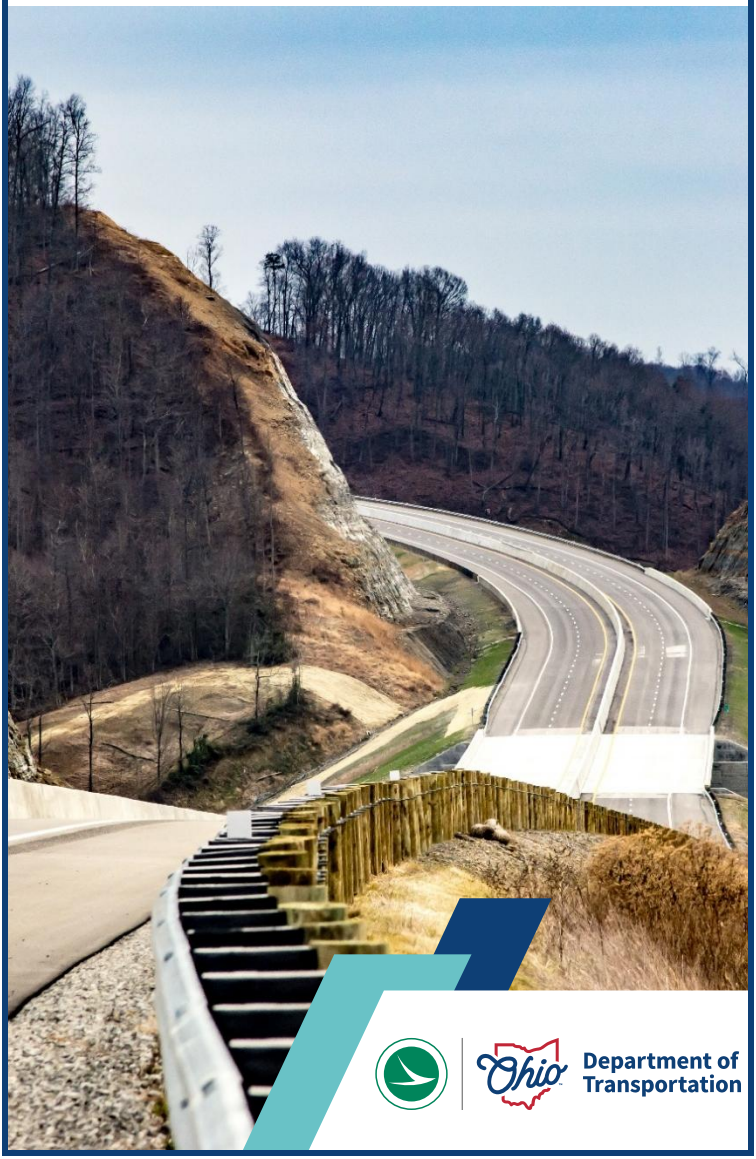
ROADSIDE SAFETY FIELD GUIDE

Guidelines for the Installation and Maintenance of Roadside Safety Hardware

2024



Ohio Department of Transportation

The following individuals prepared or reviewed this document:

Project Team

Kevin White – E.L. Robinson Engineering

Jacob Wroten – HDR

Ken Fertal – HDR

Thomas Schoen – HDR

ODOT Representatives

Adam Koenig

Andrew Holloway

Don Fisher

Jacquelin Martindale

Jennifer Alford

Josh Thieman

Victoria Beale

Published July 8, 2024

Last revised January 16, 2026

Revision Log

- March 13, 2026
  - Additional formatting changes for ADA compliance.
- January 16, 2026
  - Updated document to be ADA compliant
  - Added Type E concrete barrier, Type N concrete barrier, SGET, Delta, QuadGuard Elite M10 (standard and wide), 4F-T, NOVUS 100, MASH Buried in Backslope, MASH Bullnose, Steel Type T

Disclaimer

The purpose of this field guide is to present basic guidelines for roadside safety device installers, inspectors, and maintenance personnel. The guide presents information contained in the AASHTO *Roadside Design Guide*, 2011 along with current ODOT *Standard Construction Drawings* and ODOT *Location & Design Manual, Volume 1 – Roadway Design* at the time of publication. Roadway safety device installations are to be built and maintained to current ODOT requirements and, where applicable, manufacturers' recommendations. Note that temporary roadside safety devices have been excluded from this field guide.

Many of the devices included in this field guide are proprietary products, which are subject to change at the manufacturer's discretion. The information provided is accurate and up-to-date at the time of publication and represents the currently approved versions of these products.

Contents

Performance Criteria ix

Frequently Asked Questions..... x

100 Roadside Safety Design 1

100.1 Clear Zone..... 1

100.2 Roadside Barrier Warrants 3

100.3 Median Barrier Warrants..... 5

100.4 NHS Criteria 6

100.5 Roadside Protection 7

100.5.1 Location/Offset..... 8

100.5.2 Length of Need (LON)..... 9

100.5.3 LON Field Check 11

100.5.4 Grading for Barriers & End Treatments 14

100.5.5 Guardrail with Curbs..... 16

100.6 Median Protection.....16

100.6.1 Shielding of Fixed Objects in the Median 17

100.6.2 Mitigation of Cross Median Crashes (CMC)..... 17

100.7 Gore Area Protection 18

100.8 Protection at Drives and Side Roads 19

100.9 Protection at Bridges and Fixed Objects.....20

100.10 Protection at Drainage Structures 21

100.11 Sight Distance Considerations 22

101 Roadside Safety Devices.....23

101.1 Longitudinal Barrier.....23

101.1.1 Flexible Cable Systems 24

Valtir - CASS S3 M10 25

Brifen - WRSF..... 26

Gibraltar – TL 4 Four Cable System 27

Gregory - SAFENCE..... 28

Nucor - Nu-Cable..... 29

101.1.2 Semi Rigid Barriers 29

Type MGS Guardrail 31

Type 5 Guardrail..... 33

Type 4 Guardrail 35
101.1.3 Rigid Concrete Barriers 36
Type B and B1 Single Slope Concrete Barrier 37
Type C & C1 Single Slope Concrete Barrier 38
Type D Single Slope Concrete Barrier 39
Type E Single Slope Concrete Barrier 40
Type N Single Slope Concrete Barrier 41
New Jersey Shape Concrete Barrier 42
101.2 Characteristics of End Terminals & Impact Attenuators 43
101.2.1 Energy Absorbing 43
101.2.2 Gating 43
101.2.3 Redirection 44
101.3 Guardrail End Treatments 44
101.3.1 Type B Anchor Assembly 45
MFLEAT 46
4F-T 47
FLEAT 48
SRT-31 49
SRT-350 50
MELT 51
101.3.2 Type E Anchor Assembly 52
MSKT 53
SoftStop 54
SGET 55
SKT 56
ET-2000 57
ET-Plus 58
101.3.3 Other End Treatment Types 59
Type A Anchor Assembly 59
Type T Anchor Assembly 60
“MGS” Buried-In-Backslope 61
Thrie-Beam Bullnose (Steel-Post) 62
Type 8 Buried-In-Backslope 63
Thrie-Beam Bullnose (Wood-Post) 64
101.4 Impact Attenuators 65
101.4.1 Type 1 Impact Attenuator 65

MATT 67
CAT 350 68
FLEAT-MT 69
Brakemaster 350 70
101.4.2 Type 2 Impact Attenuator 71
QuadGuard M10 72
QuadGuard M Wide 73
TAU-M 74
Delta 75
NOVUS 100 76
QuadGuard 77
TAU-II 78
TRACC 79
101.4.3 Type 3 Impact Attenuator 80
REACT M 81
Smart Cushion 82
QuadGuard Elite M10 83
QuadGuard Elite M10 Wide 84
HEART 85
QuadGuard ELITE 86
REACT 350 87
101.5 Sand Barrels 88
Big Sandy 89
CrashGard 90
Energite III 91
Fitch Universal Module System 92
101.6 Bridge Terminal Assemblies 93
Type 1 Bridge Terminal Assembly 94
Type 2 Bridge Terminal Assembly 96
Type TST-2 Bridge Terminal Assembly 97
Type 3 Bridge Terminal Assembly 98
Type 4 Bridge Terminal Assembly 99
101.7 Concrete Barrier End Treatment 100

102 Maintenance of Roadside Safety Devices 101

102.1 General Maintenance Guidelines 101
102.2 Maintenance of Flexible Cable Systems 103
102.3 Maintenance of Semi Rigid Barrier 104
102.4 Maintenance of Guardrail End Treatments 106

102.5 Maintenance of Impact Attenuators 108
102.6 National Guidelines for W-Beam System Maintenance 109
Repair Priority Scheme 109
W-beam Barrier Repair Threshold 110
Damage Mode: Post and Rail Deflection 110
Damage Mode: Rail Deflection Only 111
Damage Mode: Rail Flattening 112
Damage Mode: Posts Separated from Rail 113
Damage Mode: Missing/Broken Posts 114
Damage Mode: Missing Blockout 115
Damage Mode: Twisted Blockout 116
Damage Mode: Non-Manufactured holes 117
Damage Mode: Damage at Rail Splice 118
Damage Mode: Vertical Tear 119
End Terminal Repair Threshold 120
Damage Mode: Damage End Post 120
Damage Mode: Anchor Cable 120
Damage Mode: Anchor Cable 121
Damage Mode: Cable Anchor Bracket 121
Damage Mode: Stub Height 122
Damage Mode: Lag Screws (Energy Absorbing Terminals Only) 122
Damage Mode: Bearing Plate 123
Damage Mode: Bearing Plate 123

Acronyms 125

Glossary 126

Resources 134

Ohio Department of Transportation: 134

Federal Highway Administration (FHWA): 134

American Association of State Highway and Transportation Officials (AASHTO): 134

Pooled Fund Programs: 134

National Cooperative Highway Research Program (NCHRP): 135

Road Safe LLC: 135

NOTES 136

Performance Criteria



A green icon indicates the system meets the current recommendations for testing and evaluating the crashworthy performance of barriers per the AASHTO *Manual for Assessing Safety Hardware* (**MASH**), 2009 and/or the updated 2016 version.



