Guidelines on Installation of Crash Barrier

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Table of Content

1. Introduction

A crash barrier or a safety barrier is a passive safety device installed longitudinally along the roadside or around specific hazards adjacent to the roadway. Its primary engineering function is to safely contain or redirect an errant vehicle that has deviated from its intended path, thereby preventing or reducing the severity of a potential accident. This is achieved by absorbing the vehicle's kinetic energy upon impact and/or guiding the vehicle back towards the roadway or bringing it to a controlled stop, thus mitigating the risk of occupants from veering off the road/striking more hazardous obstacles.

The installation of roadside crash barriers is a critical component of highway safety engineering, aimed at mitigating the severity of accidents and protecting vehicle occupants from roadside hazards such as steep slopes, fixed objects, and drop-offs. Properly designed and installed crash barriers can effectively redirect errant vehicles, minimize the risk of rollovers, and reduce the impact of collisions.

This guideline provides comprehensive instructions for the installation of crash barriers along road edges. It outlines best practices based on national and international standards, incorporating considerations related to terrain at site. It is intended for use by engineers, contractors, and regulatory authorities involved in road design, construction, and safety audits. By following the procedures and criteria outlined herein, stakeholders can ensure uniformity, effectiveness, and structural integrity in crash barrier installations across diverse roadway environments.

2. Purpose and Objectives

The purpose of this guideline is to establish a uniform and technically sound framework for installation of crash barriers to optimize road safety across the highways.

The objectives are:

a) To ensure that barriers function as intended to minimize injury and damage.

b) To provide clear and distinct installation procedures for different conditions such as in soil and rocky terrains.

c) To promote consistency in installation of crash barrier along the highways.

d) To enhance the overall resilience of roadside infrastructure against traffic-related hazards.

3. Types of crash barrier

Crash barriers can be broadly classified based on their performance characteristics and level of flexibility upon impact. The four main types are:

I. Flexible barriers, such as cable wire systems, are the most yielding type of crash barrier. They are designed to undergo significant deflection when struck by a vehicle, thereby absorbing a substantial portion of the kinetic energy. This deformation allows for controlled containment and redirection of the errant vehicle, often resulting in lower impact forces on the occupants. However, due to their high deflection, flexible systems require ample lateral clearance beyond the barrier line to perform effectively. They are typically installed in areas where space is not a constraint, such as open roadside environments.

II. Semi-rigid barriers, which include steel beam systems like W-beam or Thrie-beam guardrails, offer a balance between flexibility and rigidity. These systems are designed to deform in a controlled manner upon impact, limiting the barrier's deflection to an acceptable range while still redirecting the vehicle along its path. The energy is partially absorbed by bending and deforming the rail and posts, thereby reducing the severity of the crash. Semi-rigid barriers are commonly used in locations where moderate deflection is acceptable, and maintenance requirements are manageable.

III. Rigid barriers, such as reinforced concrete walls, exhibit negligible or no deflection upon impact. It results in the highest level of impact severity among the four types. Because of their rigid nature, they are most suitable for use in areas with limited installation space, such as bridge decks, filled roads or urban corridors, where lateral clearance is unavailable. Parapets and median barriers are typically used as rigid barriers.

IV. Earthen bunds are compacted soil embankments constructed along road edges, serving as a passive, low-cost, and environmentally friendly approach to enhancing roadside safety. It doesn't provide the same energy absorption or redirection capabilities as engineered metal or concrete barriers, but effectively prevents vehicles from veering off steep slopes. However, if not properly integrated with adequate drainage systems, earthen bunds can negatively impact pavement performance and longevity by trapping surface runoff.

(a) Flexible barrier

(b) Semi-rigid barrier

(c) Rigid barrier

(d) Earthen bund

4. Crash barrier provision criteria

Since the majority of roads in Bhutan are constructed along mountainous terrains and cut slopes, the need for crash barrier installation is significantly heightened. Almost all highway stretches pose a potential risk of vehicular overrun, making the provision of crash barriers essential for enhancing safety. However, considering budgetary constraints, it is not always possible to install crash barriers along the entire length of a roadway. Therefore, priority should be given to high-risk sections, particularly:

- Narrow road sections with limited shoulder width,
- Accident-prone areas,
- Road curves with reduced turning radius,
- Locations with steep downhill gradients or sharp drop-offs,
- Roads constructed on an embankment,
- Road segments with frequent fog or reduced visibility.

