In summary, roadside barriers perform most effectively when they are installed on slopes of 1V:10H or flatter. Caution should be taken when considering installations on slopes as steep as 1V:6H and any such installation should be offset so that an errant vehicle is in its normal attitude at the moment of impact. Depending on actual encroachment conditions, the distance from the traveled way at which a barrier can be installed and expected to perform adequately will vary, but in general, the placement recommendations shown in Figure 5-38 should be considered.

A rounded slope reduces the chances of an errant vehicle becoming airborne and affords the driver more control over the vehicle. Typically 1.2 m to 1.8 m [4 ft to 6 ft] is used for slope rounding. This rounding is generally obtained as part of the slope grading and vegetation establishment.

5.6.3 Flare Rate

A roadside barrier is considered flared when it is not parallel to the edge of the traveled way. Flare is normally used to locate the barrier terminal farther from the roadway; to minimize a driver's reaction to an obstacle near the road by gradually introducing a parallel barrier installation; to transition a roadside barrier to an obstacle nearer the roadway such as a bridge parapet or railing; or to reduce the total length of guardrail needed. The use of a flared barrier also reduces the number of barrier and terminal impacts as well as provides additional roadside space for an errant motorist to recover.

One concern with flaring a section of roadside barrier is that the greater the flare rate, the higher the angle at which the barrier can be hit. As the angle of impact increases, the severity of the crashes increases, particularly for rigid and semi-rigid barrier systems. A second disadvantage to flaring a barrier installation is the increased likelihood that a vehicle will be redirected back into or across the roadway following an impact. This situation is especially undesirable on two-way roadways where the impacting vehicle could be redirected into oncoming traffic. Testing of a flared MGS installation has shown an improvement over conventional strong-post W-beam guardrail that was crash tested in a parallel installation. The vehicles impacting the MGS system remained relatively close to the rail. The MGS passed crash testing at NCHRP Report 350 TL-3 with a 5:1 flare rate *(12)*. Terminals used with the MGS system should follow the manufacturer's recommended flare rates.

As shown in Table 5-9, the maximum recommended flare rates are a function of highway design speed and barrier type *(21, 22)*. Flatter flare rates may be used and often are, particularly where extensive grading would be required to obtain a flat approach to the barrier from the traveled way. This is often the case on existing facilities having relatively steep embankment slopes where slope flattening is not practical. It should also be noted that a flatter flare rate is suggested when a barrier is located within the shy-line offset distance. This is more applicable where the approach roadway is wider than the roadway near the obstacle and has an offset less than the suggested shy line offset. For example, if an approach roadway is wider then a bridge roadway, the use of flatter flare rates based on inside the recommend shy line values should be used.

Table 5-9. Suggested Flare Rates for Barrier Design

Design Speed		Flare Rate for Barrier Inside Shy Line	Flare Rate for Barrier at or Beyond Shy Line	
km/h	[mph]		A	B
110	[70]	30:1	20:1	15:1
100	[60]	26:1	18:1	14:1
90	[55]	24:1	16:1	12:1
80	[50]	21:1	14:1	11:1
70	[45]	18:1	12:1	10:1
60	[40]	16:1	10:1	8:1
50	[30]	13:1	8:1	7:1

Notes:
A = Suggested maximum flare rate for rigid barrier system.
B = Suggested maximum flare rate for semi-rigid barrier system.
The MGS has been tested in accordance with NCHRP Report 350 TL-3 at 5:1 flare.
Flatter flare rates for the MGS installations also are acceptable. The MGS should be installed using the flare rates shown or flatter for semi-rigid barriers beyond the shy line when installed in rock formations.

7.01.11 (continued)

Current Clear Zone Criteria

A. Treatment/Consideration of Obstacles Outside the Calculated Project Clear Zone

Occasionally, there may be opportunities to improve the roadside safety on a project for a small cost by addressing a few obstacles outside the determined clear zone. Examples of these opportunities are as follows:

1. When installing landscape items: Since we have control over the location of new items, we can provide additional protection to the motorist by applying a more generous clear area to these items. For instance, our freeway guideline for a long time has been to plant trees at least 50 feet off the edge of traffic lanes.

2. When isolated trees, volunteer growth, utility poles, etc. are present: Depending on aesthetic concerns, it may be possible to offer the motorist a very generous clear area (beyond that required by the Clear Zone Distances tables) by simply removing or relocating a few isolated obstacles.

3. Obstacles near the bottom of a ditch are more likely to be hit by an errant vehicle since the ditch tends to funnel the vehicle. Relocating the obstacle further up the back slope, or even slightly up the front slope (closer to road but still outside the clear zone limit), would usually be preferable.

4. A clear runout area beyond the toe of a traversable (smooth and free of fixed objects) but non-recoverable (between 1:4 and 1:3) foreslope is desirable since vehicles traversing this steep slope are likely to continue to the bottom. The extent of this clear runout area can be determined by subtracting the distance between the edge of traveled way and the breakpoint of recoverable foreslope from the clear zone distance. This distance should be at least 10' if feasible.

7.01.11 (continued)

B. Treatment/Consideration of Obstacles Inside the Calculated Project Clear Zone

Where the following conditions exist, it may be necessary to retain trees that otherwise would be considered for removal.

1. At landscaped areas, parks, recreation or residential areas or where the functional and/or aesthetic values will be lost.

2. Exceptional or unique trees (because of their size, species, or historic value).

3. On designated heritage roads and low speed roads (including low speed urban areas).

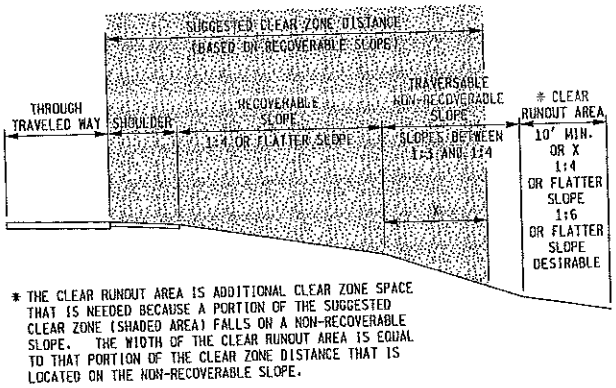
4. At locations where cumulative loss of trees would result in a significant change in character of the roadside landscape.