An orange icon indicates the system meets the recommendations for testing and evaluating the crashworthy performance of barriers per the **NCHRP Report 350**: *Recommended Procedures for the Safety Performance Evaluation of Highway Features*. **NCHRP Report 350** testing and evaluation criteria has been used since 1993 when **NCHRP Report 230**, used since 1981, was replaced. **NCHRP Report 350** has since been replaced by **MASH**.



A red icon indicates the system has been retired and is no longer allowed to be installed on ODOT's transportation system.

Frequently Asked Questions

The following questions should be considered when reviewing barrier installations in the field:

1. Is striking the hazard being shielded significantly more severe than the barrier itself; and secondly, what is the likelihood of the hazard being struck? (see section **100.2 Roadside Barrier Warrants**)
2. Are there any rigid objects above grade within the guardrail system's working width? (see section **100.5.1 Location/Offset**)
3. For existing installations, does the existing guardrail height meet criteria? (see section **101.1.2 Semi Rigid Barriers**)
4. Is the slope in front of the barrier appropriate? (see sections **101.1.1 Flexible Cable Systems** & **101.1.2 Semi Rigid Barriers**)
5. Are there curbs in combination with guardrail? (see section **100.5.5 Guardrail with Curbs**)
6. Is there adequate soil support behind the guardrail post? (see section **101.1.2 Semi Rigid Barriers**)
7. Is the guardrail installation long enough to shield the hazard? (see section **100.5.2 Length of Need**)
8. Should the guardrail be extended upstream (in advance) or downstream (beyond) to

shield other warranting hazard(s)? (see section **100.5.3 LON Field Check**)

9. Is an appropriate end treatment being used? (see section **101.3 Guardrail End Treatments**)
10. Is the grading around the end treatment (approach, adjacent, and runout distance) appropriate? (see section **100.5.4 Grading for Barriers & End Treatments**)
11. Does the guardrail end within 300 ft of the start of another guardrail run that could be connected? (see section **100.5.2 Length of Need**)

This document, used in conjunction with field reviews and appropriate ODOT manuals, practices, policies, procedures, and *Standard Construction Drawings*, provides the information needed to answer these questions and help personnel install and maintain barriers.

100 Roadside Safety Design

Roadside safety features are intended to reduce occurrences of run-off-the-road crashes and reduce the severity of impact when such an incident does occur. Safety devices are themselves fixed objects, and while they may decrease crash severity, they may also increase the total number of impacts. The potential for impacts can be reduced by placing the safety device as close to the hazard being shielded and as far from the traveled lanes as permitted by the following standards. Roadside safety devices are hazards and must result in a less severe crash than the hazard being shielded.

100.1 Clear Zone

The clear zone is defined as the unobstructed, traversable area provided beyond the edge of the through traveled way for the recovery of errant vehicles. The clear zone includes shoulders, bike lanes, or auxiliary lanes, except those auxiliary lanes that function like through lanes. Ideally, there should be no obstructions within the clear zone; however, if an obstruction cannot be removed, then engineering judgment must be used to determine how to treat it.

The clear zone distances given in **Figure 2**, may be used as minimum values. These widths are

based on design speed, traffic volume, and the combination of foreslopes and backslopes on the typical cross section for the roadway.

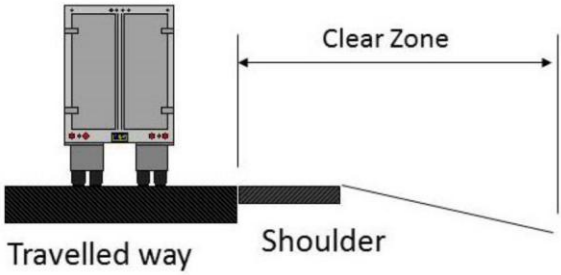


Figure 1 - Clear Zone Dimension

The preferred order of corrective treatment for fixed objects and non-traversable hazards located within the clear zone is as follows:

1. Remove the obstacle.
2. Redesign the obstacle so that it can be safely traversed.
3. Relocate the obstacle to a point where it is less likely to be struck.
4. Reduce the impact severity by using an appropriate breakaway device.
5. Shield the obstacle with a longitudinal traffic barrier designed for redirection or use a crash cushion.
6. Delineate the obstacle if the above alternatives are not appropriate.

Design Speed	Design ADT	Foreslope		Backslope		
		6:1 or Flatter	Steeper than 6:1 to 4:1	6:1 or Flatter	Steeper than 6:1 to 4:1	Steeper than 4:1
40 mph or less	<750	8 ft	8 ft	8 ft	8 ft	8 ft
	750-1500	11	13	11	11	11
	1501-6000	13	15	13	13	13
	>6000	15	17	15	15	15
45-50 mph	<750	11	13	11	9	9
	750-1500	13	18	15	13	11
	1501-6000	17	23	17	15	13
	>6000	19	26	21	19	15
55 mph	<750	13	16	11	11	9
	750-1500	17	22	17	15	11
	1501-6000	21	27	21	17	15
	>6000	23	29	23	21	17
60 mph	<750	17	22	15	13	11
	750-1500	22	29	21	17	13
	1501-6000	28	36*	25	21	16
	>6000	31*	40*	27	25	21
65-70 mph	<750	19	23	15	15	11
	750-1500	25	32*	21	19	14
	1501-6000	30	38*	27	23	18
	>6000	32*	42*	28	28	23

* Use a **maximum clear zone** of 30 feet unless a site-specific investigation or accident history indicates a high potential of continuing accidents. When the potential for continuing accidents is high, the widths in the above chart should be multiplied by the following curve correction factors to extend the clear zone on the outside of curves having a Degree of Curvature of 2 degrees or sharper.

Figure 2 - Clear Zone Widths per L&D Vol 1 Figure 600-1

100.2 Roadside Barrier Warrants

A roadside barrier is a longitudinal barrier used to shield motorists from natural or man-made obstacles located on the roadside within the clear zone where impacts are expected on one side of the barrier only. Roadside obstacles may be fixed objects or non-traversable terrain and may or may not require barrier protection if within the clear zone. Barriers should be considered in the following circumstances:

1. At bridges, piers, and abutments
2. At culverts, pipes, and headwalls with diameters or spans greater than 36”
3. At non-breakaway sign and light supports
4. At rough slopes in cut sections

5. At utility poles that cannot justifiably be relocated
6. At bodies of water or BMP detention ponds where the normal depth exceeds 1' depending on the location and likelihood of encroachment
7. At transverse ditches if the likelihood of a head-on impact is high
8. At retaining walls
9. At unprotected noise walls
10. Excessive foreslopes (see **Figure 3**)
11. Protection of others (schools, residences, businesses, pedestrians, bicyclists, etc.)

Barrier protection on city streets and urban type facilities with design speeds less than 50 mph is not normally required.

On roads with very low traffic volumes (ADT ≤ 2000), research has found that roadside clear zones provide very little benefit, and that traffic barriers are not generally cost-effective. See guidelines contained in the AASHTO *Guidelines for the Geometric Design of Low Volume Roads*, 2019 for additional information.

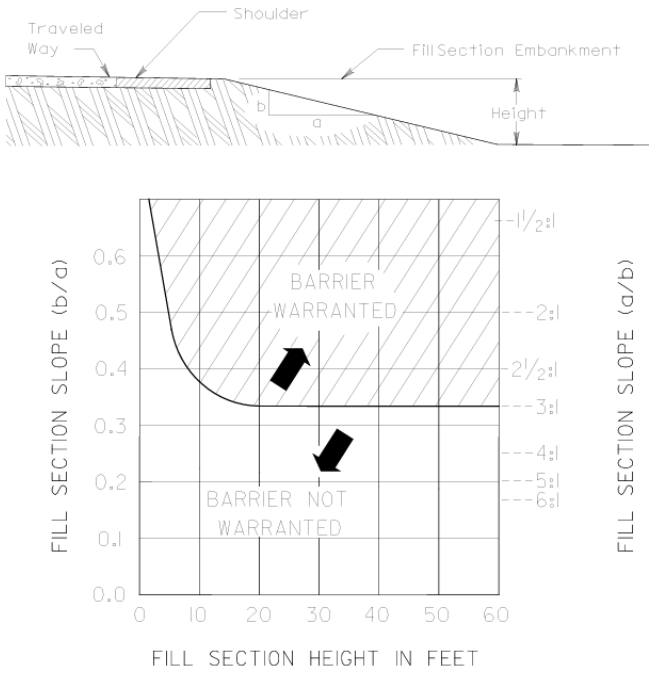


Figure 3 – Barrier Warrants for Embankments per L&D Vol 1 Figure 601-1

100.3 Median Barrier Warrants

A median barrier is a longitudinal barrier used to separate opposing traffic on divided highways having relatively flat, traversable medians. Median barrier warrants for freeways are based on the width of the median and the volume of traffic on the facility.

A median barrier may be high tensioned cable, guardrail, or concrete barrier. If the median is wide enough so that the barrier is outside the clear zone of opposing traffic, then roadside barrier warrants may be used.