Although risk assessments ideally guide the need for crash barrier installations, due to Bhutan's challenging terrain where most roads are built on cut slopes, the requirement is generally apparent and can be verified and judged by the site engineer. The verification must be based on field conditions and hazard perception, aligning with the normative guidance and engineering judgment.

As the W-beam type crash barrier is most commonly used in Bhutan, this guideline focuses on detailing the installation procedures specifically for W-beam barriers in soil and rocky stretches. All material specifications shall conform to the standards prescribed in the *Specification for Building and Road Works 2025*, published by the Ministry of Infrastructure and Transport. Additionally, a flowchart that outlines the decision-making process for determining which installation procedure to follow is depicted below.

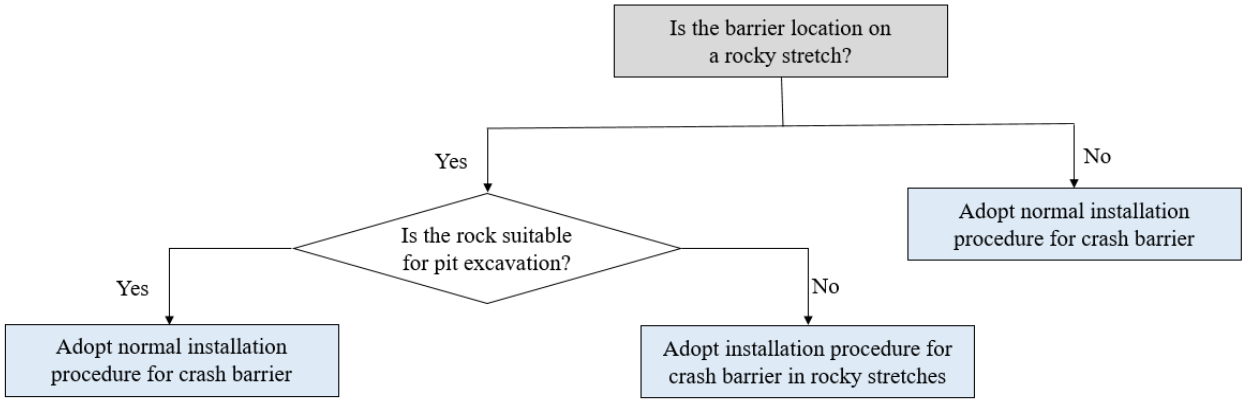

Figure 1: Flowchart for installation procedure adoption

5. General steps for installation of crash barrier

- Excavate holes to a depth of 1100 mm at 2.0 m center-to-center (c/c) spacing along the roadside alignment.
- Use ISMC channel posts of size 150 mm × 75 mm × 5 mm and length 1800 mm.
- Insert the posts into the excavated holes and cast them in M20 grade concrete with footing dimensions of 400 mm × 400 mm.
- Allow the concrete to fully set before proceeding with barrier installation.
- Assemble and erect the W-beam crash barrier by fixing the W-shaped beam, spacer channel, and other accessories to the installed posts.
- Ensure the barrier is installed over a minimum continuous length of 100 meters.
- Provide end treatments such as fish-tail terminals, energy-absorbing terminals, or flared ends to minimize impact severity at barrier ends.

