UNH T² Center Technical Note

Guardrails

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According to the National Highway Traffic Safety Administration, 80% of all run-off-road fatalities occur on rural roads. About 90% of these happen on two-lane roads. Many agencies use guardrail to reduce the number of fatalities and serious injuries resulting from run-off-road crashes.

Guardrails prevent vehicles from leaving the road and striking a hazard by containing or redirecting the vehicle.

Studies show that guardrails along the road edge reduce the number of crashes and their severity. Guardrails reduce crash rate approximately 30% and, when a crash occurred, the number of fatality and injury crashes by approximately 50%. These findings apply to new and replacement installations.

Another study explored guardrail performance with respect to reported and unreported impacts. Only six percent of reported guardrail impacts involve an injury or fatality. A portion of these guardrail crashes involved obsolete, improperly constructed, or improperly maintained barriers and atypical impact conditions. Therefore, only three percent of guardrail

Strategies for Corrective Actions

Strategy	Possible Corrective Actions
Reduce the probability of vehicles leaving the roadway	Flatten horizontal curves Provide adequate superelevation Provide standard lane widths Pave with a skid-resistant surface Widen shoulders Pave shoulders Mark center line and edge lines Delineate sharp curves Provide shoulder rumble strips
Eliminate the hazard	Remove the hazard Relocate the hazard to outside the clear-zone
Reduce the severity of the hazard	Make the hazard crashworthy or breakaway Shield with a barrier
Accept the risk and leave the hazard unprotected	Delineate the edge of traveled way Install object markers on the hazard, if appropriate

Table 1

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impacts result in injuries or fatalities

These studies show that guardrails protect drivers from potential hazards. Use guardrails conservatively as they may also be a hazard to drivers. Perform an engineering study before installing a guardrail. Analyze the severity of the hazard, the probability of an incident, cost-benefit ratio, aesthetic and environmental impacts, and other possible strategies to reduce the hazard risk. Table 1 provides alternative strategies to guardrails.

Guardrails are recommended where slopes are 1V:10H or flatter. Guardrails are not permitted on slopes steeper than 1V:6H.

When possible, avoid curbs in all high speed situations. Where drainage takes precedence and curbs are necessary, install a rub rail or stiffen the guardrail. Stiffening involves making the guardrail more rigid by reducing spacing between posts or using a stronger beam.

When installing a guardrail, follow these steps:

1. Determine the needed clear zone,
2. Identify potential hazards,
3. Analyze strategies, and
4. Evaluate roadside barriers.

The clear zone (L_c in Figure 1, page 3) is the total roadside border area, starting at the edge of the traveled way, that is available for safe use by errant vehicles. It may consist of a shoulder, a recoverable slope, a non-recoverable slope, and/or a clear run-out area. The desired minimum width is dependent upon traffic volumes, speeds, and on the roadside geometry. Hazards located beyond the clear zone do not require protection.

Potential clear zone hazards are:

- trees,
- street signs,
- utility poles,
- boulders,
- drainage devices,
- embankments, and
- guardrails.

A hazard's risk is increased by conditions such as speed limit, ADT, sharp curves, slopes, street lighting, pavement type, etc.

Install barriers based on the desired performance, cost, aesthetics, and maintenance characteristics. See the American Association of State Highway and Transportation Officials (AASHTO) *Road Design Guide*. Barrier types include:

- Three-Strand Cable,
- High-Tension Cable,
- Weak Post W-Beam,
- Box Beam,
- Strong Post W-Beam,
- Thrie-Beam,
- Modified Thrie-Beam,
- Concrete Safety Shape,
- Steel-Backed Timber Rail, and
- Precast Concrete Guardwall.

The W-Beam is most commonly used.

Select guardrails with the terrain's functional requirements in mind. Guardrails must absorb the impact of the vehicle without allowing vehicles to penetrate or run over (vault) the guardrails. At the same time, the guardrail must redirect the vehicle towards the road without snagging.