100.4 NHS Criteria

Highway safety features, including longitudinal barriers, anchor assemblies, bridge terminal assemblies and impact attenuators installed on the National Highway System (NHS) must demonstrate satisfactory crash worthy performance and be accepted by the FHWA. The AASHTO *Manual for Assessing Safety Hardware* (MASH) contains the current recommendations for testing and evaluating the crashworthy performance of barriers and has replaced NCHRP Report 350: *Recommended Procedures for the Safety Performance Evaluation of Highway Features* for the evaluation of new devices. Crashworthiness is currently accepted if either of the following conditions are met:

1. A barrier system has met all of the evaluation criteria listed in MASH or NCHRP Report 350 for each of the required crash tests.
2. A barrier system has been evaluated and found acceptable as a result of an in-service performance evaluation.

Features are evaluated to the test levels listed below and defined in NCHRP Report 350 and MASH. The six test levels correspond to the crash testing matrix below. In general, all permanent devices installed on the NHS in Ohio must meet TL-3 requirements, however, a TL-2 device may be

acceptable in low speed urban situations where a TL-3 protection is not feasible or cost prohibitive, and a TL-5 or TL-6 device may be necessary where large vehicles comprise a significant percentage of the traffic volume.

Crash Testing Matrix		
Test Level	**Vehicle**	**Speed (MASH)**
TL-1	Passenger fleet	31 mph
TL-2	Passenger fleet	44 mph
TL-3	Passenger fleet	62 mph
TL-4	Single unit delivery van	56 mph
TL-5	Tractor Trailer	50 mph
TL-6	Tanker Trailer	50 mph

Figure 4 - Crash Testing Matrix per L&D Vol 1 Section 601.3

Existing roadside safety devices located on NHS roadways should be repaired when damaged per the ODOT Office of Maintenance Operations, Volume II: *Maintenance Activities Manual*. Roadside devices located on NHS roadways that are determined to be damaged beyond repair, must be upgraded to the latest MASH compliant hardware.

100.5 Roadside Protection

Generally, the preferred solution for roadside protection is considered in the following order:

1. Install flared guardrail and either terminate the end outside the clear zone or bury it into a backslope.
2. Install tangential guardrail and terminate the end with a Type B flared end terminal.
3. Install tangential guardrail and terminate the end with a Type E tangential end terminal.
4. Install concrete barrier with acceptable end treatment.

100.5.1 Location/Offset

Guardrail is typically placed 2' offset from the edge of shoulder when no curb and should not be located closer than 4' to the edge of traveled lane. See *L&D Vol 1* Fig 301-3 for more information. Minimum barrier clearance (working width) is measured from the face of the barrier to the face of the obstacle as shown in **Figure 5,** and values are provided in **Figure 6** & **Figure 7**. Note the guardrail working widths vary depending on post spacing.

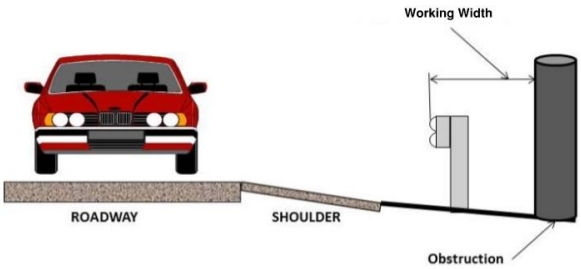


Figure 5 - Working Width Dimension

	Barrier Type	Standard Drawing	Working Width*	Typical Use
STEEL BEAM GUARDRAIL	Type MGS	MGS-2.1	5'	Roadside protection. 6'-3" Standard Post Spacing
		MGS-2.1	3'-6"	Roadside protection adjacent to fixed objects. 3'-1 1/2" Half Post Spacing
		MGS-2.1	3'	Roadside protection adjacent to fixed objects. 1'-6 3/4" Quarter Post Spacing
	MGS Barrier	MGS-2.1 MGS-6.1 MGS-6.2	5'	Narrow medians where deflections can be tolerated.
	Span Across Culvert	MGS-2.3	8'	Used primarily to span across precast structures that have limited depths of cover
	Socketed Weak Post Mounting	MGS-2.4	5'	Used primarily on precast structures that have limited depths of cover

*Working Width - The distance between the traffic face of the barrier before impact and the maximum lateral position of any major part of the system or vehicle after impact.

Figure 6 - Working Width Table per L&D Vol 1 Figure 603-2

	Barrier Type	Standard Drawing	Minimum Barrier Clearance*	Typical Use
STEEL BEAM GUARDRAIL	Type 5	GR-2.1	5' 6"	Roadside protection. 6' 3" Post Spacing /12' 6" Rails
	Type 5A	GR-2.1	3' 6"	Roadside protection adjacent to fixed objects. 3' 1-1/2" Post Spacing /12' 6" Rails
	Type 5: Barrier	GR-2.1 GR-6.1 GR-6.2	5' 6"	Narrow medians where deflections can be tolerated.
	Type 5 with Tubular Backup	GR-2.2	Width of Barrier Approx. 24"	Prefabricated structures where other guardrail system minimum barrier clearances cannot be provided.
	Long Span Across Culvert	GR-2.3	5' 0"	Used primarily to span across precast structures that have limited depths of cover.
		GR-2.4	3' 7"	

* Measured from the face of the barrier to the obstacle.

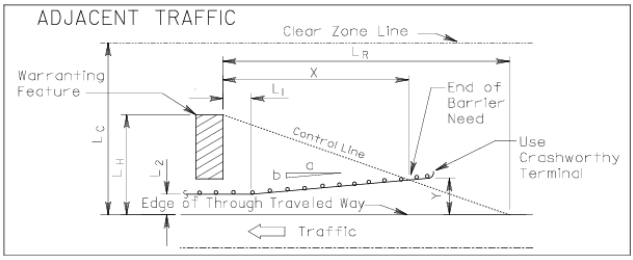
Figure 7 - Working Width Table per Archived L&D Vol 1 Figure 603-2E

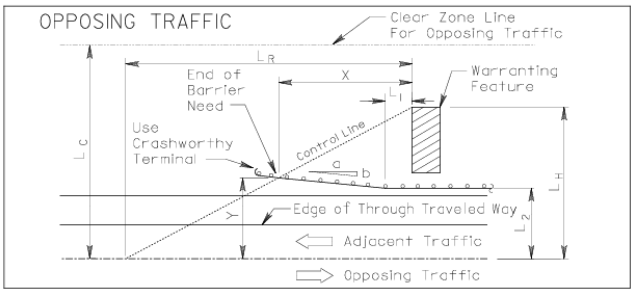
100.5.2 Length of Need (LON)

Length of need is the total length of a longitudinal barrier that is needed in advance of an area of concern (warranting feature). The length of need point in a gating end terminal or impact attenuator determines how much of the end treatment can be contributed to the length of need for the barrier. **Figure 8** should be used to determine the length of need on tangent alignments and on the inside of a horizontal

curve, and the tangential runout path method shown in **Figure 9** should be used to determine length of need on the outside of a horizontal curve.

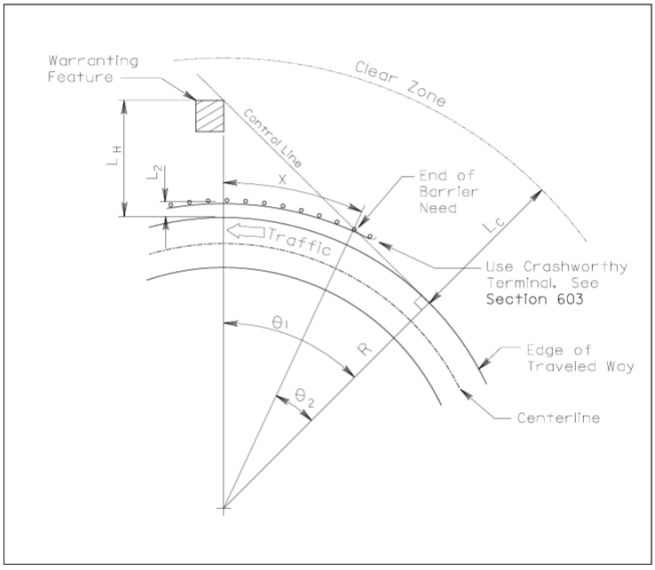
Short runs of barrier should be avoided where economically feasible. Gaps of 300’ or less between adjacent runs of guardrail should be closed.





Design Speed (mph)	Flare Rate (a:b)		Runout Length, L_R (ft) Per Design Year ADT				Formulas
	Concrete Barrier	MGS Guardrail	Over 10,000 veh/day	5,000-10,000 veh/day	1,000-5,000 veh/day	Under 1,000 veh/day	
75	20:1	7:1	415	380	335	290	X = Length of Need L_R = Runout Length L_C = Required Clear Zone L_H = Lateral Offset to Back of Warranting Feature L_2 = Lateral Offset to Face of Barrier (see Figure 301-3) L_1 = Varies (Typically measured to the end of a full panel of guardrail) If $L_H<L_C$: $X = \frac{L_H+(b/a)L_1-L_2}{(b/a)+L_H/L_R}$ $Y = L_H-X(L_H/L_R)$ If $L_H>L_C$: Substitute L_C in the above formulas.
70	20:1	7:1	360	330	290	250	
65	19:1	7:1	330	290	250	225	
60	18:1	7:1	300	250	210	200	
55	16:1	7:1	265	220	185	175	
50	14:1	7:1	230	190	160	150	
45	12:1	7:1	195	160	135	130	
40	10:1	7:1	160	130	110	100	
35	9:1	7:1	135	110	95	85	
30	8:1	7:1	110	90	80	70	

Figure 8 - Barrier Length of Need (Tangent Alignment) per L&D Vol 1 Figure 602-1



Formulas
X = Length of Need L_C = Required Clear Zone L_H = Lateral Offset to Back of Warranting Feature L_2 = Lateral Offset to Face of Barrier (See Figure 301-3, Guardrail Offset) If $L_H<L_C$: $X = (R+L_2)(\theta_1-\theta_2)$radians, where $\theta_1=\cos^{-1}(R/(R+L_H))$ and $\theta_1=\cos^{-1}(R/(R+L_2))$ R = 5729.58/Dc, where Dc = decimal degree of curve 1 degree = π/180 radians If $L_H>L_C$: Substitute L_C in the above formulas

Figure 9 - Barrier Length of Need (Curved Alignment) per L&D Vol 1 Figure 602-2

100.5.3 LON Field Check

The following is a guide for performing a check in the field to verify that adequate length of barrier is provided for adjacent traffic:

1. Stand in the shoulder, or berm if necessary to remain a safe distance from traffic, and walk along parallel to the edge line directly opposite the upstream end of the obstacle.

