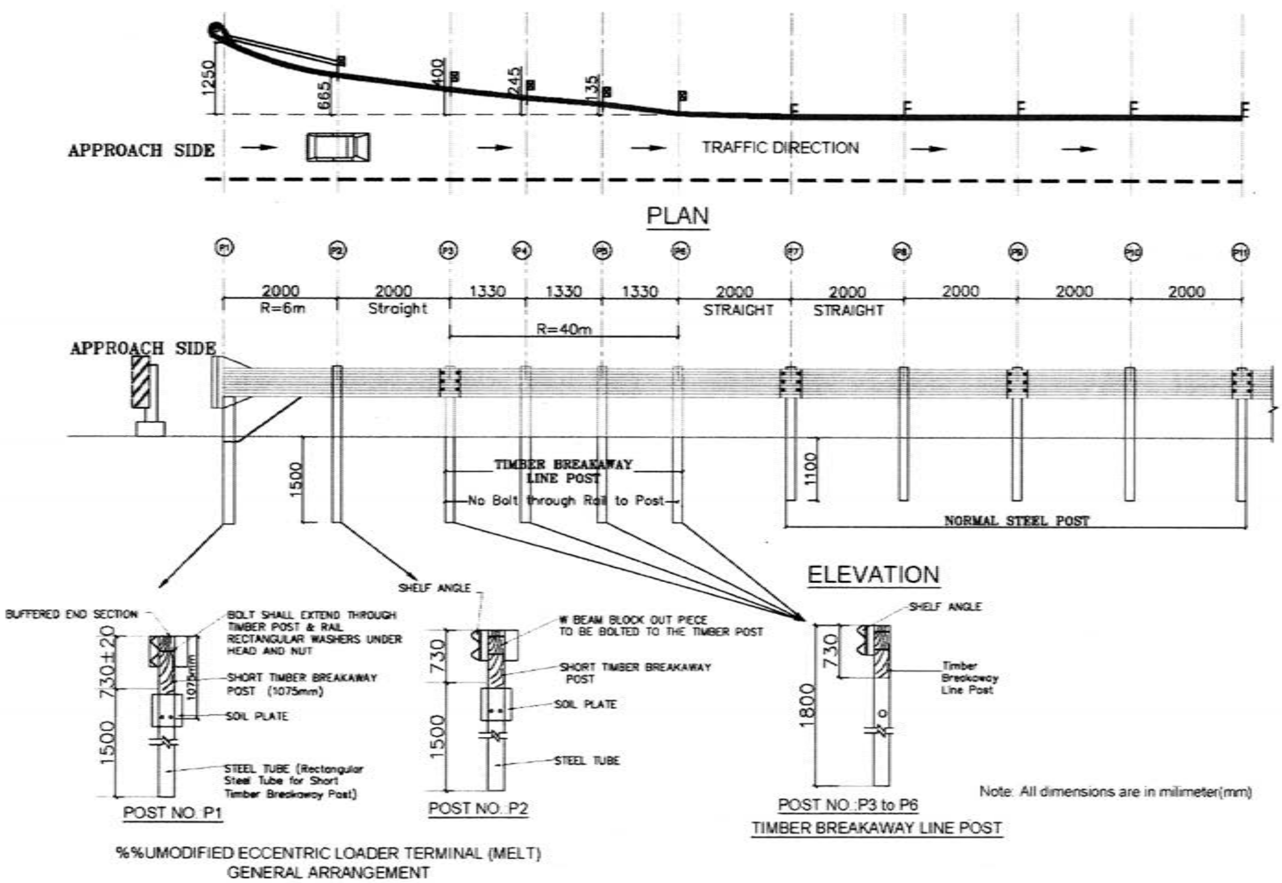


Fig. 13 Fig. Modified eccentric Loader Terminal (MELT)
Arrangement : W Beam Treatment on Approach Side

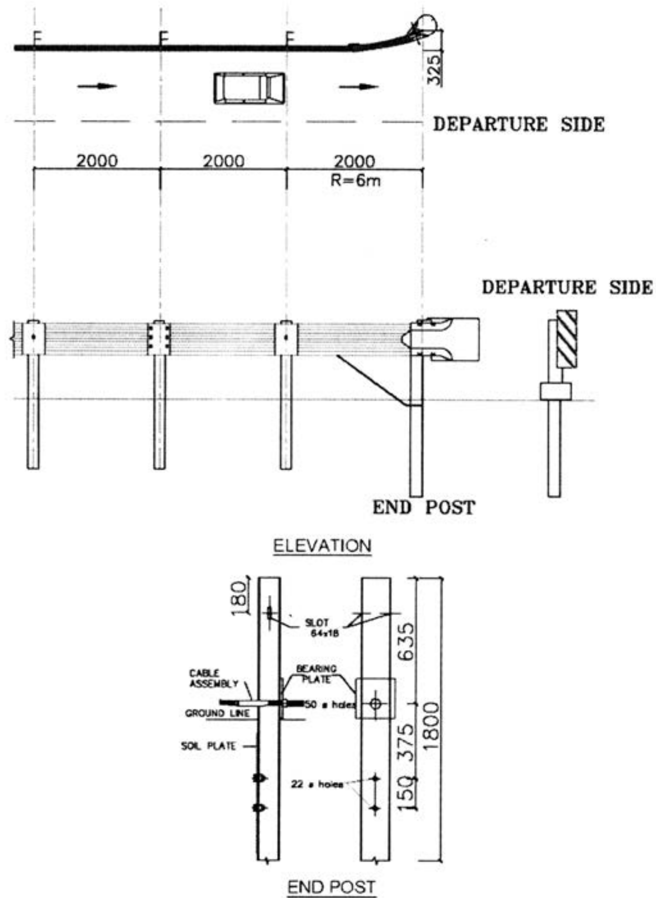


Fig. 14 Trailing Terminal (TT) Arrangement - W Beam Treatment on Departure Side

The W-beam to concrete transition shall be carried out by decreasing the post spacing, nesting one rail behind another and using steel section behind the W-beam. The transition between W-beam and concrete barrier is detailed in **Fig. 16**.