Install guardrails at the height designed by the NHDOT design specifications (http://www.nh.gov/dot/standardplans/standardplans.htm). Maintain tension and strength to survive impacts (determined by

Design Speed (mph)	Flare Rate for Barrier inside Shy Line (L_s from Figure 1) (ft)	Flare Rate Beyond Shy Line	
		Rigid	Semi-rigid
70	30:1	20:1	15:1
60	26:1	18:1	14:1
55	24:1	16:1	12:1
50	21:1	14:1	11:1
45	18:1	12:1	10:1
40	16:1	10:1	8:1
30	13:1	8:1	7:1

Table 5.7 Suggested flare rates for barrier design, *AASHTO Roadside Design page 5-32*

the terrain conditions). Each guardrail type has specifications and limitations that have been determined by crash testing.

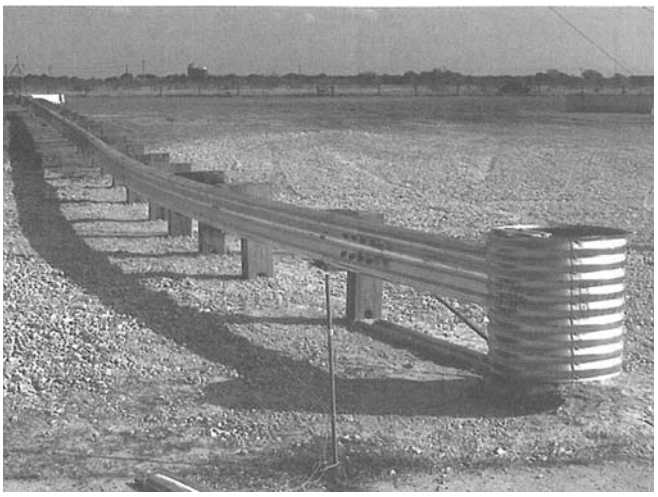
The guardrail length must safely redirect upstream traffic within the run out length (L_R). See AASHTO's *Roadside Design Guide* Table 5.8 for runout lengths at various speeds and ADTs.

Flared ends curve away from the roadway and redirect errant vehicles. Flared ends reduce the length of guardrails. To minimize the severity of an impact, do not to use too steep of a flare rate. Shield hazards from opposing traffic with a shorter guardrail lengths.

Terminals/ End Units

Install terminal end units to reduce the risk of fatal crashes. Terminals units are either energy absorbing or non-energy absorbing.