5. Behind nontraversable backslopes.

6. Behind vertical curbs, particularly in low speed areas.

7. Where shrubs and/or ornamental trees exist that would have a mature diameter of 4" or less at 4'-6" above ground line.

8. Where removal would adversely affect endangered/threatened species, wetland, water quality, or result in significant erosion/sedimentation problems.



* THE CLEAR RUNOUT AREA IS ADDITIONAL CLEAR ZONE SPACE THAT IS NEEDED BECAUSE A PORTION OF THE SUGGESTED CLEAR ZONE (SHADED AREA) FALLS ON A NON-RECOVERABLE SLOPE. THE WIDTH OF THE CLEAR RUNOUT AREA IS EQUAL TO THAT PORTION OF THE CLEAR ZONE DISTANCE THAT IS LOCATED ON THE NON-RECOVERABLE SLOPE.

7.01.11 (continued)

Current Clear Zone Criteria

C. Clear Zone Distance Chart

CLEAR ZONE DISTANCES
(IN FEET FROM EDGE OF DRIVING LANE)

DESIGN SPEED	DESIGN ADT	FILL SLOPES			CUT SLOPES		
		1:6 OR FLATTER	1:5 TO 1:4	1:3	1:3	1:4 TO 1:5	1:6 OR FLATTER
40 mph or Less	under 750	7 - 10	7 - 10	**	7 - 10	7 - 10	7 - 10
	750 - 1500	10 - 12	12 - 14	**	10 - 12	12 - 14	12 - 14
	1500 - 6000	12 - 14	14 - 16	**	12 - 14	14 - 16	14 - 16
	over 6000	14 - 16	16 - 18	**	14 - 16	16 - 18	16 - 18
45-50 mph	under 750	10 - 12	12 - 14	**	8 - 10	8 - 10	10 - 12
	750 - 1500	14 - 16	16 - 20	**	10 - 12	12 - 14	14 - 16
	1500 - 6000	16 - 18	20 - 26	**	12 - 14	14 - 16	16 - 18
	over 6000	20 - 22	24 - 28	**	14 - 16	18 - 20	20 - 22
55 mph	under 750	12 - 14	14 - 18	**	8 - 10	10 - 12	10 - 12
	750 - 1500	16 - 18	20 - 24	**	10 - 12	14 - 16	16 - 18
	1500 - 6000	20 - 22	24 - 30	**	14 - 16	16 - 18	20 - 22
	over 6000	22 - 24	26 - 32*	**	16 - 18	20 - 22	22 - 24
60 mph	under 750	16 - 18	20 - 24	**	10 - 12	12 - 14	14 - 16
	750 - 1500	20 - 24	26 - 32*	**	12 - 14	16 - 18	20 - 22
	1500 - 6000	26 - 30	32 - 40*	**	14 - 18	18 - 22	24 - 26
	over 6000	30 - 32*	36 - 44*	**	20 - 22	24 - 26	26 - 28
≥ 65 mph	under 750	18 - 20	20 - 26	**	10 - 12	14 - 16	14 - 16
	750 - 1500	24 - 26	28 - 36*	**	12 - 16	18 - 20	20 - 22
	1500 - 6000	28 - 32*	34 - 42*	**	16 - 20	22 - 24	26 - 28
	over 6000	30 - 34*	38 - 46*	**	22 - 24	26 - 30	28 - 30

* Where a site specific investigation indicates a high probability of continuing crashes, or such occurrences are indicated by crash history, the designer may provide clear zone distances greater than 30 feet as indicated. Clear zones may be limited to 30 feet for practicality and to provide a consistent roadway template if previous experience with similar projects or designs indicates satisfactory performance.

** Since recovery is less likely on the unshielded, traversable 1:3 slopes, fixed objects should not be present in the vicinity of the toe of these slopes.

7.01.11 (continued)

Current Clear Zone Criteria

D. Curve Correction Factors Table

The Curve Correction Factors Table shown below shall be applied to horizontal curves with radii less than or equal to 2950 ft. The curve correction factor (Kcz) shall be applied to the outside of curve only. The inside portion of the curve will be treated as a tangent section.

CURVE CORRECTION FACTORS (Kcz)

Radius (ft)	DESIGN SPEED (mph)						
	40	45	50	55	60	65	70
2950	1.1	1.1	1.1	1.2	1.2	1.2	1.2
2300	1.1	1.1	1.2	1.2	1.2	1.2	1.3
1970	1.1	1.2	1.2	1.2	1.3	1.3	1.4
1640	1.1	1.2	1.2	1.3	1.3	1.3	1.4
1475	1.2	1.2	1.3	1.3	1.4	1.4	1.5
1315	1.2	1.2	1.3	1.3	1.4	1.4	
1150	1.2	1.2	1.3	1.4	1.5	1.5	
985	1.2	1.3	1.4	1.5	1.5	1.5	
820	1.3	1.3	1.4	1.5			
660	1.3	1.4	1.5				
495	1.4	1.5					
330	1.5						

7.01.11 (continued)

E. Other Controlling Factors

For free access highways, the clear zone should ideally be the same as for controlled access highways, but often this is impossible as it would require complete reconstruction of the highway, and destruction of the existing roadside features. Clear zone may often be restricted by drives, intersections, ditches, narrow R.O.W., and other features. While it may be argued that the dynamics of a vehicle running off the road are no different on a free access road than they are on a limited access facility, it remains as a fact of life that there will always be obstacles of some description on free access roads - mailboxes, driveway embankments, trees, buildings, etc. Enormous numbers of these obstacles occur on the trunkline system.

7.01.11 (continued)

Continued efforts should be made to reduce these obstacles as finances permit, even though some cannot be removed without great difficulty, because of socio-environmental considerations, e.g., mature shade trees in a west-facing front yard. However safety considerations should overrule, and if need be, even these mature shade trees may have to be removed.