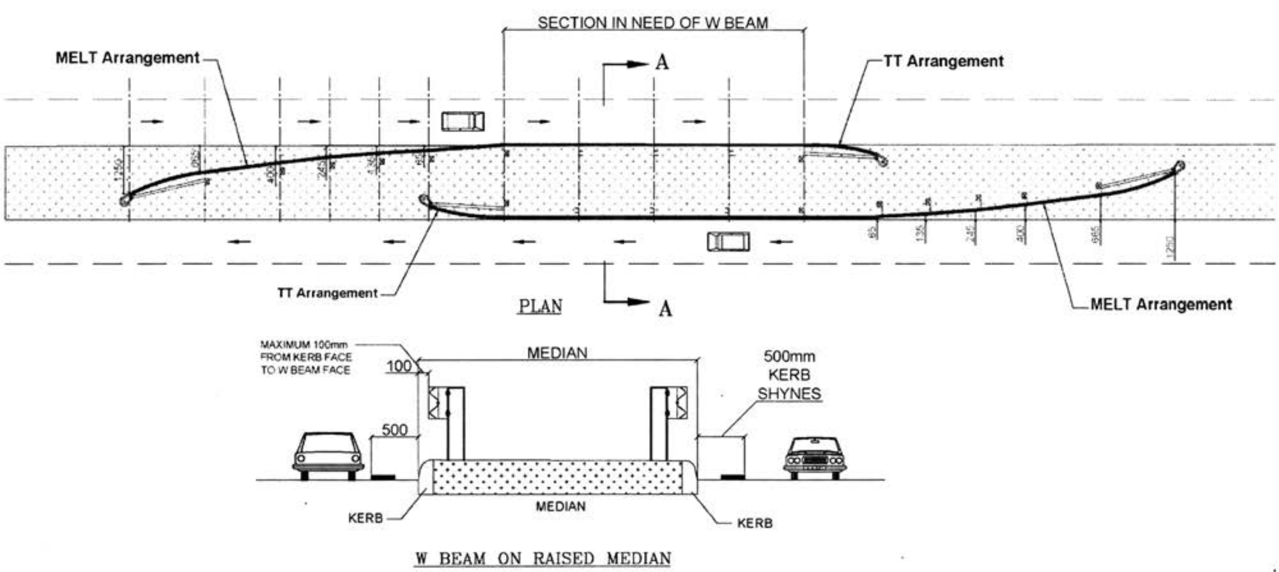


Fig. 15 Typical Layout of W beam on Median Side

At road cross sections in cutting or if the road transitions from cut to fill, the safety barriers can be anchored in backslopes. The backslope covering the anchored portion of the barriers should be graded flat, with side slopes preferably not steeper than 10:1. The anchored portion should develop tensile strength in the rail element to prevent the rail from pulling out of the anchorage. The barrier can also be anchored in an earthen berm specially constructed for this purpose, provided the new berm itself is not a hazard to the traffic. The earthen berm should be made resistant to erosion.

4.11 Placement of Road Edge Barriers of Steel

Placement recommendations determine the exact layout of the barrier and should be made by the design engineer keeping in view the lateral offset of the barrier and flare rate. The final layout shall be a site having specific combination of these factors. The barriers should be as far away from the traffic as possible and should preferably have uniform clearance between the traffic and the hazard.

As far as possible, the safety barrier should be placed beyond 2.5 m of the travelled way. For long and continuous stretches, this offset is not critical. The distance between the barrier and the hazard should not be less than the deflection of the barrier by an impact of a full sized vehicle. In case of embankments, a, minimum distance of 60 cm should be maintained between the barrier and the start of embankment slope or a hazard to prevent the wheels from dropping over the edge.

The W-beam and Thrie beam perform well on the outside of curves and even those of relatively small radius. When a kerb exists on the edge of road and on to close proximity to the travelled way, whether on shoulder or median edge lines, a distance of 100 mm shall be maintained between the vertical face of the kerb and the W-beam or Thrie beam face to ensure that the impacting vehicle does not vault over the safety barrier and at the same time reduces the nuisance hit. The steel barrier shall be placed in such a way so as not to be collided by the vehicle directly. **Fig. 17** gives the lateral clearance to be maintained in different site conditions.

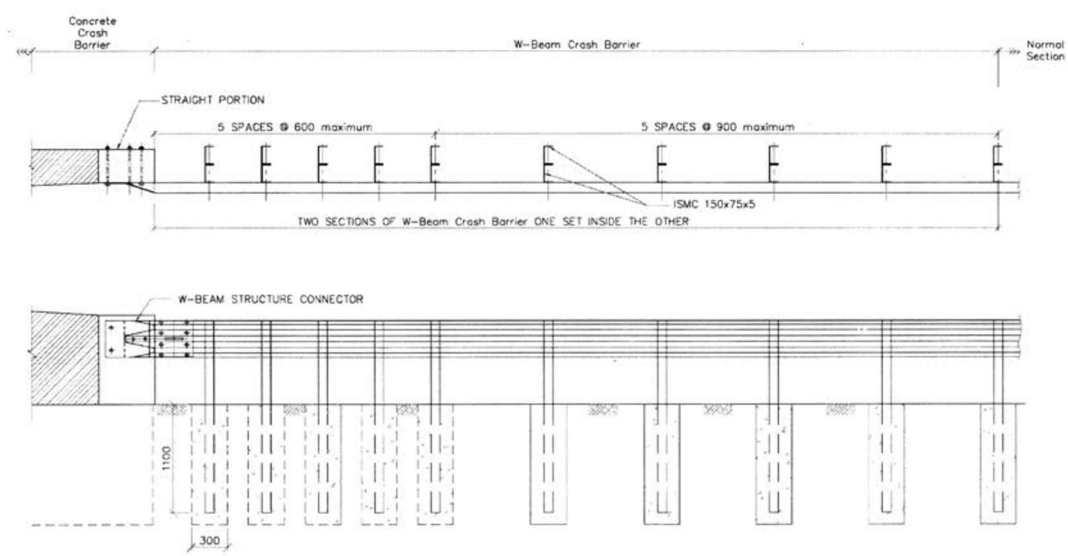


Fig. 16 W Beam To Concrete Connection Details

4.12 Wire Rope Barrier

Wire rope safety barriers have galvanized prestressed steel wire ropes (generally three or more in number) supported by galvanised steel posts at spacing of 2 – 4 m, depending upon the manufacturer's design. The overall length of the post is 680-700 mm above the ground. The posts are driven to a depth of 400 mm into the ground. Typical details are shown in **Figs. 18, and 19**. The details in **Figs. 20 and 21** show the transition from the wire rope to W-beam and wire rope to rigid barrier respectively.

Wire rope barriers shall not be used:

a) where the length of the barrier at full height would be less than 24 m;
b) on horizontal curves of radius less than 200 m;
c) on vertical sag curves of radius less than 3,000 m;
d) where high mast lighting columns are situated within 10 m of the edge of the paved surface.

4.13 Flare Rates for Edge Barriers

When edge barriers are used, they should be gradually flared Table 3 gives the flare rates depending upon the design speed.

Table 3 Flare Rates for Edge Barriers

Design Speed in km/hr.	Fare Rates	
	Rigid Barriers	Semi-Rigid Barriers
120	20:1	16:1
100	17:1	13:1
80	14:1	11:1
65	11:1	9:1
50	8:1	7:1

5 MEDIAN BARRIERS

5.1 Definition

As the name suggests, median barriers are those that are provided in the medians of highways. They accordingly protect the traffic on both the carriageways. They are intended to prevent head-on collisions, especially on highways with narrow medians, caused by out-of-control vehicles jumping across the medians. They also shield fixed objects on the median from the traffic flow.

5.2 Warrants

The requirements of a median barrier is a function of the width of the median and the traffic volume on the road. **Fig. 22** indicates the warrants for provision of median barriers in terms of the combination of median width and Average Daily Traffic (ADT) in PCUs (Passenger Car Units). At ADT less than 20,000 PCUs and with medians wider than 9 m, the probability of a vehicle crossing across the median is relatively low and median barriers in such cases are optional. Medians with width between 9 and 15 m do not warrant a barrier unless there is an adverse history of median cross-overs.