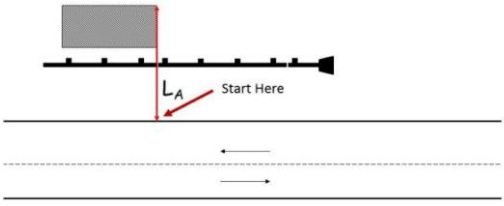


Figure 10 - LON Field Check Stand at Upstream End of Obstacle

2. Using a measuring wheel, walk upstream the appropriate runout length from table.

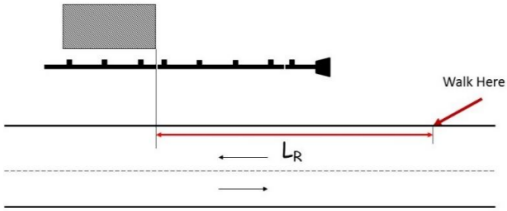


Figure 11 - LON Field Check Pace the Runout Length

3. From that point, turn and look at the back of the obstacle. (If the obstacle has no clear far side, such as a river or embankment, this distance may be limited to the design clear zone.)
4. If the proposed (or actual) guardrail installation that is non-gating crosses (or is close to) that line of sight, then the area should be adequately covered.

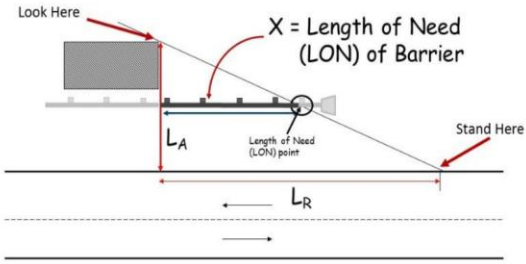


Figure 12 - LON Field Check Line of Sight to Back of Obstacle

The following is a guide for performing a check in the field to verify that adequate length of barrier is provided for opposing traffic:

5. Stand on the centerline directly opposite the downstream end of the obstacle with adequate maintenance of traffic measures in place.

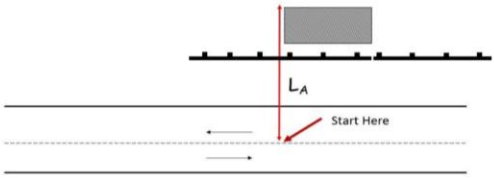


Figure 13 - LON Field Check Stand at Downstream End of Obstacle

6. Using a measuring wheel, walk downstream the appropriate runout length from table.

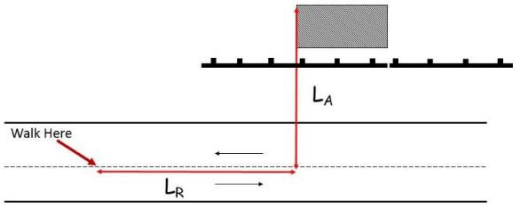


Figure 14 - LON Field Check Pace the Runout Length

7. From that point, turn and look at the back of the obstacle. (If the obstacle has no clear far side, such as a river or embankment, then this distance may be limited to the design clear zone—measured from the centerline.)
8. If the proposed (or actual) guardrail installation that is non-gating crosses (or is close to) that line of sight, then the area should be adequately covered.

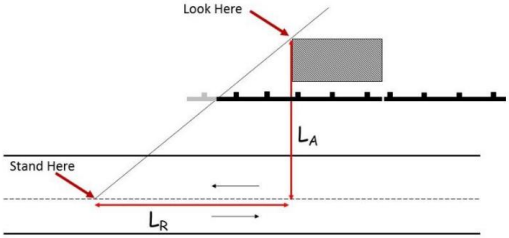


Figure 15 - LON Field Check Line of Sight to Back of Obstacle

Pay special attention to appropriately address all obstacles in the immediate vicinity that would warrant shielding. There may be other warranting obstacles near an obvious obstacle (i.e., the bridge pier), such as a steep transverse embankment within the clear zone that should be considered when determining adequate length of barrier.

100.5.4 Grading for Barriers & End Treatments

To function properly, end treatments and impact attenuators need to be installed with proper grading. The grading is designed to ensure that an impacting vehicle strikes the device at the appropriate height and with all four wheels on the ground. **Figure 16** shows minimum grading requirements for a flared anchor assembly. Note that the areas approaching and immediately adjacent to the anchor assembly should be no steeper than 1V:6H.

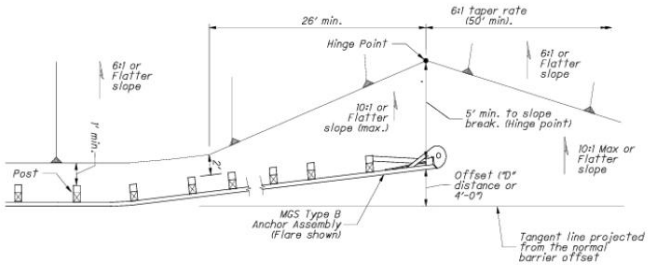


Figure 16 - Grading Plan for Flared Anchor Assemblies per SCD MGS-5.2

Figure 17 and SCD MGS-5.3 show the minimum grading requirements for a tangent anchor assembly. Note that the areas approaching and immediately adjacent to the anchor assembly should be no steeper than 1V:3H.

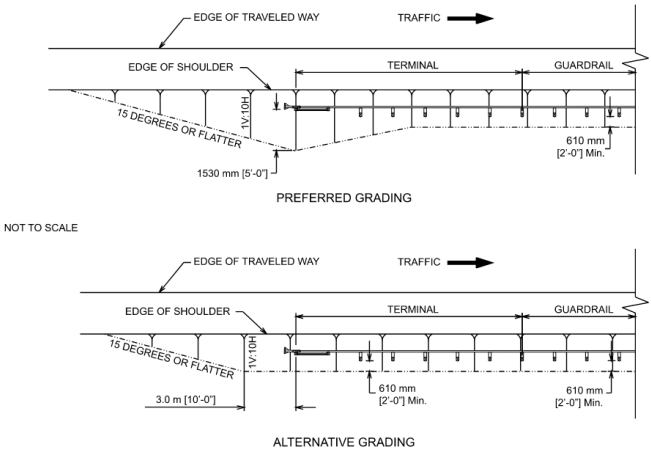


Figure 17 - Grading Section for Tangent Anchor Assemblies per AASHTO RSDG Figure 8-3

Ideally, the area immediately behind and downstream of all gating terminals should be reasonably traversable and free from fixed objects to the extent practical. A 20' by 75' area with 10:1 maximum slope is required when

practical. In most cases, longitudinal barriers should not be located on a slope steeper than 10:1.

100.5.5 Guardrail with Curbs

If guardrail is warranted and curbs are present, then the face of Type MGS guardrail should be located within 6” behind the face of the curb. Because of the vehicle vaulting potential, if the guardrail cannot be placed as described above, then the guardrail should be installed well behind the curb to allow the vehicle suspension to return to a normal state.

None of the approved anchor assemblies or impact attenuators have been designed or tested for use with curbs. The current recommendation from product vendors is to ensure curbs are not present (if practical) along the length of the product and for advance of 50’ in advance of the product.

100.6 Median Protection

Two types of shielding are necessary in medians. First, shielding of fixed objects is required if located in the clear zone of either direction of traffic. Second, if the median width warrants or a safety study shows a history or potential for Cross Median Crashes some type of barrier system may be needed.

100.6.1 Shielding of Fixed Objects in the Median

When a median hazard requires protection, the treatment depends upon the available width of the median. For the purposes of installing barrier, a median is considered wide when the barrier installed in the median does not extend into the clear zone of the opposing side of traffic. Conversely, when the guardrail run extends into the clear zone of the opposite side of traffic, the median is considered narrow.

Refer to SCD MGS-6.1 and MGS-6.2 Design A for narrow median barrier installations and Design B for wide median barrier installations.

100.6.2 Mitigation of Cross Median Crashes (CMC)

If a median barrier is determined to be necessary for shielding of CMC, then the selection of the type of barrier to be used in the median is based on several factors, including the Test Level desired, median cross section, and barrier deflection.

If cable barrier is selected to be placed in the median, the cable should be placed 8’ up the slope from the bottom of the ditch on 4:1 or flatter depressed median slopes to avoid concentrated flow, poor soil quality, and vehicle under-ride possibilities as shown in **Figure 18**. If

the median slopes are consistent, placement of cable on the slope outside of this zone is allowed. Another acceptable location for cable placement is at the top slope on one side of the median if the paved shoulder is wide enough to accommodate the minimum offset of 12' from the edge of traveled way. The maximum post spacing allowed is 15'. See *L&D Vol 1* Figures 602-3a, 602-3b, 602-4a, and 602-4b for more information.