The designer should note that the presence of an up-slope significantly reduces the clear zone width required. It is therefore seldom necessary to remove a tree or to shield an obstacle that is located at the top of a cut-slope if the elevation of the top of slope is approximately 5'-0" to 6'-0" higher than the edge of pavement. These situations should always be checked, however.

7.01.12 (revised 8-21-2017)

Types of Guardrail Used in Michigan

There are seven standard types of steel beam guardrail in addition to cable barrier found on Michigan highways. The term "Current Use" means "currently proposed for use", not necessarily what may be found existing in the field.

A. Type A (Standard Plan R-60-Series)

Description: W-beam attached directly to posts, Terminal End Shoes on ends. 12'-6" post spacing, 28" height to top of rail.

Current Use:
1. Cul-de-sacs
2. Limited to locations not exposed to through traffic.

B. Type B (Standard Plan R-60-Series)

Description: W-beam guardrail, 8" offset blocks. 6'-3" post spacing, 28" height to top of rail.

Current Use:
1. Basic type for all free access trunklines.
2. On local roads when part of a state trunkline project.

C. Type BD (Standard Plan R-60-Series)

Description: Type B with W-beam on both sides of the post, 8" offset blocks.

Current Use:
1. Limited use in medians on free access highways when median barrier is recommended.

7.01.12 (continued)

D. Type T (Standard Plan R-60-Series)

Description: Offset thrie beam rail, 8" offset blocks, 6'-3" post spacing, 34" height to top of rail.

Current Use:
1. Standard guardrail for new freeway construction (including ramps).
2. Updating existing freeways and ramps when the entire run of guardrail is being removed and replaced.

E. Type TD (Standard Plan R-60-Series)

Description: Similar to Type T except beam elements and offset blocks are installed on both sides of the post.

Current Use:
1. In freeway medians over 30' wide when median barrier is recommended. Used to update existing freeway medians when there is a significant length of guardrail being replaced or where none was constructed initially, but barrier is now recommended.

F. Type MGS-8 (Standard Plan R-60-Series)

Description: W-beam guardrail meeting MASH criteria, 8" offset blocks, standard 6'-3" post spacing, and 31" height to top of rail. Beam element splices occur between standard 6'-3" post spaces.

Current Use:
1. Standard MASH-compliant guardrail for all freeways (including ramps) and free access roadways. On projects let after December 31, 2017, Type MGS guardrail systems will be required for new guardrail installations on all freeways (including ramps) and free access roadways.

7.01.12 (continued)

Types of Guardrail used in Michigan

G. Type MGS-8D
(Standard Plan R-60-Series)

Description: Type MGS-8 with W-beam guardrail and 8" offset blocks on both sides of the post.

Current Use:

1. In all roadway medians, freeway and free access, when median guardrail is recommended and a MASH-compliant guardrail system is desired. On projects let after December 31, 2017, Type MGS guardrail systems will be required for new guardrail installations on all freeways (including ramps) and free access roadways.

7.01.12 (continued)

H. Cable Barrier (See Section 7.01.55C)

Description: Three or four steel cables mounted on steel posts, anchored and tensioned.

Current Use:

1. Medians where crash history indicates cross median crashes and rigid barrier is not warranted.

2. Special situations where up to 90 degree impacts can be expected and larger deflections can be tolerated.

7.01.14 (continued)

Guardrail Surface Finish

C. Corrosion-Resistant Guardrail Replacement Policy

The Engineering Operations Committee, meeting on January 20, 1989, decided that all existing corrosion resistant, or "rusty steel", guardrail encountered on proposed Interstate resurfacing or reconstruction projects should be removed and replaced as part of the project. On projects involving bridges only, the nominal provisions of the approach guardrail anchorage shall be replaced if the rail elements are rusty steel. Where guardrail at the bridge approaches is part of a more extensive installation, the decision to replace will be made on the merits of the specific project. See Section 7.01.44 for upgrading local roads.

7.01.15 (revised 8-21-2017)

Guardrail Terminals

On projects let on or before June 30, 2018, all of the following guardrail terminals may be used for new construction and where specified for updating.

On projects let after June 30, 2018, the guardrail terminal types identified in items G and H are required for new construction and where specified for updating. On projects let after June 30, 2018, the guardrail terminal types identified in items A through F will be prohibited for new construction and where specified for updating.

A. Guardrail Approach Terminal, Type 1B (Standard Plan R-61-Series)

Current Use:

1. On one or both ends of Guardrail, Type B and Guardrail, Type MGS-8 located within the clear zone of approaching traffic, where a Type 1 (flared) guardrail terminal is desired.

B. Guardrail Approach Terminal, Type 1T (Standard Plan R-61-Series)

Current Use:

1. On one or both ends of Guardrail, Type T located within the clear zone of approaching traffic, where a Type 1 (flared) guardrail terminal is desired.

7.01.15 (continued)

C. Guardrail Approach Terminal, Type 2B (Standard Plan R-62-Series)

Current Use:
1. On one or both ends of Guardrail, Type B and Guardrail, Type MGS-8 located within the clear zone of approaching traffic, where a Type 2 (tangent) guardrail terminal is desired.

D. Guardrail Approach Terminal, Type 2T (Standard Plan R-62-Series)

Current Use:
1. On one or both ends of Guardrail, Type T located within the clear zone of approaching traffic, where a Type 2 (tangent) guardrail terminal is desired.

E. Guardrail Departing Terminal, Type B (Standard Plan R-66-Series)

Current Use:
1. Departing end of Guardrail, Type B, on one-way roadways.
2. Departing end of Guardrail, Type B, on two-way roadways when located outside the clear zone.

F. Guardrail Departing Terminal, Type T (Standard Plan R-66-Series)

Current Use:
1. Departing end of Guardrail, Type T, on one-way roadways.
2. Departing end of Guardrail, Type T, on two-way roadways when located outside the clear zone.

7.01.15 (continued)

G. Guardrail Departing Terminal, Type MGS (Standard Plan R-66-Series)

Current Use:
1. Departing end of Guardrail, Type MGS-8, on one-way roadways.
2. Departing end of Guardrail, Type MGS-8, on two-way roadways when located outside the clear zone.