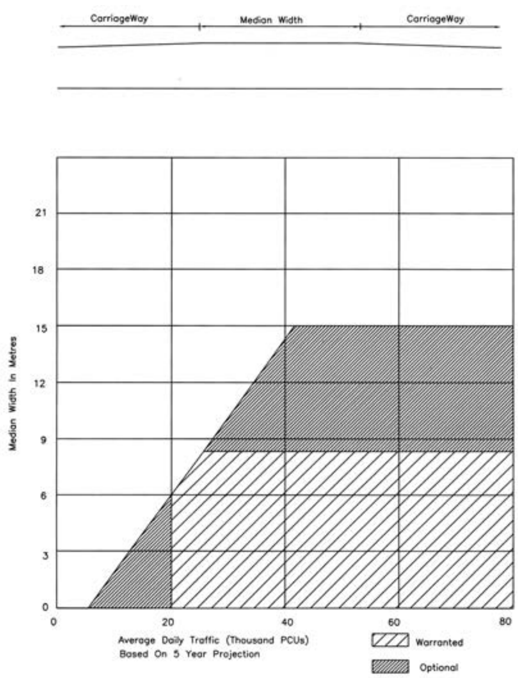


Fig. 22 Warrants for Median Barriers
(Source : Ref. 1)

Median barriers may be impractical, where a road has a large number of closely spaced median openings since the barrier needs to be terminated with an end treatment at these points.

For an existing highway, an evaluation of the number of median openings, accident history, alignment, sight distance, design speed, traffic volume and median width need to be made prior to taking a decision to install a median barrier.

Median barriers should also be provided to shield fixed objects in a narrow median. If necessary, median barriers should be flared to encompass a fixed object, which may be a lamp post, foundation of overhead signs, bridge pier etc.

On rural sections of highways where speeds are likely to exceed 50 km/ hr, raised and kerbed medians are conducive to accidents. Better alternative is to provide depressed medians. The minimum width of depressed median shall be 4 m, and median barriers shall be placed centrally.

However, several sections of highways in India exist with kerbed medians of a width of 4-5 m In such cases, Blocked-out “W” Beam Type of Steel Barrier (**Fig. 24**) or Blocked-out thrie Beam Steel Barrier (**Fig. 25**) are to be provided behind the kerbs. Considering the vehicle trajectory over kerbs, when safety barriers are to be installed on kerbed medians, the safety barrier should be placed in such a way that the vehicle bumper would hit directly on the safety barrier than first with the face of the raised kerb, and the distance between the vertical face of the kerb and W-beam shall not be more than 100 mm. The placement details are given in **Fig. 15**.

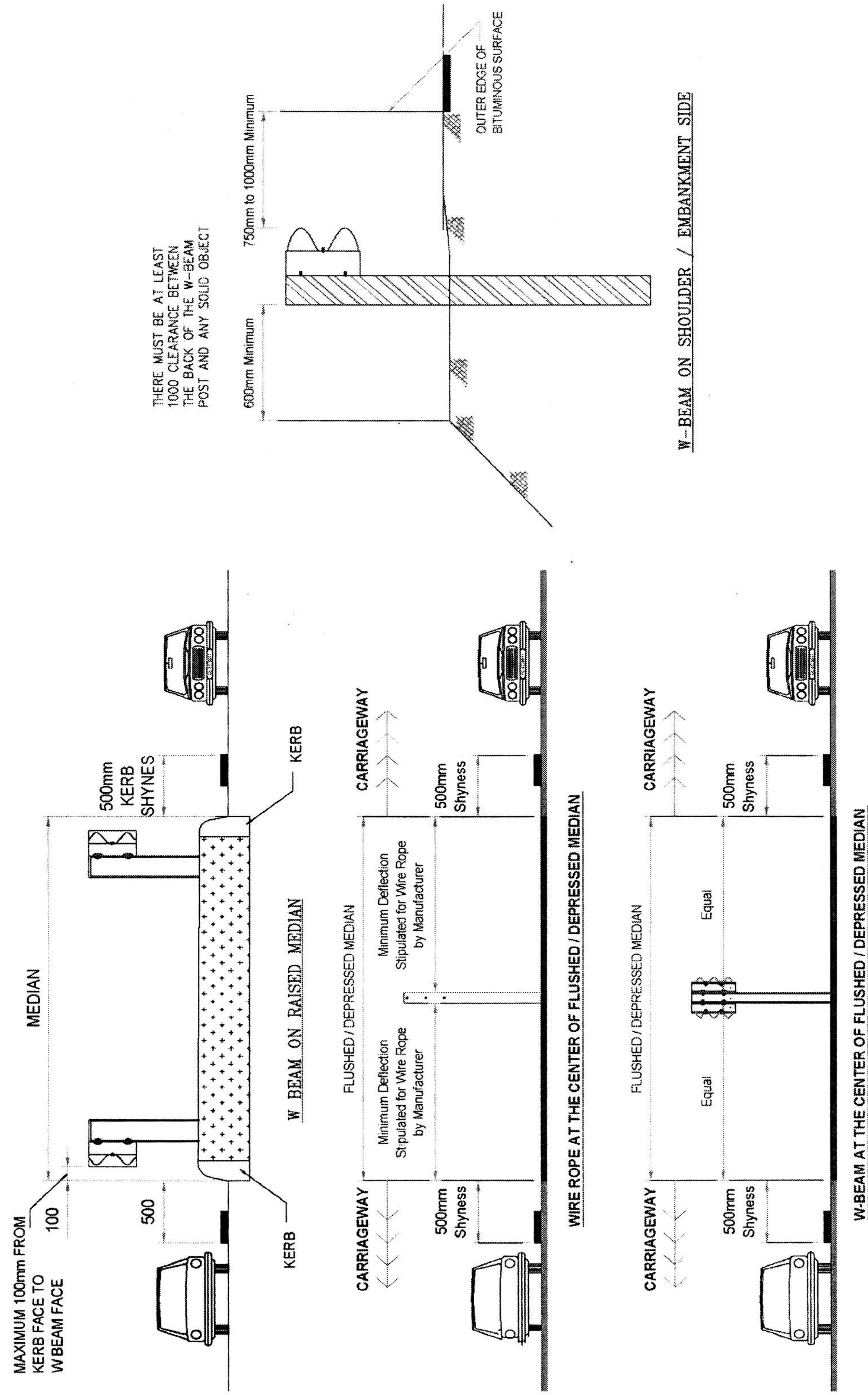


Fig. 17 Lateral Clearance for Different Barriers

5.3 Selection Guidelines for Median Barriers

5.3.1 *Main Objective Criterion*

The main objective criterion for the selection of the most appropriate median barrier system is that it must satisfy performance requirements at minimum total cost (i.e., initial construction plus maintenance costs).

5.3.2 *Barrier Capability*

While in most situations, a standard barrier which can effectively re-direct passenger cars and light vans and trucks will suffice, for locations with poor geometrics, high traffic volumes and speeds and high proportion of heavy trucks, higher performance level barriers will be necessary.

5.3.3 *Barrier Deflection Characteristics*

Flexible or semi-rigid barriers are suitable for relatively wide, flat medians provided that the design deflection distance is less than half the median width. Where the medians are narrow, within the heavily trafficked road, a rigid barrier will be appropriate, having practically no deflection when hit.

5.3.4 *Compatibility*

The appropriate type of median barrier will also depend on its compatibility with other median features such as overhead sign supports, street light poles and bridge piers. If a non-rigid barrier is used in such cases, crashworthy transition sections must be available to stiffen the barrier locally, if the fixed object is within the design deflection distance of the barrier. Additionally crashworthy end treatment is also necessary, if the barrier begins or terminates in a location where it is likely to be struck by an errant motorist.