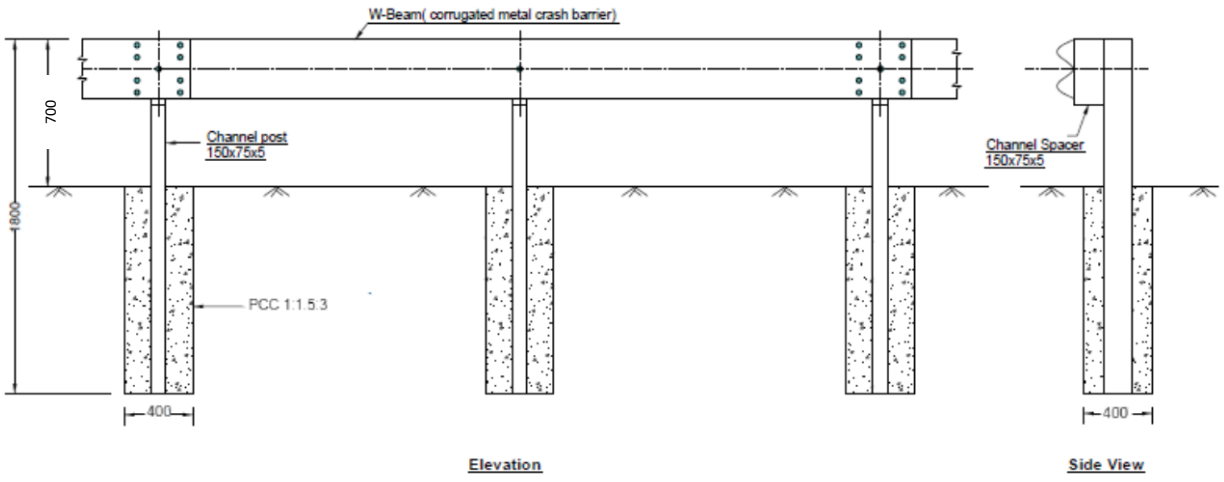

Figure 2: Elevation & side view of general method of crash barrier installation
Source: SBRW, 2025

6. Installation of crash barrier in rocky stretches

- Ensure that the crash barrier installation area is properly graded and leveled, even on sloped ground, to provide a straight and uniform alignment. The surface should be free of undulations or uneven elevations to avoid misalignment or difficulties during post and barrier installation.
- Drill vertical holes of diameter 32 mm and depth of 975 mm (depending on the quality of rock) into the rock using pneumatic or hydraulic rotary drills.
- Clean the drilled holes thoroughly using a wire brush or compressed air to remove dust, debris, and moisture, ensuring a clean bonding surface.
- Inject cement slurry (1:4) to about 2/3rd of the hole depth and insert anchor rods, typically galvanized threaded steel rods (M16 with 16 mm nominal diameter, Grade 8.8 strength) of length based on embedment depth + protrusion above base plate around 75 mm while rotating to ensure full contact.
- Allow it to cure for at least 48 hours depending on the grout used and ensure firm set before proceeding with the next steps.
- Where the rock surface is irregular, construct a plain cement concrete (M20) leveling pedestal of 380 x 300 x 50 mm. Cure as per good practice.
- Place the ISMC channel post of 700 mm length welded to a base plate (typically 330 mm x 250 mm x 10 mm) over the protruding anchor rods.
- Use high-strength washers and locking nuts (M16 nuts) and tighten accordingly to its required torque.
- Ensure vertical alignment of posts and maintain a uniform post height of 700 mm above ground level.
- Assemble and erect the W-beam crash barrier by fixing the W-shaped beam, spacer channel, and other accessories to the installed posts.
- Provide end treatments such as fish-tail terminals, energy-absorbing terminals, or flared ends to minimize impact severity at barrier ends.

Note: Since the base plate welded to the channel post will be 700 mm in length, it can be integrated with the conventional crash barrier, considering that site conditions may vary. However, proper and uniform leveling must be ensured to maintain the effective functionality of the barrier system.

To ensure functional performance, the crash barrier system shall be installed with a ***minimum continuous length of 100 m****. Discontinuous or short barrier segments are not recommended, as they fail to provide adequate containment or shielding effectiveness.*