H. Guardrail Approach Terminal, Type 2M (by Special Provision)

Current Use:
1. On one or both ends of Guardrail, Type MGS-8 located within the clear zone of approaching traffic.
2. May also be used on one or both ends of Guardrail, Type T or Guardrail, Type B with an appropriate transition section (refer to Standard Plan R-60-Series).

7.01.16 (revised 3-21-2016)

Guardrail Attachment to Bridges and Walls

The following guardrail anchorage details are in current use for new construction and where specified for upgrading and are detailed on Standard Plans R-67-Series, B-22-Series, B-23-Series:

A. Guardrail Anchorage, Bridge, Detail T-1 (Standard Plan R-67-Series)

Current Use: (Two uses detailed)
1. Use when connecting Guardrail, Type T, or Type MGS-8 to Bridge Barrier Railing, Type 4, 2-Tube, 4-Tube, or aesthetic parapet tube without expansion at backwall.
2. Use when connecting Guardrail, Type T, or Type MGS-8 to Bridge Barrier Railing, Type 4, 2-Tube, 4-Tube, or aesthetic parapet tube with expansion at backwall.

B. Guardrail Anchorage, Bridge, Detail T-2 (Standard Plan R-67-Series)

Current Use:
1. Use when connecting Guardrail, Type B to Bridge Barrier Railing, Type 4, 2-Tube, 4-Tube, or aesthetic parapet tube without expansion at backwall.

C. Guardrail Anchorage, Bridge, Detail T-3 (Standard Plan R-67-Series)

Current Use:
1. Use when connecting Guardrail, Type B to Bridge Barrier Railing, Type 5 without expansion at backwall.

D. Guardrail Anchorage, Bridge, Detail T-4 (Standard Plan R-67-Series)

Current Use:
1. Use when connecting Guardrail, Type T, or Type MGS-8 to Bridge Barrier Railing, Type 5 without expansion at backwall.

7.01.16 (continued)

E. Guardrail Anchorage, Bridge, Detail T-5 (Standard Plan R-67-Series)

Current Use: (Two uses detailed)
1. Use when connecting Guardrail, Type B to Bridge Barrier Railing, Type 4, 2-Tube, 4-Tube, or aesthetic parapet tube with expansion at backwall.
2. Use when connecting Guardrail, Type B to Fillerwalls.

F. Guardrail Anchorage, Bridge, Detail T-6 (Standard Plan R-67-Series)

Current Use:
1. Use when connecting Guardrail, Type T, or Type MGS-8 to Fillerwalls.

G. Guardrail Anchorage, Bridge, Detail A-1 (Standard Plans B-22-Series and B-23-Series)

Current Use:
1. Use when connecting Guardrail, Type T, or Type MGS-8 to Bridge Railing, Thrie Beam Retrofit.

H. Guardrail Anchorage, Bridge, Detail A-2 (Standard Plans B-22-Series and B-23-Series)

Current Use:
1. Use when connecting Guardrail, Type B to Bridge Railing, Thrie Beam Retrofit.

I. Need for Additional Expansion

The Guardrail Anchorage, Bridge details on Standard Plan R-67-Series will accommodate thermal deck movement up to about 4". If the expected thermal deck movement will exceed 4", the Road designer should consult with the Bridge designer to decide the method for providing the additional expansion required in the guardrail.

7.01.17 (continued)

Strength Requirements of Steel Beam Guardrail

MASH Test Level	Test Vehicle Designation and Type	Impact Conditions		
		Vehicle Weight Kg (lbs)	Speed km/h (mph)	Angle Degrees
1	1,100C (Passenger Car) 2,270P (Pickup Truck)	1,100 (2,420) 2,270 (5,000)	50 (31) 50 (31)	25 25
2	1,100C (Passenger Car) 2,270P (Pickup Truck)	1,100 (2,420) 2,270 (5,000)	70 (44) 70 (44)	25 25
3	1,100C (Passenger Car) 2,270P (Pickup Truck)	1,100 (2,420) 2,270 (5,000)	100 (62) 100 (62)	25 25
4	1,100C (Passenger Car) 2,270P (Pickup Truck) 10,000S (Single Unit Truck)	1,100 (2,420) 2,270 (5,000) 10,000 (22,000)	100 (62) 100 (62) 90 (56)	25 25 15
5	1,100C (Passenger Car) 2,270P (Pickup Truck) 36,000V (Tractor-Van Trailer)	1,100 (2,420) 2,270 (5,000) 36,000 (79,300)	100 (62) 100 (62) 80 (50)	25 25 15
6	1,100C (Passenger Car) 2,270P (Pickup Truck) 36,000T (Tractor-Tank Trailer)	1,100 (2,420) 2,270 (5,000) 36,000 (79,300)	100 (62) 100 (62) 80 (50)	25 25 15

7.01.18 (revised 10-21-2013)

Suggested Shy Line Offset Values

Shy line offset is the distance from the edge of traveled way in which a roadside object will not be perceived as an obstacle or result in the driver reducing speed or changing the vehicle's path of travel.

Design Speed (mph)	Shy Line Offset (L_S) (ft)
80	12
75	10
70	9
60	8
55	7
50	6.5
45	6
40	5
30	4

7.01.19 (revised 8-21-2017)

Suggested Runout Lengths for Barrier Design

Runout length is the distance from the object being shielded to the point the vehicle is assumed to depart from the roadway.

	Traffic Volume (ADT) veh/day			
	Over 10,000	Over 5,000-10,000	1000-5000	Under 1000
Design Speed (mph)	Runout Length L_R (ft)	Runout Length L_R (ft)	Runout Length L_R (ft)	Runout Length L_R (ft)
80	470	430	380	330
70	360	330	290	250
60	300	250	210	200
50	230	190	160	150
40	160	130	110	100
30	110	90	80	70

7.01.20 (revised 7-18-2016)

Guardrail Deflection

Being flexible barriers, both steel beam guardrail and cable barriers are expected to deflect under impact. This deflection is a result of deformation of the beam element or stretching of the steel cable, fracturing of the post (if wood) or bending of the post (if steel), and lateral displacement of the post in the soil. It is therefore necessary that room for deflection be provided between the back of the rail system (e.g. back of posts) and the object or area being shielded. For design purposes, use the chart at the end of this section for the recommended minimum design offset distances of the various guardrail systems. Refer to Section 7.01.55C, "Cable Barrier", for expected deflections and offset recommends of cable barrier systems.