5.3.5 *Costs*

As for roadside barriers, the initial cost of a median barrier increases with strength but maintenance costs decrease with increased strength. The costs of personal injuries to the driver and occupants as well as damage to impacting vehicle should also be considered. If a barrier is located in the centre of a median (where it is less likely to be struck by a vehicle) and during repairs, closing of a traffic lane is not required, flexible or semi-rigid barrier is to be preferred. If, however, the barrier has to be placed immediately adjacent to the traffic lane, a rigid barrier is to be preferred.

5.3.6 *Maintenance*

The same considerations as applicable to roadside barriers also apply to the median barriers; however, collision maintenance is usually a more important factor for median barriers. In order to avoid closing down of traffic for repairs or replacement of damaged barriers, which poses a hazard both for the maintenance team and the motorists, a rigid concrete barrier is to be preferred for high speed, high volume expressways.

5.3.7 *Terrain*

The type of terrain between the edge of the carriageway and the barrier can significantly affect the impact performance of the barrier. Kerbs and sloped medians (including superelevated sections) are two important features to be considered. A kerb, either when used alone or when placed in front of a median barrier, should not be used for purposes of redirecting errant vehicles. For sloped medians, the recommendations are shown in **Fig. 23**.

5.3.8 *Aesthetic and Environmental Considerations*

The same considerations as applicable to roadside barriers also apply to median barriers.

5.4 Types of Median Barriers

The following types of median barriers are recommended for use:

i) Blocked-out “W” beam type Steel Barrier

ii) Blocked-out Thrie beam Barrier

ii) Wire Rope Barrier

5.5 Blocked out “W” Beam type Steel Barrier

The blocked-out “W” beam type steel median barrier shall be similar to the road edge barrier described in para 4.6 earlier, except that the “W” beam shall be provided on both sides of the post with similar spacers. Typical details are given in **Fig. 24**.

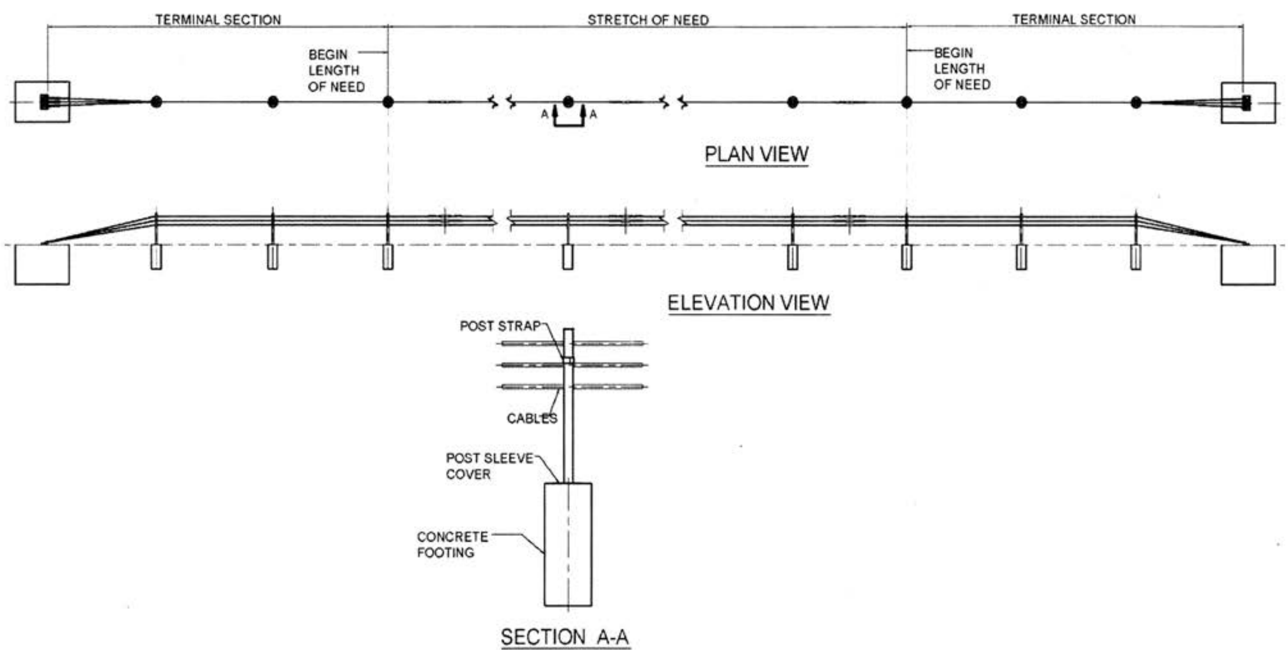


Fig. 18 Typical details of Wire Rope safety Barrier

5.6 Blocked-out Thrie Beam type Steel Median Barrier

The blocked-out thrie beam type steel median barrier shall be similar to the road edge barrier described in para 4.7 earlier, except that the “W” beam shall be provided on both sides of the post with similar spacers. Typical details are given in **Fig. 25**.

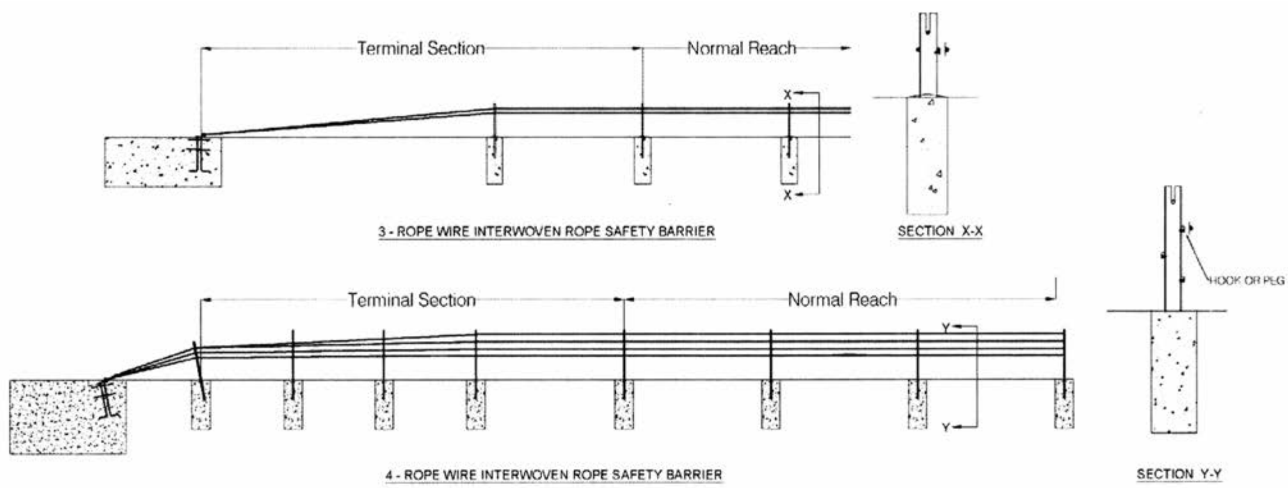


Fig. 19 Typical Details of Interwoven Wire Rope safety Barrier

5.7 Wire Rope Barrier Used in the Median

The wire rope barrier used in medians is the same arrangement as on the road edge barrier as the weaving of the ropes ensure the performance of the barrier is the same when impacted on either side. When used in medians, the wire rope barrier has been proven to be effective in containing and arresting heavier vehicles due to the embedding of the rope in the vehicles structure. **Photo 1 and 2** illustrate the arrangement.