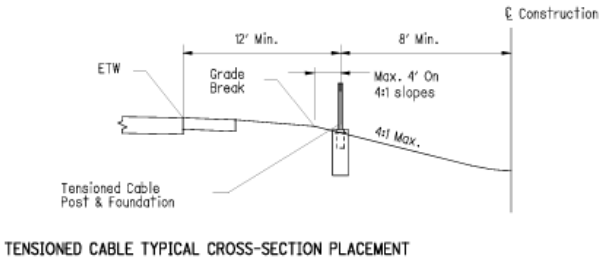


Figure 18 - Tensioned Cable Typical Cross-Section Placement per L&D Vol 1 Figure 602-3b

If installed in the clear zone, cable systems need to be terminated with crashworthy anchors. The maximum allowable distance between cable anchors is 3000 ft. Guardrail or concrete barrier should still be utilized to protect existing fixed objects as cable barrier should not be used as the primary means of shielding fixed objects in highway medians.

100.7 Gore Area Protection

Diverging gores are locations where one or more lanes of a road carrying traffic in the same

direction diverge away from each other. Impact attenuators are typically used to terminate the ends of longitudinal barriers located in diverging gores.

100.8 Protection at Drives and Side Roads

When normal mainline guardrail is interrupted by a side road or drive, the opening should be designed as shown in **Figure 19**.

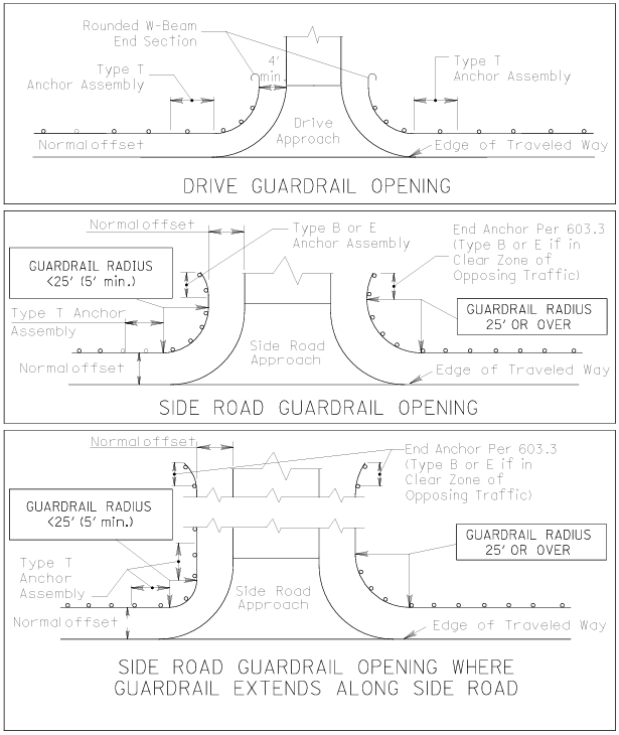


Figure 19 - Guardrail Openings per L&D Vol 1 Figure 603-3

100.9 Protection at Bridges and Fixed Objects

Concrete barrier end protection, utilizing guardrail with bridge terminal assemblies, shall be used at the approach end of bridge parapets, and other similar fixed objects, on all facilities where the design speed is 50 mph or greater. See SCD MGS-6.1 for details. Pier protection in narrow medians and along the roadside is often accomplished using concrete barrier.

Flared guardrail should be provided at overpasses and on safety and clear zone grading projects according to SCD MGS-6.1. Flared guardrail should be provided at underpasses or other fixed objects on safety and clear zone grading projects according to SCD MGS-6.2.

There are occasionally areas where the calculated lengths of need are impractical. An example would be where a drive or intersection is located too close to a bridge and cannot be relocated. In such cases, the approach guardrail length may be reduced as necessary. In no case shall the minimum treatment be less than shown in **Figure 20**.

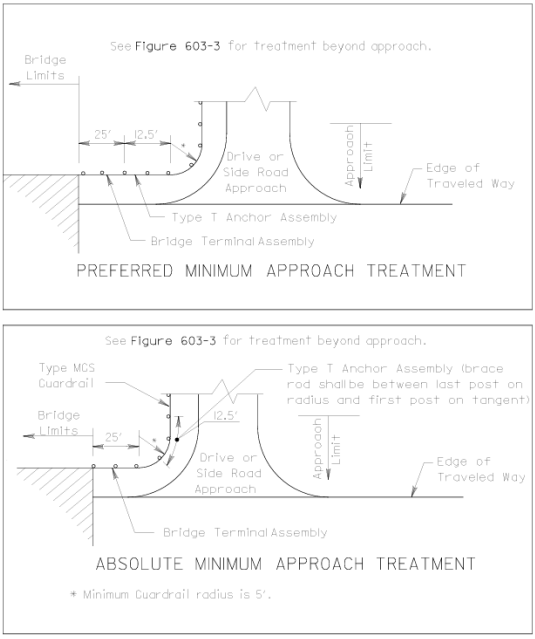


Figure 20 - Minimum Approach Treatment per L&D Vol 1 Figure 603-4

100.10 Protection at Drainage Structures

In general, no part of an unshielded drainage feature within a clear zone graded roadway, excluding curbs, should extend more than 4” above the surrounding terrain.

Transverse pipes with diameters or spans greater than 36” should either be extended outside of the clear zone when practical or shielded. Half-height headwalls should be placed at transverse pipe ends with diameters or spans less than or equal to 36” and the pipe extended outside of the clear

zone when practical where clear zone or safety grading is provided.

Intersecting embankments are slopes that are transverse to the roadway. They are usually created by median crossovers, intersecting roadways and driveways. These slopes are typically struck head-on by vehicles that have left the traveled way. Median crossovers on Interstates/Freeways shall use a 12:1 slope. Embankment slopes for side roads should be as flat as practical, and drainage pipes underneath side roads should be located outside of the mainline clear zone where practical. The intersecting embankment slopes for driveways should be as flat as practical with protruding drainage appurtenances and exposed pipes ends managed depending on roadway grading and pipe diameter or span.

100.11 Sight Distance Considerations

The introduction of longitudinal barriers may have an adverse effect on both horizontal and intersection sight distances. The effect on both distances should be investigated at all locations where barriers are used.

101 Roadside Safety Devices

The goal of any highway roadside safety device is simply to assist in providing a forgiving roadside for an errant motorist by either containing, redirecting, or decelerating the vehicle without causing serious injuries to the occupants of the vehicle or to other motorists, pedestrians, or work zone personnel. Other features may readily break away, allow a controlled penetration, or allow the vehicle to safety traverse over.

Roadway safety device shop drawings can be found on ODOT's Roadway Approved Products List website.

101.1 Longitudinal Barrier

Longitudinal barriers function by containing and redirecting impacting vehicles. They are typically classified into three types based on relative strength characteristics: flexible, semi-rigid and rigid.

Deflection characteristics of a longitudinal barrier system determine the minimum clearances between the face of the barrier and the face of the object it shields as discussed in section **100.5.1 Location/Offset**.

101.1.1 Flexible Cable Systems

Cable systems are considered flexible systems in that they tend to exhibit large deflections when impacted. Although large deflections can be problematic, they produce a relatively soft impact allowing for a gradual deceleration of the vehicle.

While generic low tension cable systems are no longer allowed to be constructed on ODOT's system, proprietary high tension four cable systems are used in medians of divided highways as a method of preventing cross median crashes. Although proprietary in nature, high-tensioned systems consist of the same standard cable mounted under substantial tension between anchors, but each system has its own light weight steel post.

Systems shall have a maximum deflection of 8' and the maximum longitudinal distance between posts shall be 15'. Posts are to be set in socketed concrete foundations with a 4' wide no mow strip. Transitions to w-beam guardrail are not allowed.

MASH*

Valtir - CASS S3 M10



Figure 21 – CASS S3 M10 image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Valtir LLC
- **Test Level**: *MASH 2009 TL-3 & TL-4
- **Characteristics:**
    - Utilizes S3 X 5.7 lb. LF I-Beam line posts
    - Four-cable, high tension system
    - Widened cable spread from 17.4″ to 42.4″ above ground
    - Top two cables are positioned in a vertical slot and two non-woven bottom cables are retained with hook bolts
    - NCHRP 350 & MASH TL-3 can be used on 4:1 or flatter slopes
    - NCHRP 350 TL-4 can be used on 6:1 or flatter slopes
    - MASH TL-4 can be used on 10:1 or flatter slopes

NCHRP 350

Brifen - WRSF



Figure 22 – WRSF image per manufacture's website

- Manufacturer Website
- **Manufacturer: Brifen USA Inc.**
- **Test Level**: NCHRP-350 TL-3 & TL-4
- **Characteristics:**
  - Wire Road Safety Fence (WRSF)
  - Utilizes Steel Z-Post line posts
  - Four-cable, high tension system
  - Widened cable spread from 18.5″ to 36.5″ above ground
  - The top cable rests in a vertical slot while the 3 lower woven cables are positioned at 6" intervals using plastic pegs
  - Can be used on flat grade for TL-4 and 4:1 or flatter slopes for TL-3