7.01.20 (continued)

It should be noted that the recommended offset distances should not be treated as absolute values, since guardrail deflection may vary for different impact conditions, soil types and moisture contents, thawed or frozen ground, different types of posts, different types of anchorages, and differing lengths of installation. Therefore, the recommended offset distances should be treated as minimums, and larger offset distances between the back of the rail system (e.g., back of posts) and the object or area being shielded should be provided where feasible. In general and, where feasible, the offset should be increased by 12 inches or more beyond the recommended minimum value. If specific site conditions are such that it is predictable that greater deflection values may occur, and space for deflection is restricted, then shorter post spacing or deeper embedment of posts should be considered. Shorter post spacing is only effective, however, if the full effect of proper post embedment is realized. See Section 7.01.41D, "Guardrail Posts at or near the Shoulder Hinge Line". See also Section 5.5.2, 2011 AASHTO Roadside Design Guide.

7.01.20 (continued)

Guardrail Deflection

Guardrail	Post Spacing	Minimum Design Offset *
Type T	1'-6¾"	1'-2"
Type T	3'-1½"	1'-8"
Type T	6'-3"	2'-0"
Type B	1'-6¾"	1'-6"
Type B	3'-1½"	2'-0"
Type B	6'-3"	3'-0"
Type MGS-8	1'-6¾"	2'-5"
Type MGS-8	3'-1½"	2'-11"
Type MGS-8	6'-3"	3'-6"
Type MGS-8 Adjacent to Curb	6'-3"	4'-1"
Type MGS-8 Near Shoulder Hinge Point **	6'-3"	4'-1"

* An additional 12" or more is desirable where feasible

** Less than 2'–8" from the shoulder hinge point to the face of guardrail post

The Zone of Intrusion (ZOI) is the region measured above and behind the face of a barrier system where an impacting vehicle or any major part of the system may extend during an impact. For a typical TL-3 system, the ZOI extends between 18" and 30" behind the traffic side face of the barrier. Where practical, the designer should keep objects out of this area. See Section 5.5.2, 2011 AASHTO Roadside Design Guide, for additional ZOI guidance.

7.01.25 (revised 3-26-2018)

Guardrail Approach Terminals

Crashworthy end treatments are critical to guardrail installations. An approach terminal is designed to redirect an impacting vehicle and to reduce the occurrences of a vehicle being penetrated, rolled, or vaulted in an end on hit. The following section describes the characteristics and uses of approved standard treatments.

A. Type 1 Terminals

Type 1 Guardrail Approach Terminals are flared gating terminals. On projects let on or before June 30, 2018, this is the preferred design when grading limits allow for the appropriate 4'-0" offset of the terminal end from the tangent extension of the standard line of guardrail run. When the Type 1 terminal is called for on plans by reference to Standard Plan R-61-Series, the contractor may use one of three terminal options. Descriptions of the current approved options are described in this section.

On projects let after June 30, 2018, Type 1 guardrail terminals will not be permitted for new construction and where specified for updating until further notice.

1. Slotted Rail Terminal (SRT)

The SRT was adopted by the Department in 1995 when FHWA mandated the discontinued use of the BCT. It subsequently became the first guardrail terminal to pass the NHCRP Report 350 crash test criteria.

The concept of a slotted rail terminal consists of longitudinal slots cut into the W-beam rail element to control the location of dynamic buckling thus reducing the potential for impact or penetration of the occupant compartment by the buckled rail element.

The SRT was originally intended as a retrofit or replacement for the BCT ending.

The SRT uses many of the same components used in the BCT. It also uses features common to other end treatments such as the yoke and strut and controlled release terminal (CRT) posts. The parabolic flare of the SRT is identical to that of the BCT, simplifying the retrofit of existing terminals.

2. Flared Energy Absorbing Terminal (FLEAT)

FLEAT was adopted in 1998 after it passed NCHRP Report 350 crash testing. Among other reasons, it was chosen as an alternate for the SRT because of the similarities in the components and installation configuration of the two systems. In addition to these similarities to the SRT and other flared terminals, the FLEAT includes an energy absorbing impact head. Unlike the SRT, the 4'-0" offset of the FLEAT is a straight taper rather than a parabolic flare.

3. Minimum Offset

The Type 1 Terminal is designed to have a minimum offset of 4'-0", measured from the tangent line of the guardrail run. Whenever conditions allow, the line of guardrail designed in advance of the terminal should be flared to further increase the total offset of the terminal from the traveled lane. On curved roadways the offset is measured from the circular extension of the standard rail alignment along the curve.

Sometimes on certain minor trunklines and a great number of local roads, the end post may have to be placed on the slope beyond the shoulder hinge point, in which case care should be taken that the terminal end shoe and the steel sleeves are not left "high" nor placed too low.

7.01.25 (continued)

Guardrail Approach Terminals

B. Type 2 Terminals

Type 2 terminals are tangent, energy absorbing terminals. They are used when proper grading cannot be achieved to accommodate the 4'-0" offset called for with the Type 1 terminals. When the Type 2 terminal is called for on plans by reference to Standard Plan R-62-Series, or by special provision, the contractor may use one of the terminal options with the following caveat.

On projects let after June 30, 2018, Type 2B and 2T guardrail terminals will not be permitted for new construction or for updating terminals. Instead, Type 2M guardrail terminals will be required for new installations and for updating guardrail terminals.

1. Extruder Terminal (ET) (Type 2B & 2T)

The ET was installed experimentally by the Department in 1993 and was used occasionally when special situations called for a non-flared terminal. In 1995 the ET became the first non-flared terminal to meet the NCHRP Report 350 crash test criteria. Frequent use of the ET led to its upgraded status as a standard plan in 1997. It features an impact head that, when hit head on, flattens the guardrail beam element as the head translates down the terminal rail. The flattened rail is then extruded away from the impacting vehicle.