Photo 1 and 2 Median Wire Rope Safety Barrier

5.8 End Treatment for Steel Median Barriers

The steel median barriers shall be provided with a “turned-down-guard-rail” end treatment as described in para 4.9 except that no flaring is to be provided.

5.9 Concrete Median Barriers

Concrete median barriers are rigid barriers having a sloped front in each face. The barriers shall be constructed by one of the following methods:

a) in situ between fixed forms
b) in situ between sliding forms
c) in pre-cast units.

A profile of the concrete median barrier constructed in-situ and anchored to the carriageway by dowels is given in **Fig. 26**. A design with pre-cast units is given in **Fig. 27**.

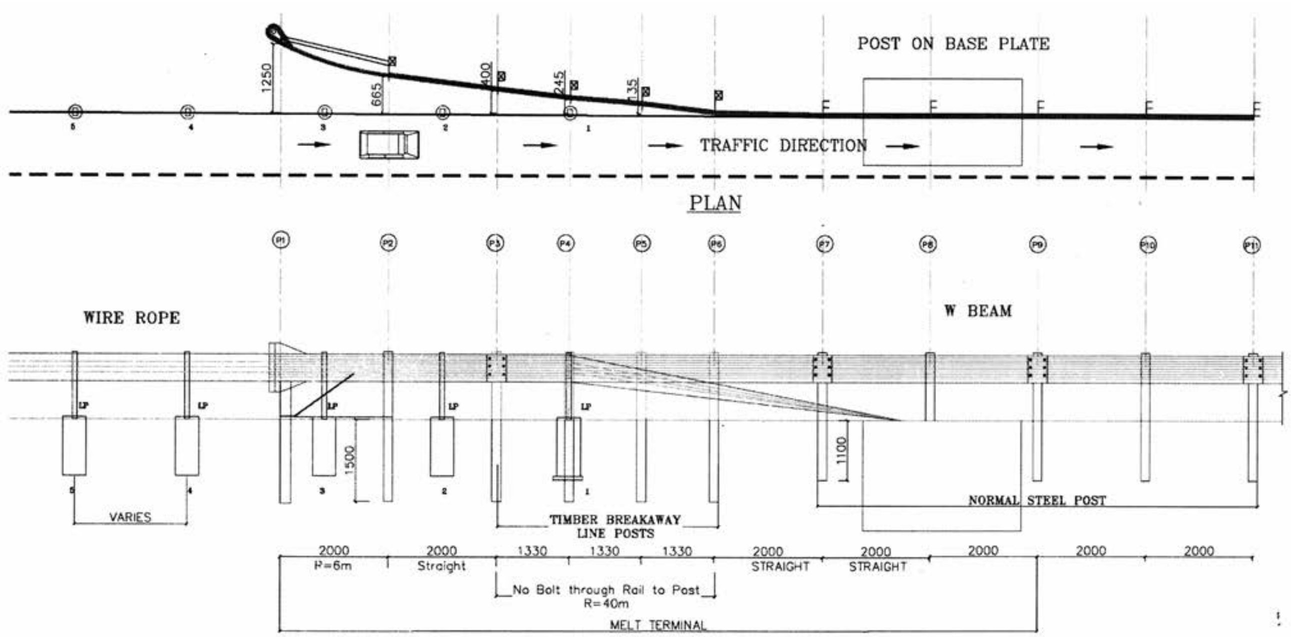


Fig. 20 Typical Details on Wire Rope to W Beam Barrier

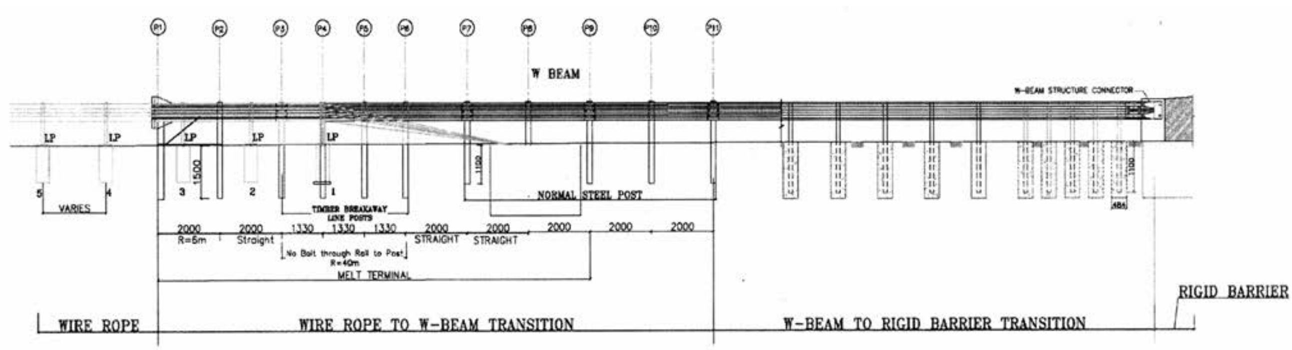


Fig. 21 Typical Details on Wire Rope to Rigid Barrier

The method of attaining the transition at the end of the installation is illustrated in **Fig. 28**. The barriers shall be terminated sufficiently away from the median openings with the twin objectives of preventing impact by the turning traffic and providing adequate sight distance to the turning traffic.

5.10 Placement Recommendations for Median Barriers

At locations, where the two adjacent carriageways are at the same level, the barrier shall be placed in the centre of the median, duly taking into consideration the drainage requirements. The placement of median barriers, in cases where the two carriageways are at different levels is a function of the slopes between the two medians. Recommended placement for various combinations is indicated in **Fig. 23**.

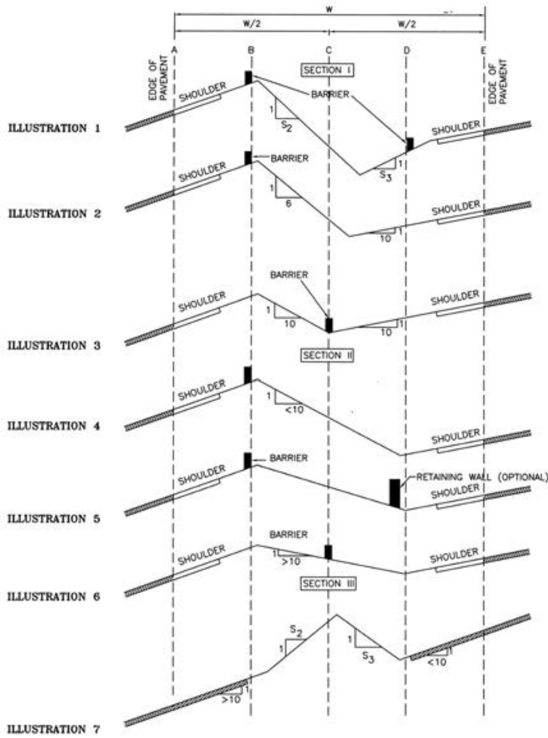


Fig. 23 Recommended Median Barrier Placement in Non-Level Medians
(Source : Ref. 1)

