SAFETY IN HIGHWAY ROAD DESIGN – PART 2
HILL ROADS

CERTIFICATE COURSE ON ROAD SAFETY AUDIT FOR BRO OFFICERS
HEADQUARTERS, BRO
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Hill Road Safety
per IRC: 99-2018


Sec. 5.9 Checklist for hill roads safety assessment as per IRC 99-2018

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<tr>
<th>Low</th>
<th>Normal Drops or Climb (Straight Stretch) (Fig. 5.31)</th>
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<td>• Post speed limits signs.</td>
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<td>• Provide centre and edge line markings with road studs.</td>
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<tr>
<th>Steep Drops/Climbs on Straight Stretches (Fig. 5.32)</th>
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<tr>
<th>Blind Bends With or Without Steep Drops/Climbs (Fig. 5.33)</th>
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Hill Road Safety per IRC: 99-2018

IRC: 99-2018 – recommends measures at horizontal curves/bends on hill roads, when the vertical slope is “normal”

Hill Road Safety per IRC: 99-2018

Measures recommended for hairpin curves/bends on hill roads
Hill Road Safety per IRC: 99-2018

Measures recommended for hairpin curves/bends on hill roads

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.


Section 16 of IRC SP 48-1998 pertains to “Safety on Hill Roads”

16.1 General
16.2 Causes of Accidents
16.3 Safety on Hill Roads
16.4 Engineering Measures
16.5 Enforcement Measures
16.6 Education Measures
16.7 Safety Analysis
16.8 Geometric Deficiency
16.9 Problem of High Altitude/Snow Fall Areas
16.10 Rock Fall, Shooting Boulders, Unstable Areas, etc.
16.11 Vehicles Rolling into Valley
16.12 Low Visibility
16.13 Icing Areas
16.14 Miscellaneous
16.15 Construction Sites
16.16 Ribbon Development
16.17 Traffic Management
16.18 Gate System for UP and DOWN Traffic
Rods in Hill Areas

• **Alignment** – primarily governed by the topography

• **Classification**
  • *Based on traffic needs, socio-economic, administrative or strategic considerations*
  • National Highways / State Highways / Major District Roads / Other District Roads / Village Roads

Rods in Hill Areas

• **Classification (cont’d)**
  • *Based on topographical considerations:*
    • Arterial roads (National / State Highways and Major District Roads)
      • Major valley roads – run in major valleys along rivers/streams or in some cases, depending upon topography, near to the ridge line
      • Inter-valley roads – traverse through different valleys, connecting one major valley to another either running near to the ridge line or across slope of hill ranges, rising from one valley to the ridge and going down to the next valley and so on
    • Link roads (Other District Roads and Village Roads)
      • These take off from Arterial roads to link villages/production areas in small/sub-valleys
Roads in Hill Areas

• Ecological Considerations
  • Construction of roads in hilly region disturbs the ecosystem in many ways. The main ecological problems associated with hill roads construction are:

  I. Geological disturbances
  II. Land degradation and soil erosion
  III. Destruction and denuding of forest
  IV. Interruption and disturbance to drainage pattern
  V. Loss of forestry and vegetation
  VI. Aesthetic degradation
  VII. Siltation of water-reservoirs

  • These factors underline the need to plan, align and construct hill roads after careful thought

Roads in Hill Areas

Selected points (Appendix 14, IRC:SP:48-1998) on which attention is required during planning, construction and maintenance of hill roads

- Adequate attention must be paid while selecting road alignment, that landslide/erosion prone areas are avoided as far as possible
- While selecting the road alignment the advice of geotechnical engineers and geologists, forest and soil conservation experts should be taken right from the start
- During the process of road construction, cut and fill method should be resorted to in order to cause minimum disturbance
- Heavy rock blasting should be avoided and controlled blasting should be resorted to by using a low explosive charge
- Blasting should be adequately supervised by technical personnel
Roads in Hill Areas

Selected points (*Appendix 14, IRC:SP:48-1998*) on which attention is required during planning, construction and maintenance of hill roads (cont’d)

- Selection of blasting holes should be so done as to avoid large scale disturbance to the rock face, developing cleavage planes/cracks and opening up fissures, etc.
- Spoil from cut/blasted rock should not be thrown haphazardly along the valley slopes as these are likely to cause heavy siltation/choking of water channels/streams, and cause damage to agricultural lands
- **Cut slopes should be rendered stable in the construction stage itself by cutting at the correct angle and benching, etc., including slope stabilising structures like drains, breast walls, pitching, etc.**

Wherever considered appropriate on the basis of a technical study conducted for the purpose, funds should be provided in the project estimates for the treatment of the unstable areas both above road level and below road formation.