7.01.25 (continued)

2. Sequential Kinking Terminal (SKT) (Type 2B & 2T)

The SKT was successfully crash tested in 1997 and adopted by the Department as a standard Type 2 terminal alternate in 1998, replacing the BEST. The materials and configuration of the SKT were more compatible with the ET. Like the FLEAT, its impact head includes a deflector plate that produces sequential kinks in the beam element before extruding it away from the impacting vehicle.

3. Type 2M Terminals

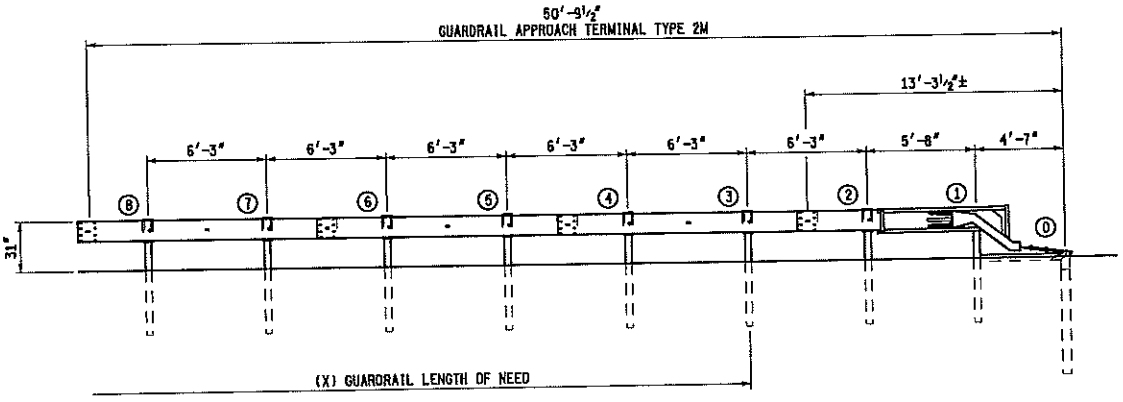
Type 2M terminals are similar to the Type 2 terminals except they are MASH-compliant. They are specified by special provision and required on projects let after June 30, 2018 for new installations and when updating guardrail terminals. These terminals are intended to be attached directly to Type MGS-8 guardrail. Therefore, designers will need to include an appropriate transition section for connecting a Type 2M guardrail terminal to either Type B or Type T guardrail (refer to Standard Plan R-60-Series). Current Type 2M terminals available for use are the MSKT, the Soft-Stop, and the MAX-Tension. See drawings below specifying the length of each terminal.

Contact the Geometrics Design Unit, Design Division, for additional information regarding MASH-compliant guardrail terminals.

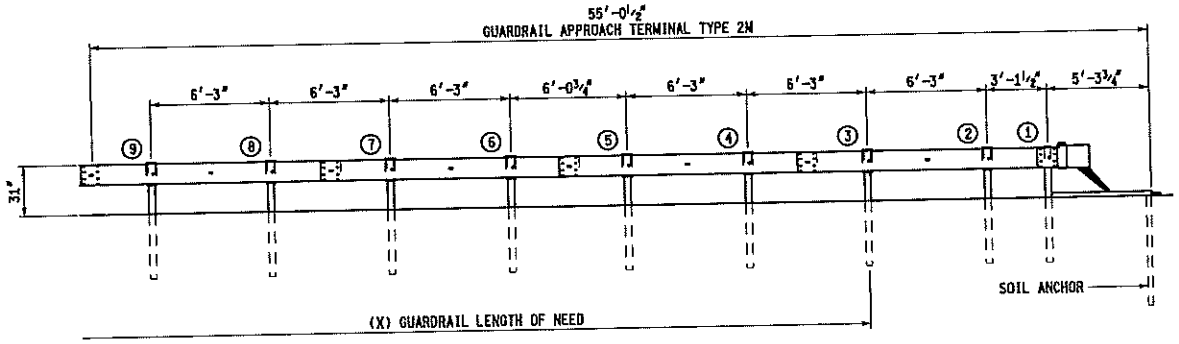
4. Minimum Offset

The original intent of the Type 2 terminals was to provide endings that required no offset. This was the orientation used in the crash tested system. It was later determined by the FHWA that a 12" offset would be acceptable without further testing. This minimal offset was adopted in Standard Plan R-62-Series in order to minimize the number of nuisance accidents that may occur when the impact head was located close to or encroaching on the shoulder.

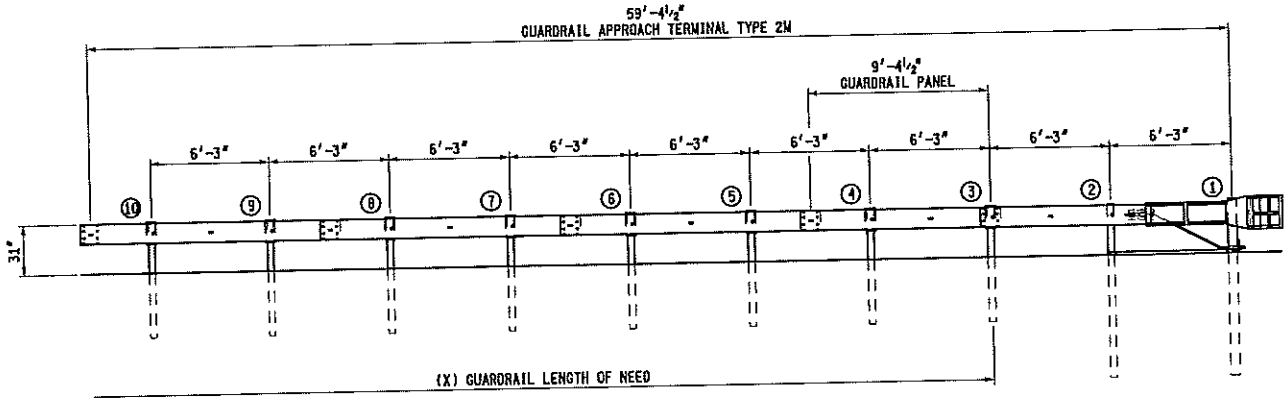
7.01.25 (continued)



Soft-Stop



MAX-TENSION



MSKT

7.01.30 (continued)

Guardrail at Embankments

C. Maximum Height of 1:2 Slope Without Barrier

Barrier is not warranted on 1:2 fill slopes up to about 5' height. See Section 7.01.30A, Height-Slope Guidelines.