NCHRP 350

Gibraltar – TL 4 Four Cable System



Figure 23 – TL-4 Four Cable image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Gibraltar
- **Test Level**: NCHRP-350 TL-3 & TL-4
- **Characteristics**:
  - Utilizes 3 ¼" x 2 ½" C-Section line posts
  - Four-cable, high tension system
  - Widened cable spread from 20″ to 39″ above ground
  - Cables and posts attached with hairpins and lockplates
  - All cables on same side of each post and posts alternate sider of cables
  - Can be used on 6:1 or flatter slopes for TL-4 and 4:1 or flatter slopes for TL-3

NCHRP 350

Gregory - SAFENCE



Figure 24 – SAFENCE image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Gregory Industries, Inc.
- **Test Level**: NCHRP-350 TL-3 & TL-4
- **Characteristics**:
  - Utilizes SAFENCE® C-post line posts
  - Four-cable, high tension system
  - Widened cable spread from 18.9″ to 28.3″ above ground
  - The open slot in the line posts holds cables in position

NCHRP 350

Nucor - Nu-Cable



Figure 25 – Nu-Cable image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Nucor
- **Test Level**: NCHRP-350 TL-3 & TL-4
- **Characteristics**:
  - Utilizes Nucor U-Channel line posts
  - Four-cable, high tension system
  - Widened cable spread above ground varies based on TL and slope
  - Cables and posts attached with locking hooks
  - Can be used on 6:1 or flatter slopes for TL-4 and 4:1 or flatter slopes for TL-3

101.1.2 Semi Rigid Barriers

ODOT's approved semi rigid barriers include: Type 5 and Type Midwest Guardrail System (MGS) guardrail – both strong post w-beam guardrail systems. New guardrail designs should utilize MGS while Type 5 guardrail should be limited to repair locations of existing Type 5 guardrail.

The three major components of a strong post barrier are the rail, posts, and blockouts. This ribbon of rail acts to capture impacting vehicles and to dissipate energy up and down the rail length. The tension on the rail from an impact can be transferred a considerable distance. Proper anchoring of the rail at both ends is critical in achieving proper performance.

Paving around posts is not advisable if the thickness of the pavement would hinder the post rotation. 3" of asphalt pavement is the maximum allowable thickness for paving under guardrail.

Guardrail panels are to be lapped in the direction of travel of the adjacent traffic as shown by **Figure 26**. Although the chance of snagging on the end of a rail panel during impact is unlikely, reverse lapping is problematic for some maintenance activities (for example plowing snow). Rail lapping is also an important indicator of the quality of the installer's workmanship.



Figure 26 - Rail Lapping Image

MASH

Type MGS Guardrail



Figure 27 – Type MGS Guardrail image

- **Test Level**: MASH 2016 TL-3
- **Characteristics**:
  - Height (h): 31” standard height (±1”)

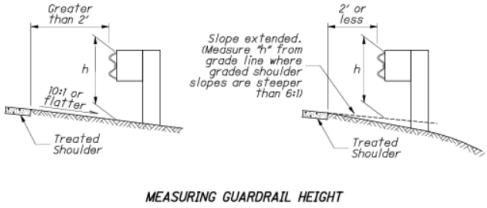


Figure 28 - Measuring Guardrail Height per SCD MGS-2.1

  - Note: when subsequent projects, such as resurfacings, affect the height of existing guardrail, adjustment is not required if the finished height is within ±3” of the standard height
  - Rail Splice: mid-span (between posts)
  - Post: W6x9 steel, W6x8.5 steel, 6”x8” wood, approx. 8” dia. wood posts, or an alternate from the Roadway Approved Products List (see CMS Section 710.12 for details) 6’ in length with a 3’-4”

minimum embedment depth (37” for round wooden posts)

- Standard Post Spacing: 6’-3” (reduced post spacing as shown on SCD MGS-2.1)
- Blockout: 6” wide x 12” deep x 14 ¼” long wood/plastic, or an alternate from the Roadway Approved Products List
- Maximum Foreslope: 10:1
- Maximum Flare Rate: 7:1
- Working Width: 5’ (standard post spacing), 3’-6” (half post spacing), 3’ (quarter post spacing) – see section 100.5.1 Location/Offset

- **Variations**:
  - Barrier Design Guardrail – addition of blockouts and rail on the opposite side of the posts as shown on SCD MGS-2.1
  - Long Span Guardrail - span up to 25’ across culverts as shown on SCD MGS-2.3.
  - Long Posts – long posts required where posts cannot be placed at least 1’ in front of the slope break point as shown on SCD MGS-1.1
  - Footing Anchor – mount posts located over a drainage inlet or structure with a cover less than 3’-4” to footing anchor as shown on SCD MGS-1.1
  - Socketed Weak Post – attach guardrail to headwall as shown on SCD MGS-2.4

NCHRP 350

Type 5 Guardrail



Figure 29 - Type 5 Guardrail image

- **Test Level**: NCHRP-350 TL-3
- **Characteristics**:
  - Height (h): 29” standard height (± 1”)

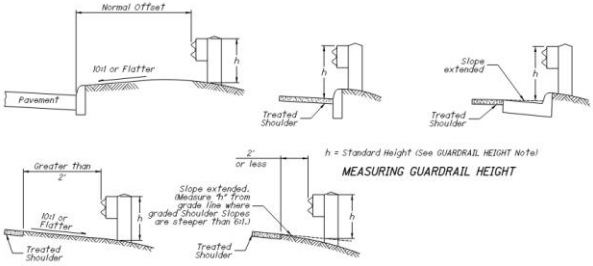


Figure 30 - Measuring Guardrail Height per PIS GR-1.1

  - Note: when subsequent projects, such as resurfacings, affect the height of existing guardrail, adjustment is not required if the finished height is within ±2.5” of the standard height
  - Rail Splice: at post
  - Post: W6x9 steel, W6x8.5 steel, 6”x8” wood, or 8” ± 1” dia. wood posts at top 6’ in length with a 3’-5” minimum embedment depth

- Standard Post Spacing: 6’ – 3” (reduced post spacing as shown on PIS GR-2.1)
- Blockout: 6” wide x 8” deep x 14” long, wood/plastic
- Maximum Foreslope: 10:1
- Maximum Flare Rate: varies with design speed, see PIS GIR-5.1
- Working Width: 5’-6”(standard Type 5 post spacing), 3’-6” (Type 5A post spacing) – see section 100.5.1 Location/Offset
- Variations:
- Barrier Design Guardrail – addition of blockouts and rail on the opposite side of the posts as shown on PIS GR-2.1
- Long Span Guardrail - span up to 25’ across culverts as shown on PIS GR-2.3 and GR-2.4
- Long Posts – 9’ long posts required where less than 2’ of graded shoulder width (10:1 or flatter) exists, measured from the face of the guardrail as shown on PIS GR-1.1
- Footing Anchor – mount posts located over a drainage inlet or structure to footing anchor as shown on PIS GR-1.1, or anchor per the details shown on PIS GR-2.2
- Nested Type 5 Guardrail with Tubular Backup – guardrail placed across culverts as shown on PIS GR-2.2
- Type 5MR - Median barrier guardrail system with a single rubrail as shown on PIS GR-5MR

RETIRED

Type 4 Guardrail

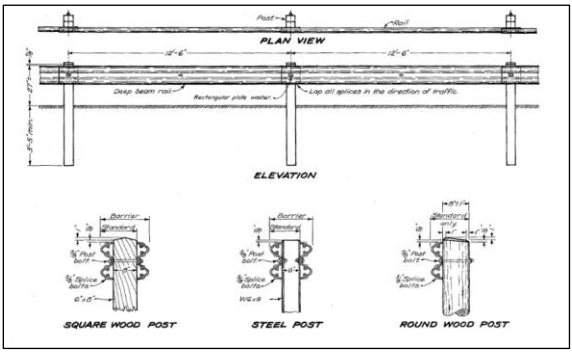


Figure 31 - Type 4 Guardrail archived SCD image

- **Characteristics**:
  - Height: 27”
  - Rail Splice: at post
  - Post: W6x8.5 steel, 6”x8” wood, or 8” ± 1” dia. wood posts at top 5’-9” in length
  - Standard Post Spacing: 12’ – 6”
  - Blockout: none

101.1.3 Rigid Concrete Barriers

Concrete barriers are used in locations where barrier deflections cannot be tolerated. Because of its rigidity and shape, it is very effective for small angle impacts and is preferred for use where the chance of impacting it at an angle of 15 degrees or greater is minimal. It also requires less maintenance than steel beam guardrails. Overall impact severities for these barriers are usually greater than the other types of systems.

ODOT's previous standard was the NJ safety shape barrier. This barrier type has a 3" vertical portion at the base which plays no significant role in the performance of the barrier but provides an allowance for one future pavement overlay. The NJ shape can be utilized on very short lengths where existing NJ barrier is present. ODOT changed its standard concrete barrier shape to that of a single slope in 2003. Single slope barriers have advantages of better crash test performance for TL-3 vehicles, and the capability of being a TL-5 barrier. It is also capable of having multiple pavement overlays placed next to it without having to reset the barrier.