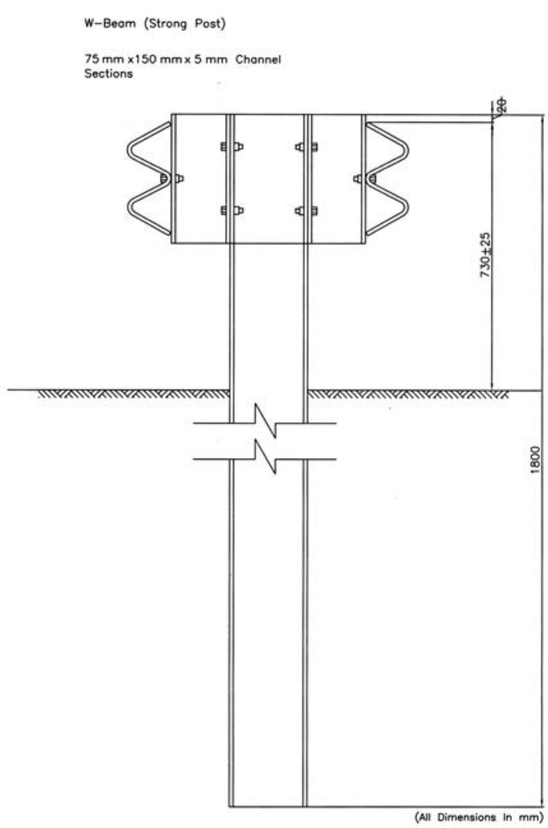


Fig. 24 Typical Details of 'W' Beam Median Barrier

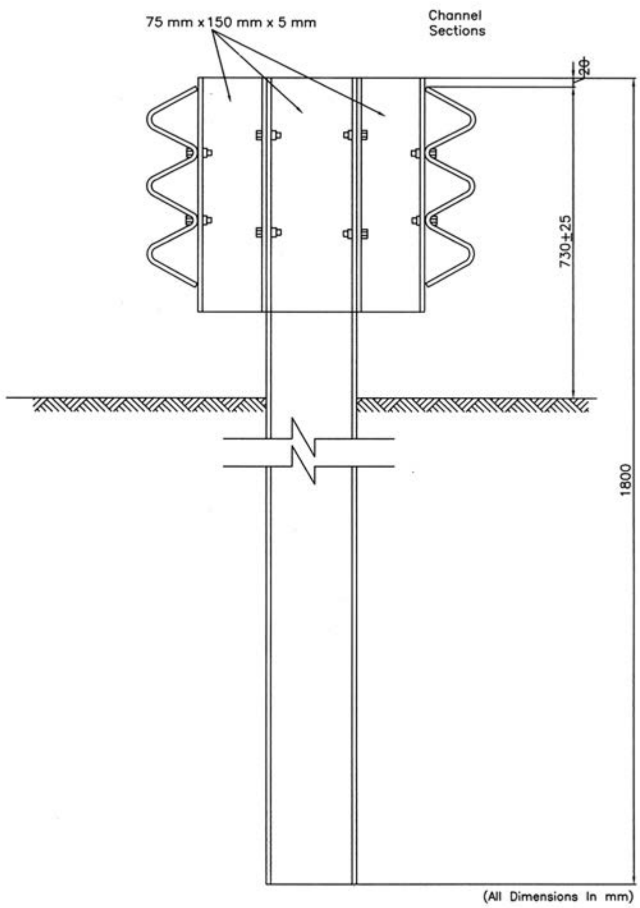


Fig. 25 Typical Details of Thrie Beam Median Barrier

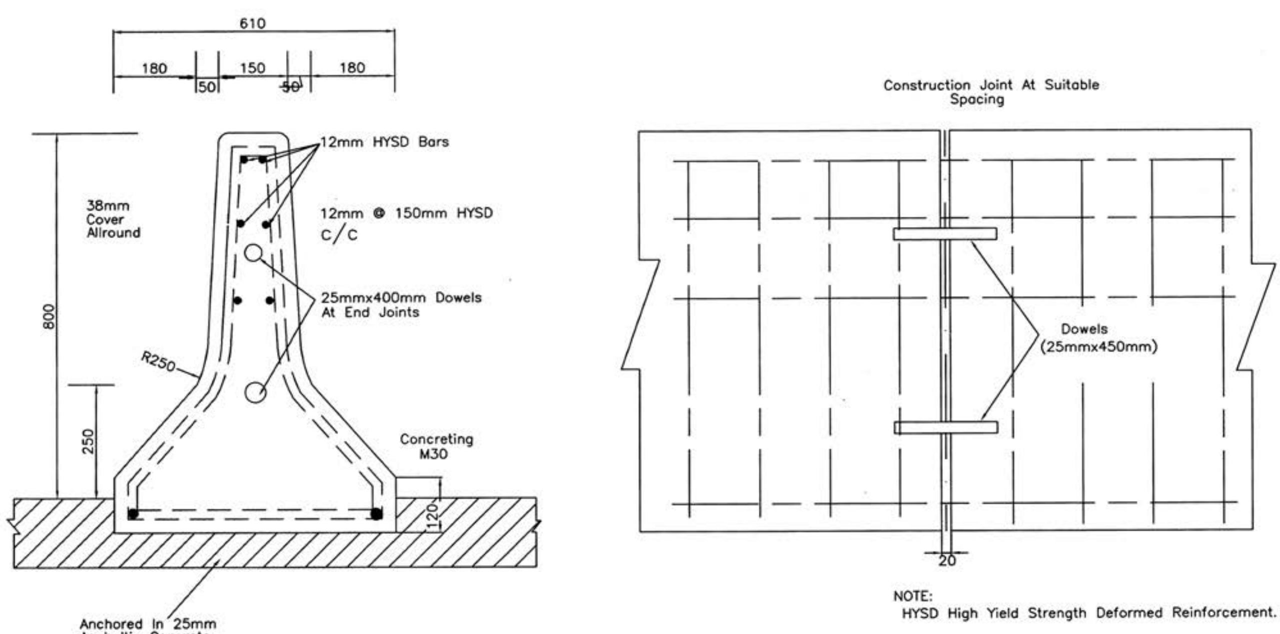


Fig. 26 Roadside/Median Barrier Cast-In-Situ Design
(Source Ref.2)