D. Flattening Slopes to Eliminate Guardrail

On limited access projects, guardrail may be eliminated if the fill slopes are flattened to 1:4 or flatter. In order to eliminate guardrail on free access projects, the fill slope should also be flattened to 1:4 or flatter, unless additional R.O.W. would be required. If there are no obstacles or severe inclined slopes within the clear zone or at the toe of the fill slope, a 1:3 slope or flatter may then be considered.

E. Length of Barrier at Embankments (New Construction)

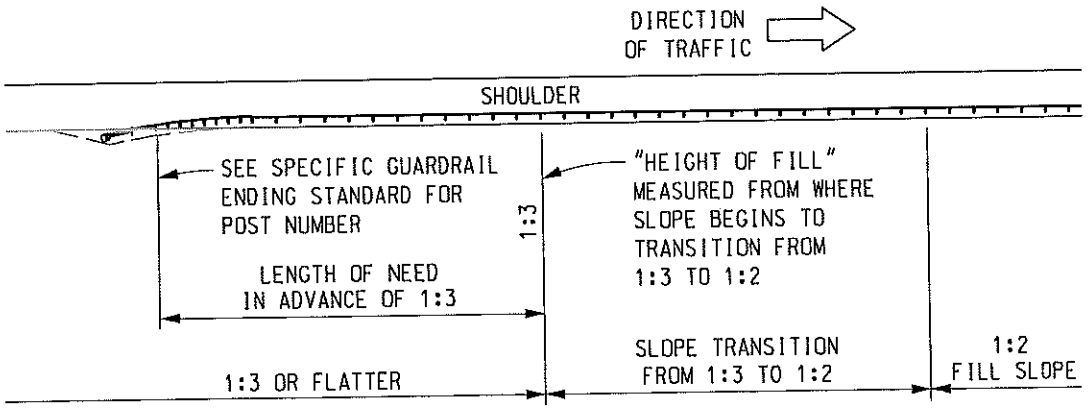
When determining the length of barrier required to shield an embankment slope (does not apply to barn roof sections), the designer must first determine the beginning of the 1:4 slope and where the slope steepens to 1:3. Using Standard Plan R-59-Series, which shows flared installations, the limits of the endings can be determined. Field personnel should check the length and slope rate of the fill section and make any necessary adjustments; sometimes the length will be adequate, but it may be necessary to "slide" the barrier one way or the other to fit actual conditions.

7.01.30 (continued)

F. Length of Barrier at Embankments (Upgrading Projects)

When a flared guardrail installation is not feasible and a parallel guardrail installation must be used, the following chart and diagram should be used to determine the length of barrier needed in advance of a 1:3 slope.

GUARDRAIL AT EMBANKMENTS (PARALLEL INSTALLATIONS)				
HEIGHT OF FILL AT 1:3 (ft)		LENGTH OF NEED IN ADVANCE OF 1:3 (ft)		
OVER	TO	70 mph	60 mph	50 mph
5	10	147	121	100
10	12	197	171	122
12	14	235	205	153
14	16	269	238	179
16	18	296	262	198
18	20	316	280	212
20	22	331	294	223
22	24	343	305	231
24	25	349	309	235



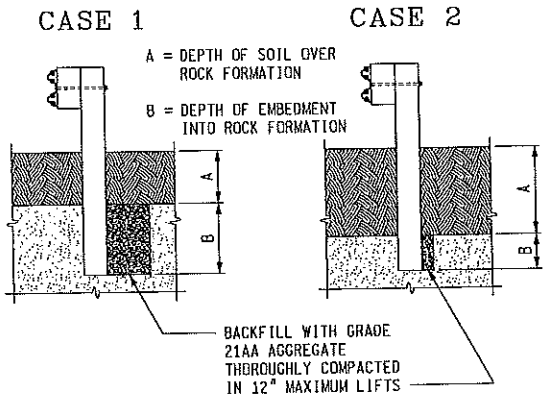
7.01.33 (continued)

Maintaining Guardrail Strength When One or More Posts Must Be Omitted

C. Placing Guardrail in Rock

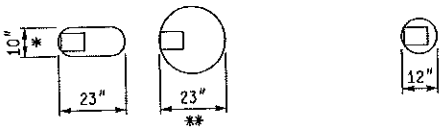
Rock formations, which occur more frequently in the Upper Peninsula, may prevent the full embedment of guardrail posts. When only a partial embedment of posts can be obtained, backing the guardrail according to the method illustrated in Standard Plan R-72-Series is an option to individually drilling each hole. If the number of post locations in the influence of the rock formation would force the length of the backed guardrail section to exceed that allowed in the standard, the affected posts holes will have to be drilled. If the depth of soil overlying the rock formation is 18" or greater, the hole diameter required for steel posts is 8" (12" for wood) and full post embedment depth is required. If the depth of soil overlying the rock formation is less than 18", the hole diameter required for steel posts is 21" (23" for wood) and a 24" embedment depth into the rock is required. A strong-post W-beam guardrail exhibits better performance if the post is allowed to rotate in the soil. Thus, the post should not be placed in the center of the hole, but at the front, so the backfill is behind the back of the post. This work should be included by special provision.

7.01.33 (continued)

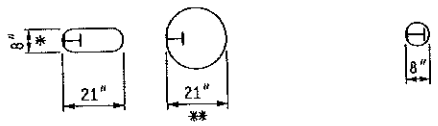


* WIDTH MAY BE INCREASED TO 15" TO ACCOMMODATE CONSTRUCTION TOLERANCES.