Steps should be taken to stabilise the existing roads within a fixed time frame.

All cut/denuded slopes should be treated with vegetative turfing.

Deforestation during the construction of road should be kept to the minimum and should be done only in consultation with Forest Authorities.

Any cutting of trees must be replaced by planting 3 to 4 times the number so that at least an equal number survives.
Roads in Hill Areas

Selected points (Appendix 14, IRC:SP:48-1998) on which attention is required during planning, construction and maintenance of hill roads (cont’d)

- Drainage of water from roadside should be given adequate attention and an effective system of drainage should be constructed to lead the run-off to natural water courses
- In particular, suitable Intercepting and catch water drains should be provided above the cut slopes for the speedy and safe disposal of water
- It should be ensured that water is not drained into villages

Roads in Hill Areas

- The IRC does not emphasize this enough, but it is critical that a Geotechnical Engineer and a Geologist be involved before the route for a new hill road is finalized
- This is critical because the primary safety issue during construction and during operation of a hill road is the stability of the slope on which the road is constructed
Hill Road Profiles

- Typical hill road profile requires some form of slope construction and stabilization as hill roads are formed mostly by cutting into the hill and thereby disturbing the natural stability of slopes.
- Water courses along the slopes cause erosion affecting road stability.
- Soil movement along slopes tend to disturb the road formation.
- All of the above have to be effectively countered to obtain a stable road.
Why Government at All Levels Needs Trained Transportation Planners and Engineers

W-Beam Crash Barrier Installed along the Eastern Peripheral Expressway – the two billion dollar “showpiece” highway in the NCR

• Note the placement of the W-beam barrier behind a hard curb
• The intended purpose of a W-beam crash barrier is to absorb impact and minimize the chance of a vehicle bouncing back into traffic
• Placing a crash barrier behind a hard curb makes it useless for its intended purpose

Problems with Thrie-Beam Installation
Midwest Guardrail System

The MGS Guardrail is an updated W-Beam barrier system designed to handle today's modern vehicles with higher center of gravity (such as SUVs).

Differences:

• The MGS top of the rail height is 31" (≈ 785 mm) rather than 27 5/8" (≈ 700 mm)
• The blockout is 12" (30 mm) rather than 8" (20 mm)
• The MGS W-Beam guardrail splices occur mid-span between posts rather than at the post

Source: Midwest Guardrail System | MGS Guardrail W-Beam Barrier | Gregory Highway (gregorycorp.com)

MGS Post Footing Detail

Image Source: Fig. 13 from Caltrans (2019). Traffic Safety Systems Guidance. California Department of Transportation. 
Under-Pavement Concrete Beam System for Installation of Guardrails on Hill Slopes

Roller Barriers (a South Korean innovation)
Roller Barriers

- Consist of plastic (ethylene-vinyl acetate) cylinders on steel tubes
  - Ethylene-vinyl acetate (EVA) is a highly elastic resin which suffers little damage on impact
- Absorb impact and minimize vehicles bouncing off
- Minimum damage to vehicles
- When a car hits the barrier, the plastic cylinders spin on impact – the kinetic energy of the impact is ‘absorbed’ and dissipated as rotational energy
  - Which tends to propel the vehicle forward rather than potentially breaking through an immovable barrier

Roller Barriers (cont’d)

- The dual-frame system allows direct contact for a range of tire sizes, preventing functional loss of steering control
- Easily installed and maintained on curved road
- Lower frequency of repair when compared to other traditional barrier systems
- Barrels can be replaced individually
- High visibility due to coloration and self luminescence
- Installed cost is about 4 times that of a standard W-beam barrier
  - (₹ 1 crore/km vs ₹ 25 lakh/km)
- Repair costs are about 1/3 that of a standard W-beam barrier
Roller Barriers

Top Rail Splice
Stopper Boards
LED Guide Lamp
Shock Absorbing Roller
Reflective Band
Stopper Boards
Bottom Rail Splice

Rolling Barrier (RGS-TL3-A) H1000 x W1000 – TL3

Rolling Barber (RGS-TL3-A)

700 700 700 700 700 700

Plan View:

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<tr>
<th>Rolling Barber (RGS-TL3-A)</th>
<th>H 1000 x W 1000 – TL3</th>
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Detail "A"


https://onlinepubs.trb.org/onlinepubs/circulars/ec220.pdf