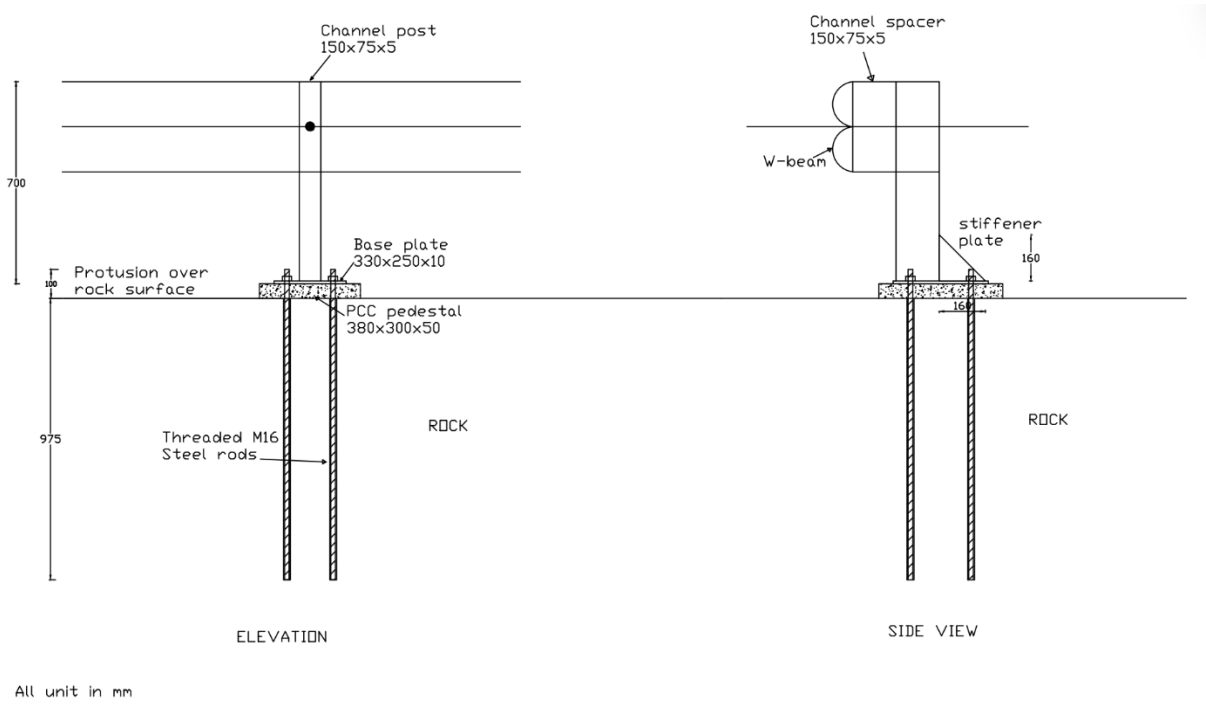

Figure 3: Elevation and side view of crash barrier installation in rocky stretch

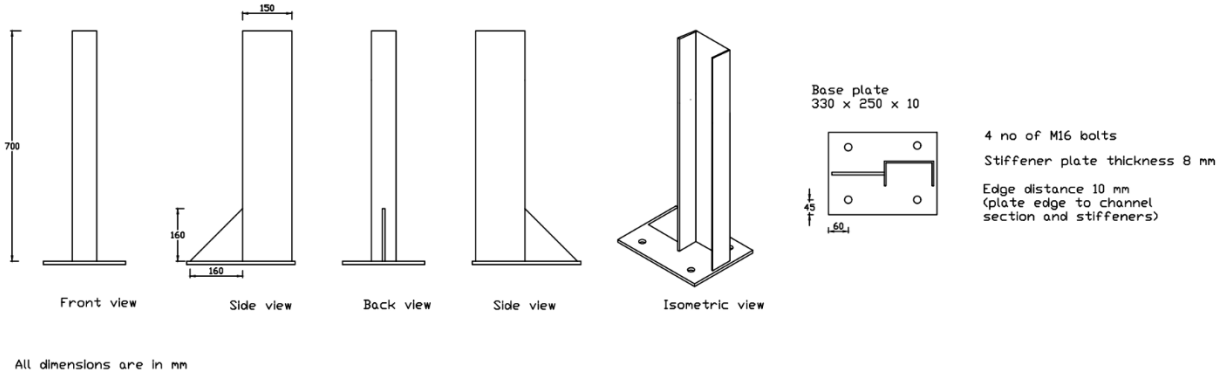

Figure 4: Details of base plate

7. End-treatments for steel edge barriers

Proper end-treatment of steel beam crash barriers is a critical safety requirement to ensure the effective functioning of the barrier system. The blunt end of an untreated W-beam barrier poses a severe hazard, as it can penetrate or launch a vehicle during a frontal collision. End-treatments are specifically designed to mitigate these risks by absorbing or dissipating the vehicle's kinetic energy, thereby reducing the impact severity on the occupants.