MASH

Type B and B1 Single Slope Concrete Barrier

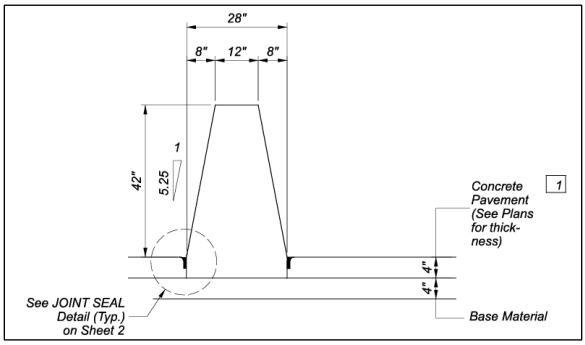


Figure 32 - SCD RM-4.3 Barrier image

- **Test Level:** MASH 2016 TL-3 with capability of being a TL-5
- **Characteristics:**
  - Type B is 28” wide at the base and 42” tall
  - Type B1 is 33.75” wide at the base and 57” tall with the additional height serving as a glare screen
  - See SCD RM-4.3 for details

MASH

Type C & C1 Single Slope Concrete Barrier

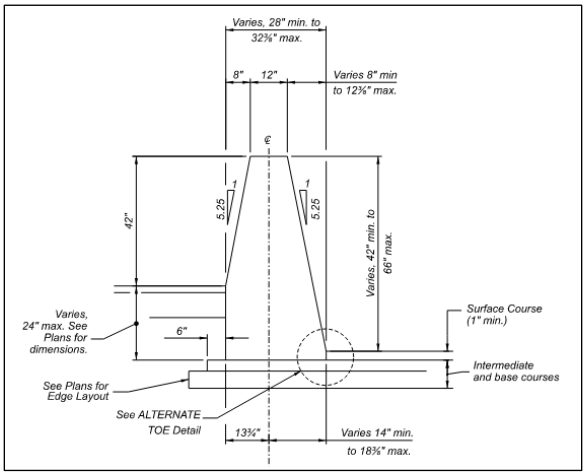


Figure 33 - SCD RM-4.3 Barrier image

- **Test Level**: MASH 2016 TL-3 with capability of being a TL-5
- **Characteristics**:
  - Used at narrow medians where the difference in elevation on either side of the barrier is less than or equal to 24”
  - Type C varies in width and has one side with a fixed height of 42” while the other side can vary in height from 42” to 66”
  - Type C1 varies in width and has one side with a fixed height of 57” while the other side can vary in height from 57” to 81” with the additional height serving as a glare screen
  - See SCD RM-4.3 for details

MASH*

Type D Single Slope Concrete Barrier

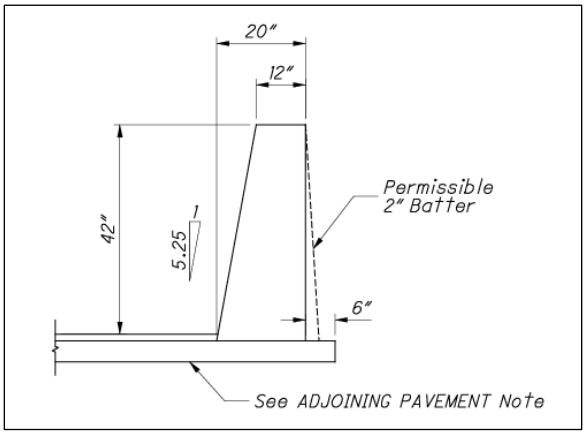


Figure 34 - SCD RM-4.5 Barrier image

- **Test Level**: *Expected to meet MASH 2016 TL-3 criteria based on Type B crash testing
- **Characteristics**:
  - Type D is 20” wide at the base and 42” tall with the single slope profile on only one side of the barrier
  - See SCD RM-4.5 for details

MASH

Type E Single Slope Concrete Barrier

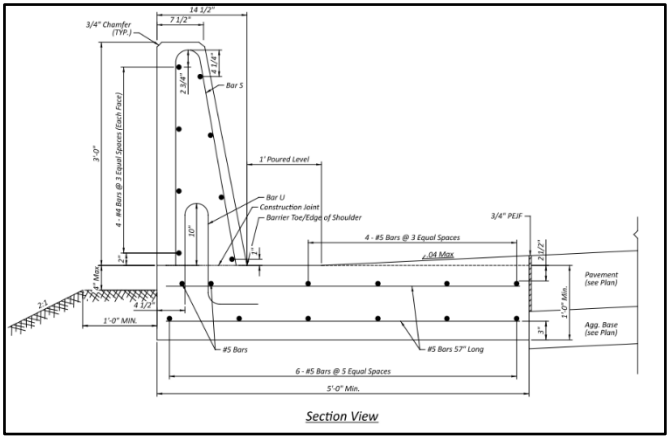


Figure 35 - SCD RM-4.9 Barrier image

- **Test Level**: MASH 2016 TL-4
- **Characteristics**:
  - The Type E concrete barrier is a 36” height single slope barrier with a foundation; the foundation can be a moment slab or grade beam
  - Top width is 7.5” and base width is 14.5”
  - See SCD RM-4.9 for details

MASH

Type N Single Slope Concrete Barrier

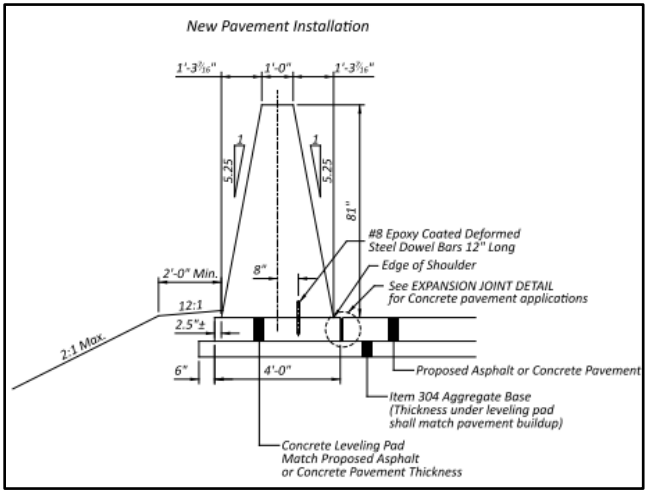


Figure 36 - SCD RM-4.8 Barrier image

- **Test Level**: MASH 2016 TL-3 with capability of being a TL-5
- **Characteristics**:
  - Type N is 3.57’ wide at the base and 81” tall with the single slope profile on both sides of the barrier
  - Top width is 1’-0”
  - Type N barrier doubles as a noise barrier
  - See SCD RM-4.8 for details

RETIRED

New Jersey Shape Concrete Barrier

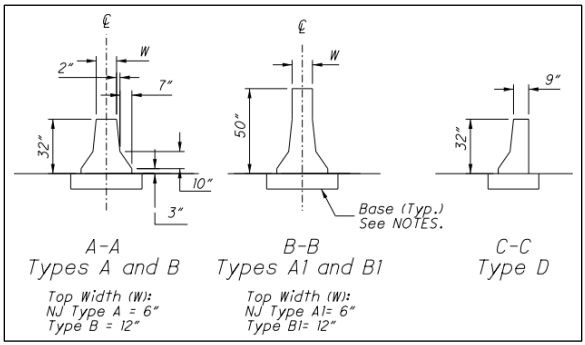


Figure 37 - PIS NJ-SSCB-TRANS Barrier image

- **Test Level**: NCHRP-350 TL-3
- **Characteristics**:
  - Safety shape barrier with a 3” vertical portion at the base
  - Barrier rests on concrete base
  - Type A and B are 32” tall with 6” and 12” top widths, respectively
  - Type A1 and B1 are 50” tall with 6” and 12” top widths, respectively
  - Type D is 32” tall with a 9” top width and safety shape on only one side of the barrier
  - See PIS NJ-SSCB-TRANS for details

101.2 Characteristics of End Terminals & Impact Attenuators

An end terminal functions by either decelerating the vehicle to a safe stop within a relatively short distance permitting controlled penetration of the vehicle behind the device, containing and redirecting the vehicle, or a combination of both. End treatments must also be capable of developing the full tensile strength of the rail elements.

Impact attenuators are designed primarily to safely stop a vehicle within a relatively short distance.

Crashworthy end treatments and impact attenuators can be classified as either energy absorbing or not, gating or non-gating, and redirective or non-redirective.

101.2.1 Energy Absorbing

When a vehicle impacts an energy absorbing end terminal, energy from the impact is dissipated in a variety of ways through the deformation of the vehicle's crush zone and also from the barrier itself.

101.2.2 Gating

A non-gating system will bring an impacting vehicle to a controlled stop or redirect it while a

gating system will allow a vehicle impacting the system at an angle to pass through the system along the same general path. Gating guardrail end terminals will remove very little of the impacting energy, thus vehicles will pass through the system at close to the impacting speed.

101.2.3 Redirection

A redirective system will redirect an impacting vehicle away from a fixed object when the system is struck at an angle on the side. A non-redirective system will allow a vehicle to continue in approximately the same direction until it comes to a stop.

101.3 Guardrail End Treatments

Lettings after Jan 1st, 2023 require 2016 Mash crash tested guardrail end treatments for new, permanent installations. NCHRP-350 guardrail end treatments may be repaired. For each ODOT Type system, all products and product configurations listed in that Type are considered equal.

Figure 38 provides guidance on anchor assembly selection criteria.

Table 603-1

Foreslope	New Construction / Major Reconstruction	3R, HSP and Bridge Replacement
6:1 or flatter	Buried-in-Backslope or Type B	Buried-in-Backslope or Type B
Steeper than 6:1 up to 4:1	Buried in Backslope or Type B	Buried in Backslope or Type E
Steeper than 4:1	Type E	Type E

Figure 38 – L&D Vol 1 Anchor Assembly Use Table 603-1

101.3.1 Type B Anchor Assembly

The Type B anchor assembly is a flared, redirective, gating end terminal. The Type B may be used as an approach end treatment for guardrail on any roadway. The Type B cannot be used when the back side of the device is in the clear zone of bidirectional traffic. The Type B products require a recovery area immediately behind the terminal detailed on SCD MGS-5.2 and PIS GR-5.2.