** 24" DIAMETER HOLE MAY BE USED.



WOOD POST PLAN VIEWS



STEEL POST PLAN VIEWS

FOR OVERLYING SOIL DEPTHS (A) RANGING FROM 0 TO 18". THE DEPTH INTO ROCK (B) IS EQUAL TO 24".

FOR OVERLYING SOIL DEPTHS (A) RANGING FROM 18" TO FULL POST EMBEDMENT DEPTH. THE REQUIRED DEPTH INTO ROCK (B) IS EQUAL TO FULL POST EMBEDMENT DEPTH MINUS (A).

7.01.33 (continued)

Maintaining Guardrail Strength When One or More Posts Must Be Omitted

D. Guardrail Posts through Paved Surfaces

Guardrail posts embedded into paved surfaces present a problem similar to that of guardrail posts in rock formations. The paved surface will not allow the posts to rotate in their embedment (to distribute vehicle loads through the post into the embedment material) prior to breaking. Thus, an area of pavement around the post know as "leave out" must be omitted to allow the post to rotate. For both steel and wood posts, the size of the leave out should be an area of about 15" x 15" (square or round). The most critical measurement is the distance from the back of post to the back edge of the leave out, which should be a minimum of 7". After post installation, patching material is generally placed around the guardrail post in the "leave out" area. This work should be included by special provision.

7.01.33 (continued)

E. Additional Blockouts on Guardrail Posts

Double blockouts (16" deep) may be used to increase the post offset to avoid obstacles such as curbs. Except at terminals, there is no limit to the number of posts in a guardrail run that use double blockouts. Under special circumstances, one or two posts in a run of guardrail may employ as many as four blockouts (up to 36") to provide proper clearance. There should be no voids between blockouts when using double or multiple blockouts. Furthermore, for aesthetic reasons, double or multiple blockouts should be installed without creating sudden changes in guardrail alignment.

When using double or multiple blockouts, steps must be taken to prevent the placement of guardrail posts on steep fill slopes beyond the shoulder hinge point. Placing conventional length guardrail posts on steep fill slopes may result in posts having insufficient soil embedment depth, thereby reducing the post's strength to resist overturning. See Section 7.01.41.D, 8'-0" Posts, for guardrail post length requirements when placing guardrail at or near the shoulder hinge line.

7.01.34 (revised 10-21-2013)

7.01.34 (continued)

Guardrail in Conjunction with Curb

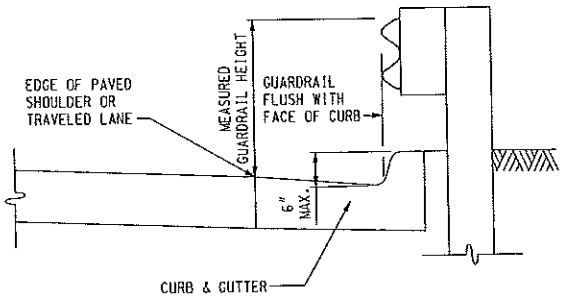
When a vehicle strikes a curb, the trajectory of that vehicle depends upon several variables including the size and suspension characteristics of the vehicle, its speed and angle of impact, and the height and shape of the curb itself. Generally, the use of curb on high speed roadways (design speed greater than 50 mph) is discouraged.

If guardrail/curb combinations are used when design speeds are less than 45 mph, the curb height should be 6" or less, with the face of guardrail being located either flush with the face of curb or at least 8' behind it.

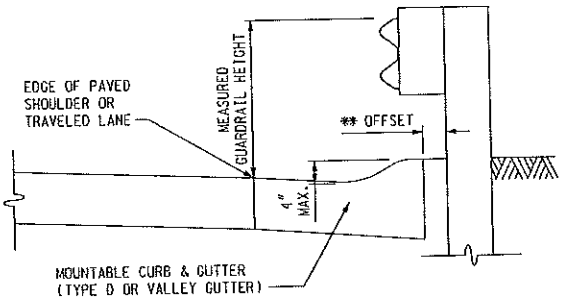
For design speeds of 45 mph or 50 mph, a 6" curb (or less) may be used if the guardrail is located flush with the face of curb. If an offset from the curb is desired, the curb height should be 4" or less with the guardrail being located at least 13' behind the curb.

If guardrail/curb combinations are necessary when the design speed is greater than 50 mph, a mountable curb (Type D curb or valley gutter) should be used, and the curb height should be 4" or less, with the face of guardrail being located flush with the face of curb. .

When guardrail is located flush with the face of curb, the rail height should be measured from the front edge of the gutter pan, which is the point on the gutter pan that is closest to the edge of the traveled lane. At greater distances (typically 8'-0" to 13'-0") the rail height should be measured from the ground just in front of the guardrail.

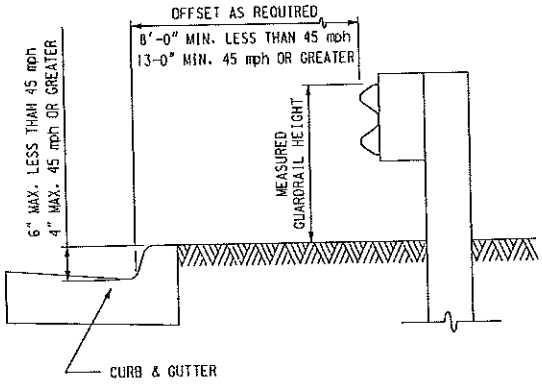


GUARDRAIL WHEN CURB IS ADJACENT TO
EDGE OF PAVED SHOULDER OR TRAVELED LANE
(DESIGN SPEED 50 mph OR LESS)



** 2" WHEN CURB IS PLACED NEXT TO SHOULDER
10" WHEN CURB IS PLACED NEXT TO TRAVELED LANE

GUARDRAIL WHEN CURB IS ADJACENT TO
EDGE OF PAVED SHOULDER OR TRAVELED LANE
(DESIGN SPEED GREATER THAN 50 mph)



GUARDRAIL - CURB OFFSET
WHEN GUARDRAIL IS PLACED AWAY FROM CURB