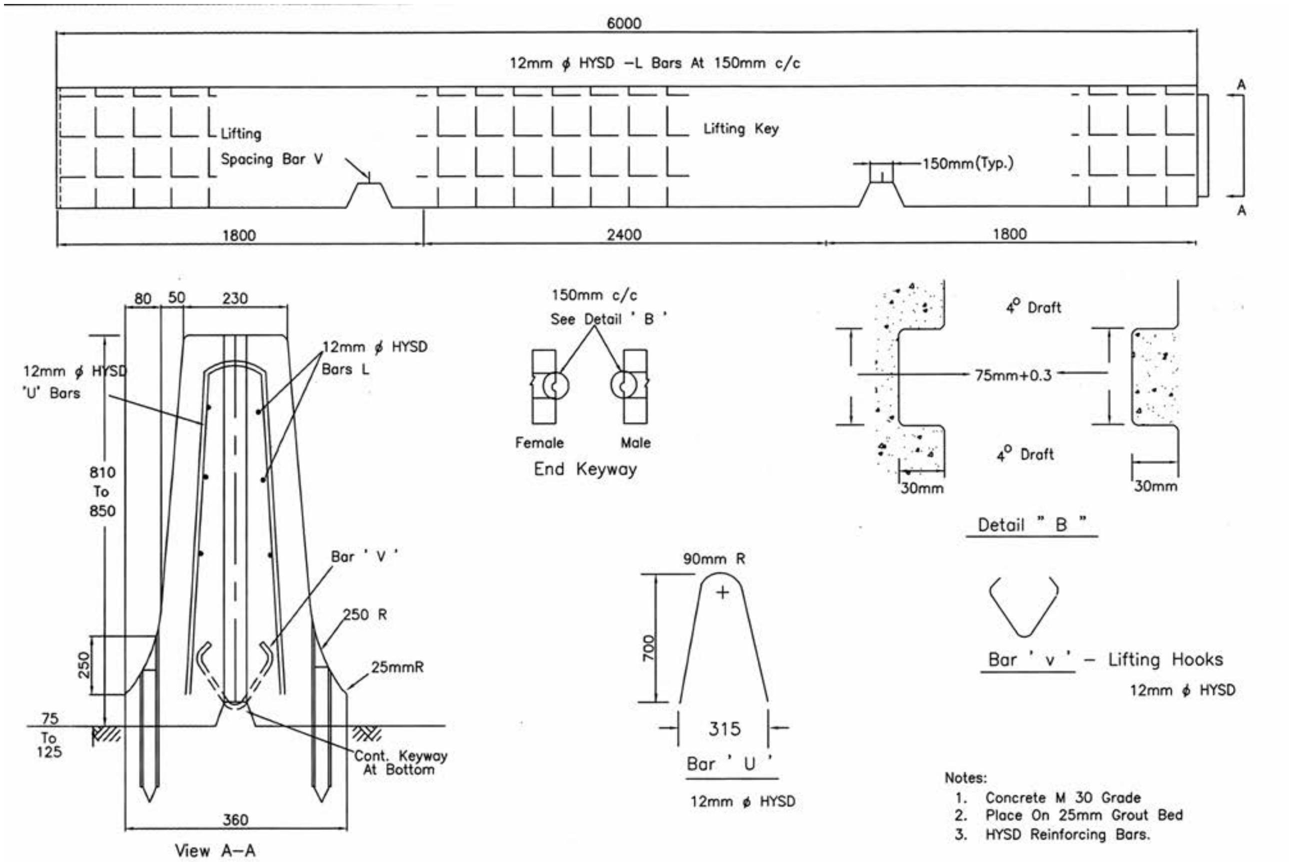


Fig. 27 Median Barrier Precast Design
(Source Ref. 2)

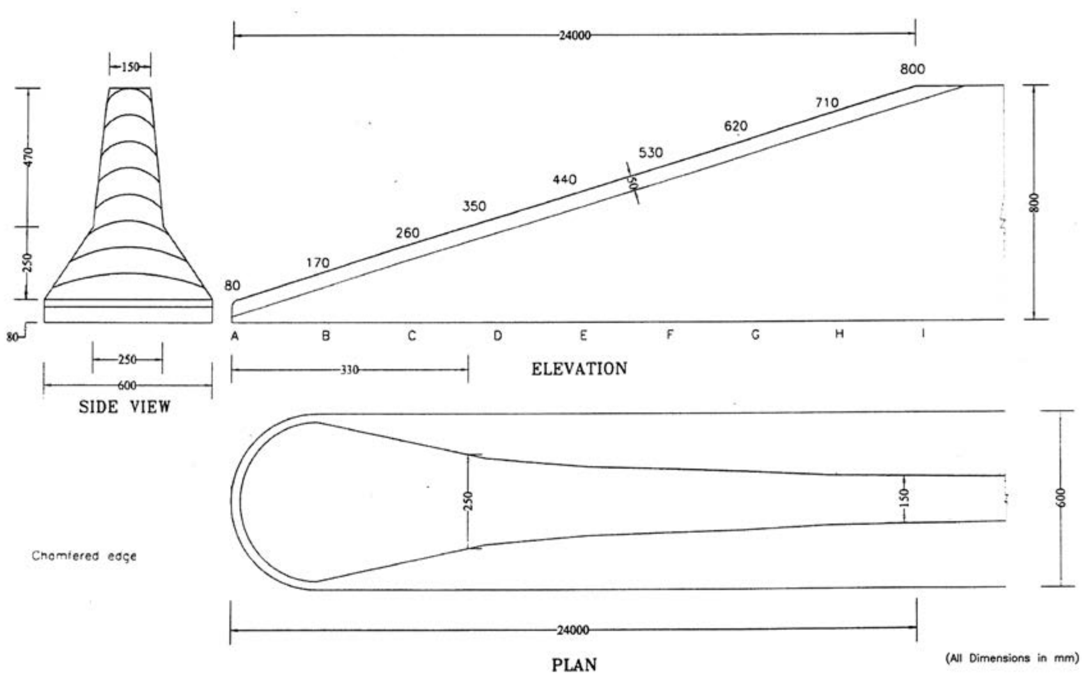


Fig. 28 Method of Arranging Transition at End of Installation
(Source Ref. 1)

5.11 Safety Barriers on Bridge Decks and Hill Roads

5.11.1 *Barriers on Bridge Decks*

On grade-separated structures, the parapets and railings can be replaced by cement concrete safety barriers. A typical design is enclosed in **Fig. 29**. The reinforcing bars of the barrier can be as shown in **Fig. 26**, and these bars can be extended downwards into the structural RCC slab.