Energy absorbing terminals stop a vehicle safely



MELT Unit

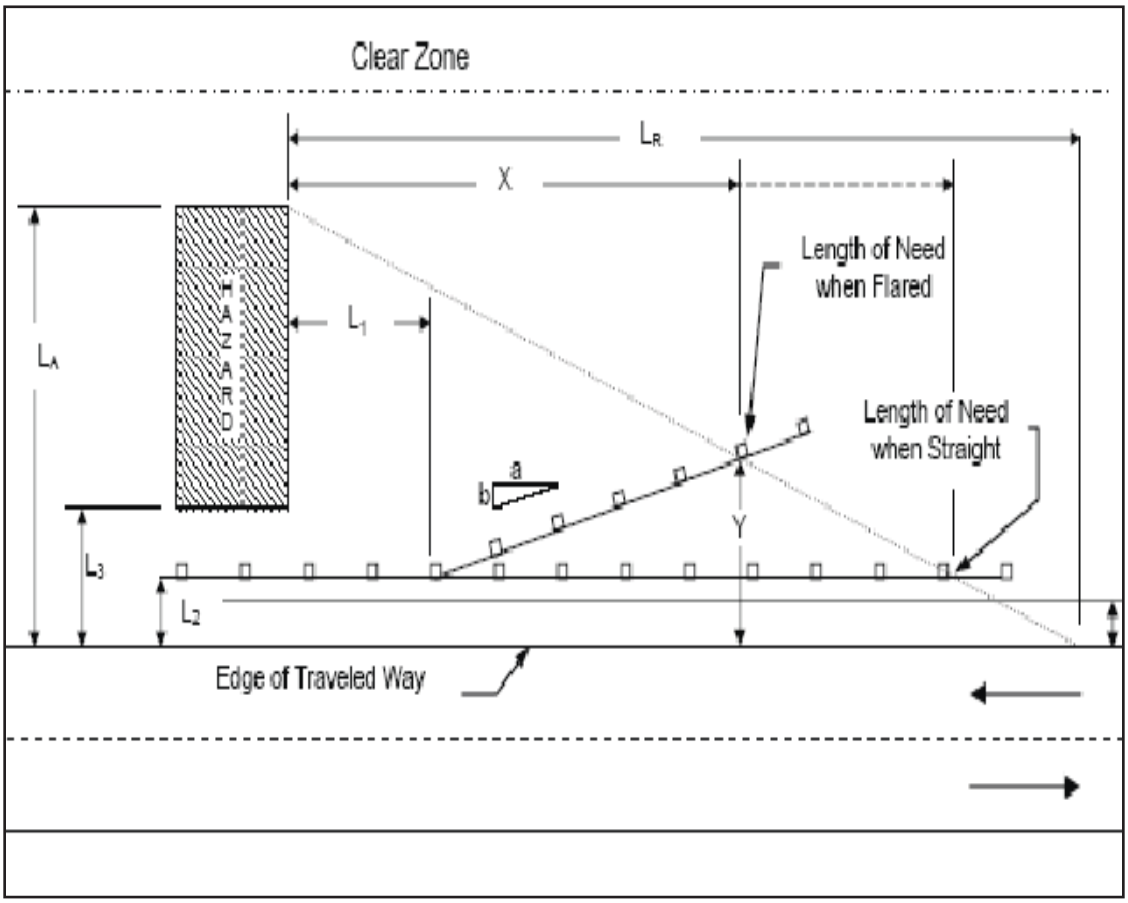


Figure 1

in a short distance (usually about 50 ft.) while non-energy absorbing terminals do not significantly reduce a vehicle's speed. The New Hampshire Recommended Technical Standards for New Roads (UNH T^2 Center) suggests using the Modified Eccentric Loader Type (MELT) terminal; however, other terminal units may be permitted by local agencies such as Flared Energy Absorbing Terminal (FLEAT), Eccentric Loader Type (ELT), etc.

Install a transition section, when joining two sections of different guardrail types or when a section of guardrail meets a bridge pier or other rigid object. Gradually increase stiffness in transition sections from the less stiff to the stiffer barrier. Transition sections follow the same design guidelines as guardrails.

Guardrails should be continuous. There shouldn't be space of less than 200 feet between guardrails.

Obstacle	Warrants
Bridge piers, abutments, and railing ends	Shielding generally required
Boulders	Judgment decision based on nature of fixed object and likelihood of impact
Culverts, pipes, head walls	Judgment decision based on size, shape, and location of obstacle
Cut & fill slopes (smooth)	Shielding not generally required
Cut & fill slopes (rough)	Judgment decision based on likelihood of impact
Ditches (parallel)	Judgment decision based on slope of ditch
Ditches (transverse)	Shielding generally required if likelihood of head-on impact is high
Embankment	Judgment decision based on fill height and slope
Retaining Walls	Judgment decision based on relative smoothness of wall and anticipated maximum angle of impact
Sign/ luminaire supports	Shielding generally required for non-breakaway supports
Traffic signal supports	Isolated traffic signals within clear zone on high-speed rural facilities may warrant shielding
Trees	Judgment decision based on site specific circumstances
Utility poles	Shielding may be warranted on a case-by-case basis
Permanent bodies of water	Judgment decision based on location and depth of water and likelihood of impact

References

The New Hampshire Recommended Technical Standards for New Roads http://www.t2.unh.edu/pubs/new.pdf

http://www-nrd.nhtsa.dot.gov/departments/nrd-30/ncsa/STSI/33_NH/2006/33_NH_2006.htm 1/22/08

AASHTO Roadside Design Guide. 2002.

USDOT & FHWA Barrier Guide for Low Volume and Low Speed Roads. 2005

http://www.fhwa.dot.gov/programadmin/clearzone.cfm 3/7/08

http://www.atssa.com/galleries/default-file/W-beam_Case_Study.pdf 3/12/08

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