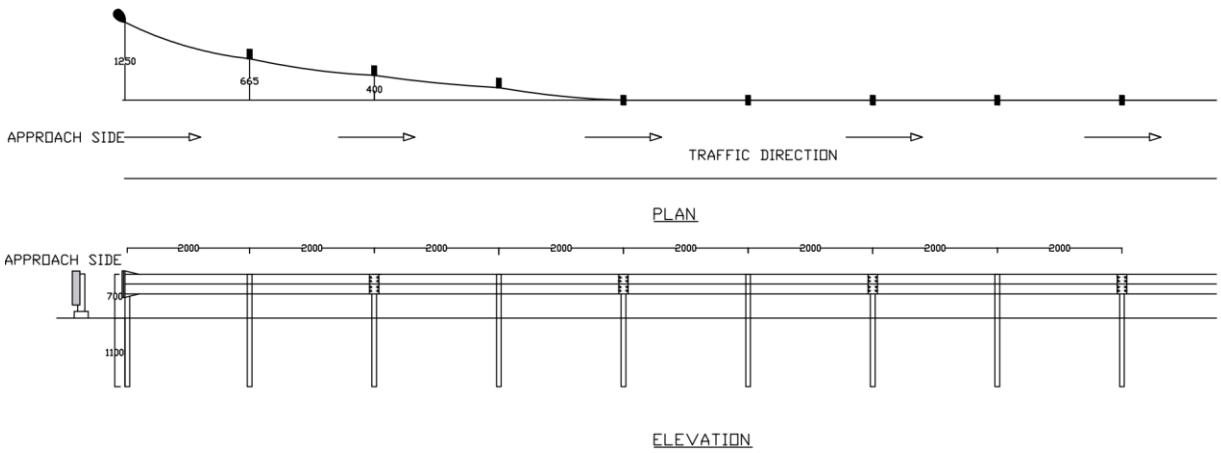

Figure 5: Arrangement of post on the approach side

The end treatment on the approach side should be provided as illustrated in *Figure 5*. This configuration incorporates a flared layout system, designed to allow progressive energy dissipation during a crash. It requires adequate space for proper implementation and is recommended for use on medium to high-speed roads. Where space permits, this type of end treatment should be prioritized. However, in cases where sufficient space is not available, a standard end treatment may be used, similar to that adopted on the departure side which conforms to *Figure 6.* It is a simple geometric solution, where the W-beam is bent downward or buried into the ground. It does not provide impact energy dissipation and is not suitable for high-speed or head-on impacts.

When assembling the W-beam crash barriers, it is essential to ensure that the beams are overlapped in the direction of the traffic flow. The upstream beam must overlap the downstream beam by a minimum of 150 mm, thereby preventing vehicle snagging during impact. This configuration enhances the structural continuity and safety performance of the barrier system. Furthermore, hazard marker posts should be installed at both the starting and terminal ends of each crash barrier section. These posts serve as clear visual indicators for approaching drivers, enhancing visibility and safety, especially in low visibility areas or poor weather conditions.

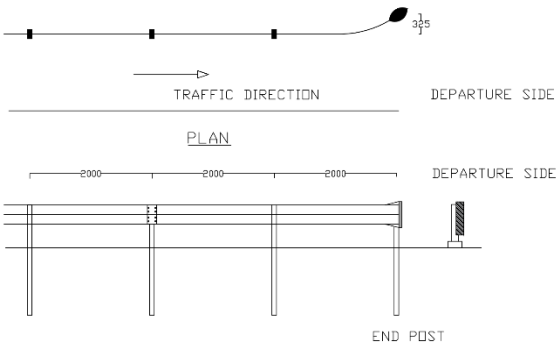

Figure 6: Arrangement of post on departure side

Figure 7: Example of a fish tail

8. Conclusion

This guideline has outlined the standard procedures for the installation of crash barriers in both soil and rocky terrains. Uniform adoption of these methods is critical to ensuring road safety, especially in areas with steep drop-offs, limited roadway width and foggy/low visibility areas. All materials and installation practices shall conform to the specifications set forth by the Ministry of Infrastructure and Transport as per the *Specifications for Building and Road Works, 2025*. Field engineers are strongly advised to consult this document during planning and execution phases to maintain consistency, durability, and safety performance across the national road network.

9. References

[1] Specifications for Building and Road Works, 2024. Ministry of Infrastructure and Transport

[2] Specifications for Building and Road Works, 2025. Ministry of Infrastructure and Transport

[3] Guidelines for Traffic Safety Barriers, Indian Roads Congress 119, 2015

[4] UK crash barrier standards (Armco, F.H. Brundle)