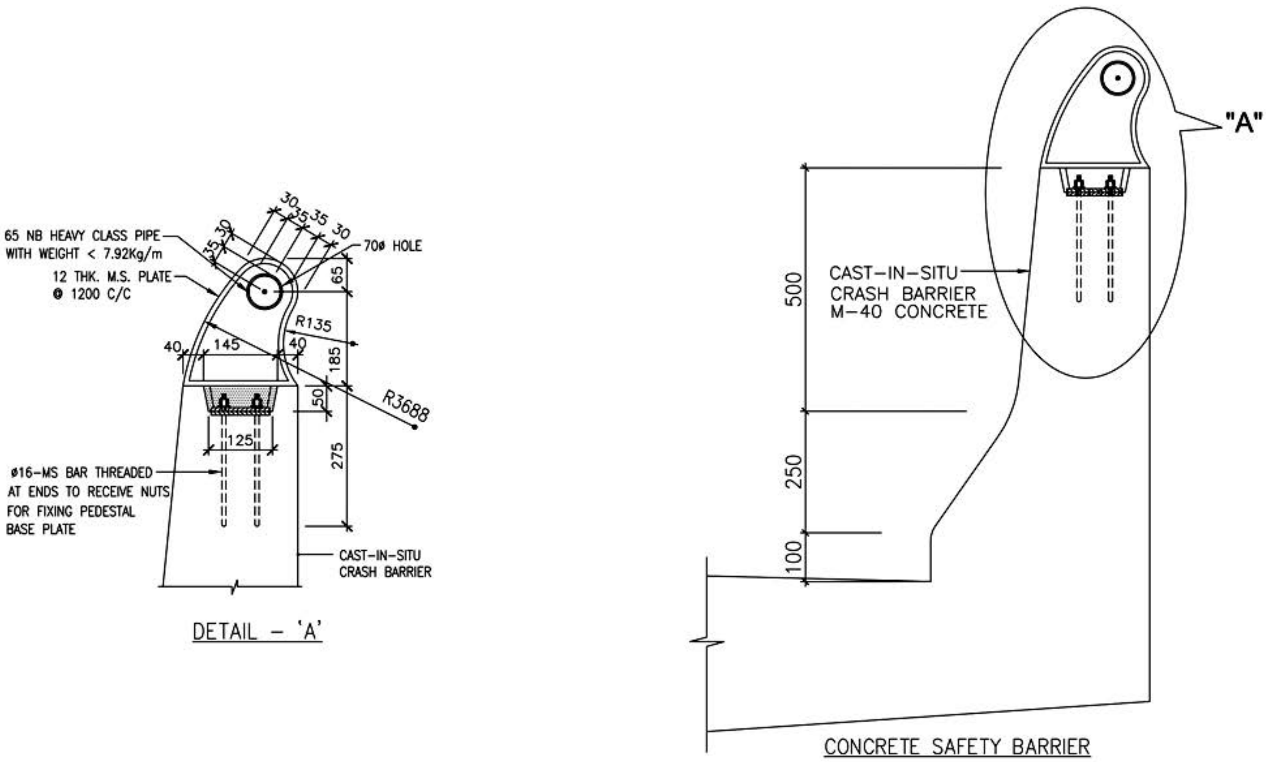


Fig. 29 Concrete Safety Barrier at Bridge Deck

5.11.2 *Safety Barriers on Hill Roads*

The conventional method of providing safety on the valley side of hill roads is through dry stone masonry parapets with bands of masonry in cement mortar. This option is mainly because of cost consideration and the easy availability of stone obtained from blasting the hill face. However, a W-Beam metal barrier is a good option, though costlier.

6 GENERAL RECOMMENDATIONS

6.1 Raised Kerbs or Drains

Raised Kerbs or drains should not be provided between the carriageway and the barriers. These destabilise the vehicle balance and disturb its equilibrium before it strikes the barrier, thus defeating the essential purpose of safety and redirection of the impacting vehicles. It is a good practice to avoid kerbed and raised medians in dual carriageways of highways.

6.2 Maintenance

6.2.1 *Routine Maintenance*

Routine maintenance comprises only occasional cleaning and painting; right-of-way mowing of grass and vegetation control. However, if preservative-treated wood posts and galvanised steel posts/ rail compartments are used, there is only a nominal routine maintenance requirement.

6.2.2 *Collision Maintenance*

All repairs or adjustments to barriers that are necessitated by vehicle impact fall under this category of maintenance. Bulk of the maintenance costs are usually due to collision repairs and these costs, to a large measure, influence the selection of the most appropriate system. The number of impacts that may be expected to occur will depend on the traffic speed and volume, distance between the edge of carriageway and barrier and road geometrics. The extent of barrier damage naturally depends on the strength of the railing system, given a particular impact situation. On very high speed facilities like expressways where the rail repair is difficult and collisions with the barrier are frequent, a rigid traffic barrier is to be preferred. In flexible barriers, the possible re-use of the post and rail systems after a vehicle impact is to be considered; if beyond repair, only the salvage value is to be considered.

6.2.3 *Simplicity in Design; Material and Storage*

The expertise required for the repairs on the part of the repair team of technicians should be an important consideration in the selection of a particular barrier system. The design of the barrier system should be such that it is easy to repair any damaged components or to replace them. It is always advantageous to use only a few barrier systems along the highways for which the various components are standardised, so that the needed repairs to a barrier, after being hit by a vehicle, can be carried out conveniently and expeditiously with the spare parts stored in adequate numbers/quantities.

ANNEXURE I

FORMAT FOR RECORDING FIELD PERFORMANCE OF SAFETY BARRIERS

1.	Location	:	State, Name of Road, Kilometre
2.	Type of Safety Barrier	:	Edge/ Median Rigid (Concrete)/ Flexible (Cable Type)/ Semi-Rigid (Steel beam)
3.	Give Sketch of Location	:	
4.	Year of installation	:	
5.	Damage suffered	:	1) Month/year 2) Vehicle involved (Car/ Bus/ Truck/ Two-wheeler/ Other) 3) Damage suffered (Description, Photo) 4) Cost of Repair 5) Casualties (Fatal/ Injury/ Damage to vehicle)
6.	General Recommendations of Safety Expert	:	1) Adequacy of design 2) Placement 3) Any Improvements needed

ANNEXURE II

SPECIFICATIONS FOR SAFETY BARRIERS

1. Precast Concrete Safety Barrier

Precast Concrete Barrier shall be of reinforced cement concrete and the minimum grade of concrete shall be M40. The maximum size of the aggregate shall be limited to 12 mm. the precast members shall be removed from the moulds as soon as practicable and shall be kept damp for a period of at least 10 days, during which period they shall be protected from sun and wind. Any precast member that becomes chipped, marred or cracked before or during the process of placing shall be rejected.

2. Cast In-Situ Concrete Safety Barrier

The cast in-situ concrete safety barrier shall be of reinforced concrete and the minimum grade of concrete shall be M40. Forms shall be fabricated conforming to the desired shape as shown in the drawings. It shall be ensured that no form joint appears on plane surfaces. For bridges/ viaducts of length more than 500 m horizontal slip forms shall be used for casting of the crash barriers. All corners in the finished work shall be true, sharp and clean-cut and shall be free from cracks, spalls or other defects.

3. Metal Safety Barriers

All steel elements including posts, W-Beam sections, channel sections, bolts, nuts, hardware and other steel fittings shall be galvanised or painted with an approved paint. If galvanised, all elements shall be free from abrasion, rough or sharp edges, and shall not be kinked, twisted or bent. Damaged galvanised surfaces, edges of holes and ends of steel sections cut after galvanising shall be cleaned and re-galvanised. The posts and W-Beam sections shall be assembled true to alignment and camber as shown in the drawings. The metal safety barriers shall be compliant with test acceptance criteria of European EN 1317-2 standard or NCHRP 350 for containment levels of N2, H1 and H2 or NCHRP 350 for containment levels TL-3 and TL-4. The manufacturer shall provide all applicable crash test reports that confirm the barrier to have passed the crash tests conducted by an international accredited cash testing laboratory having all the needed testing facilities.

4. Wire Rope (cable) Barriers

The wire rope (cable) barriers shall be compliant with test acceptance criteria of European EN 1317-2 standard, for containment levels N2, H1 and H2. The manufacturer shall provide all applicable crash test reports that confirm the barrier to have passed the crash tests conducted by an international accredited crash testing laboratory having all facilities for carrying out cable safety barrier tests for the desired containment levels. The cables shall be made of galvanised steel wire ropes prestressed to the modulus prescribed by the manufacturer. During installation, each cable shall be post-tensioned to exhibit a tension prescribed by the manufacturer. The cables shall be located in slots in the top of the posts. The posts shall be of galvanised steel posts anchored into ground using a concrete block of grade M 30 or into a socket of an approved design. The wire rope shall be anchored into the ground at the ends by using concrete blocks of grade M 30 and dimensions as specified by the manufacturer.

SOURCE REFERENCES

1. Guide for Selecting, Locating and Designing Traffic Barriers, American Association of State Highway and Transportation Officials, 1977.
2. B.S. 6579: Part-7: 1988, Specifications for Concrete Safety Barrier, British Standards Institution, London, 1988.