MASH

MFLEAT



Figure 39 – MFLEAT image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Road Systems, Inc.
- **Accepted for use on NHS Route**: Yes
- **Guardrail Type**: MGS and Type 5
- **Test Level**: MASH 2016 TL-3
- **Characteristics**:
  - Type B anchor assembly, flared, redirective, gating end terminal
  - MASH-compliant Flared Energy Absorbing Terminal (MFLEAT)
  - 39′-7″ straight flared length with 3' offset
  - Square impact head
  - Triangular ridge welded to top of impact head, angled along traffic-side edge
  - Impact head feeder guide chute is enclosed along traffic-side with 1 oval opening
  - Ground strut assembly between posts 1 & 2
  - BLON at post 4
  - Other features similar to the FLEAT system

MASH

4F-T



Figure 40 – 4F-T image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Valtir LLC
- **Accepted for use on NHS Route**: Yes
- **Guardrail Type**: MGS and Type 5
- **Test Level**: MASH 2016 TL-3
- **Characteristics**:
  - Type B anchor assembly, flared, redirective, gating end terminal
  - 34'-4 ½" straight flared length with 4' offset
  - 4'-2" c/c post spacing
  - Rectangular impact head
  - Ground strut assembly between posts 1 & 2
  - BLON at Post 4

NCHRP 350

FLEAT



Figure 41 – FLEAT-SP image per manufacture's website

- Manufacturer Website (FLEAT-SP)
- Manufacturer Website (FLEAT-SP-MGS)
- **Manufacturer**: Road Systems, Inc.
- **Accepted for use on NHS Route**: Yes
- **Guardrail Type**: MGS and Type 5
- **Test Level**: NCHRP-350 TL-2 & TL-3
- **Characteristics**:
  - Type B anchor assembly, flared, redirective, gating end terminal
  - FLared Energy Absorbing Terminal (FLEAT)
  - 25'-0" straight flared length with offset between 1′-8″ and 2′-8″ for TL-2
  - 37'-6" straight flared length with offset between 2′-6″ and 4′-0″ for TL-3
  - Rectangular impact head
  - Square bar welded to top of impact head, angled along traffic-side edge
  - Impact head feeder guide chute is open along traffic-side with 2 vertical struts
  - No ground strut assembly
  - BLON at post 3

NCHRP 350

SRT-31

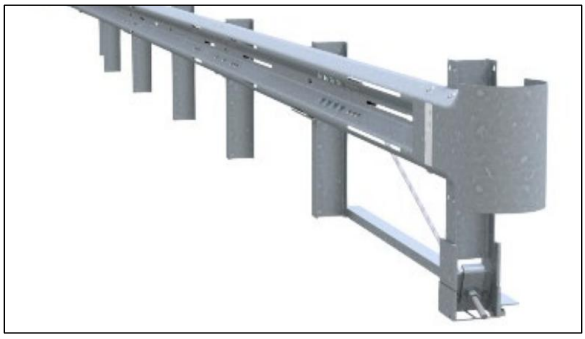


Figure 42 – SRT-31 image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Valtir LLC
- **Accepted for use on NHS Route**: Yes
- **Guardrail Type**: MGS
- **Test Level**: NCHRP-350 TL-3
- **Characteristics**:
  - Type B anchor assembly, flared, redirective, gating end terminal
  - Slotted Rail Terminal (SRT)
  - 40'-7 ½" straight flared length with 4' offset
  - 31" guardrail height
  - Curved buffer end section, no impact head
  - Longitudinal slots on w-beam rail element
  - Ground strut assembly between posts 1 & 2 on outside
  - BLON at post 3

NCHRP 350

SRT-350



Figure 43 – SRT-350 image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Valtir LLC
- **Accepted for use on NHS Route**: No
- **Guardrail Type**: Type 5
- **Test Level**: NCHRP-350 TL-3
- **Characteristics**:
  - Type B anchor assembly, flared, redirective, gating end terminal
  - Slotted Rail Terminal (SRT)
  - 6 and 8 post systems available
  - 6 post system:
    - 37'-6" straight flared length with 4' offset
    - 6'-3" post spacing
  - 8 post system:
    - 37'-6" parabolic flared length with 3', 3'-6", or 4' offset
    - 4'-2" post spacing changes to 6'-3" post spacing between posts 1 & 3
  - 27-¾" guardrail height
  - Curved buffer end section, no impact head
  - Longitudinal slots on w-beam rail element
  - Ground strut assembly between posts 1 & 2
  - BLON at post 3

RETIRED

MELT



Figure 44 – MELT image

- Manufacturer Website: N/A
- **Manufacturer**: non-proprietary
- **Accepted for use on NHS Route**: No
- **Guardrail Type**: Type 5
- **Test Level**: NCHRP-350 TL-2
- **Characteristics**:
  - Type B anchor assembly, flared, redirective, gating end terminal
  - Modified Eccentric Loader Terminal (MELT)
  - 37’-6” parabolic flared length with a 4’ offset
  - Curved buffer end section, no impact head
  - Uses standard w-beam rail elements
  - Ground strut assembly between posts 1 & 2
  - Comprised of wood posts only

101.3.2 Type E Anchor Assembly

The Type E anchor assembly is a tangent, redirective, gating end terminal. The Type E may be used as an approach end treatment for guardrail on any roadway. The Type E cannot be used when the back side of the device is in the clear zone of bidirectional traffic. The Type E products require a recovery area immediately behind the terminal detailed on SCD MGS-5.3 and PIS GR-5.3. The terminal should be offset to minimize the potential for impacts caused by vehicles clipping the portion of the impact head that protrudes in front of the face of the guardrail. The preferred offset method is detailed on SCD MGS-5.3 and PIS GR-5.3. The Type E should not be installed over a radius but may be installed with a 50:1 flare over the full length of the terminal or with a 25:1 flare over the first 25’ of the device.

MASH

MSKT



Figure 45 – MSKT-SP-MGS image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Road Systems, Inc.
- **Accepted for use on NHS Route**: Yes
- **Guardrail Type**: MGS
- **Test Level**: MASH 2016 TL-2 & TL-3
- **Characteristics**:
  - Type E anchor assembly, tangent, redirective, gating end terminal
  - MASH-compliant Sequential Kinking Terminal (MSKT)
  - 25'-0" length with no offset required, but straight flared offset between 0'-1' is recommended for TL-2
  - 50'-0" length with no offset required, but straight flared offset between 1'-2' is recommended for TL-3
  - Square impact head
  - Impact head feeder guide chute is enclosed along traffic-side with 2 oval openings
  - Ground strut assembly between posts 1 & 2
  - BLON at post 3

MASH

SoftStop



Figure 46 – SoftStop image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Valtir LLC
- **Accepted for use on NHS Route**: Yes
- **Guardrail Type**: MGS
- **Test Level**: MASH 2016 TL-1, TL-2, & TL-3
- **Characteristics**:
  - Type E anchor assembly, tangent, redirective, gating end terminal
  - 25'-9 ½" length for TL-1, 38'-3 ½ length for TL-2, 50'-9 ½" length for TL-3
  - Maximum straight flared offsets of 6" for TL-1, 1' for TL-2, and 2' for TL-3
  - Narrow, 7" wide, rectangular impact head
  - First rail element is cut longitudinally, threaded through impact head feeder guide chute
  - Embedded steel anchor with ground strut upstream of Post 1
  - BLON at post 3

MASH

SGET



Figure 47 – SGET image per manufacture's website

- Manufacturer Website
- **Manufacturer**: SPIG
- **Accepted for use on NHS Route**: Yes
- **Guardrail Type**: MGS
- **Test Level**: MASH 2016 TL-3
- **Characteristics**:
  - Type E anchor assembly, tangent, redirective, gating end terminal
  - 50'-0" system length
  - Maximum straight-line flare of 2' over entire system length.
  - Ground strut assembly between posts 1 & 2
  - BLON at post 3

NCHRP 350

SKT



Figure 48 – SKT-SP image per manufacture's website

- Manufacturer Website (SKT-SP)
- Manufacturer Website (SKT-SP-MGS)
- **Manufacturer**: Road Systems, Inc.
- **Accepted for use on NHS Route**: No
- **Guardrail Type**: MGS & Type 5
- **Test Level**: NCHRP-350 TL-2 & TL-3
- **Characteristics**:
  - Type E anchor assembly, tangent, redirective, gating end terminal
  - Sequential Kinking Terminal (SKT)
  - 25'-0" length with no offset required, but straight flared offset between 0'-1' is recommended for TL-2
  - 50'-0" length with no offset required, but straight flared offset between 1'-2' is recommended for TL-3
  - Square impact front face
  - Impact head feeder guide chute is open along traffic-side with 2 vertical struts
  - No ground strut assembly
  - BLON at post 3

RETIRED

ET-2000



Figure 49 – ET-2000 image

- Manufacturer Website: N/A
- **Manufacturer**: Valtir LLC (discontinued)
- **Accepted for use on NHS Route**: No
- **Guardrail Type**: MGS & Type 5
- **Test Level**: NCHRP-350 TL-3
- **Characteristics**:
  - Type E anchor assembly, tangent, redirective, gating end terminal
  - Predecessor to ET-Plus
  - 46'-10 ½" length with offset between 0' to 2'
  - Square impact head
  - Impact head feeder guide chute is open along traffic-side with 1 vertical strut
  - Rectangular holes in 1st rail allow for attachment of the tabs of the cable anchor bracket
  - Ground strut assembly between posts 1 & 2
  - BLON at post 3

RETIRED

ET-Plus



Figure 50 – ET-Plus image

- Manufacturer Website: N/A
- **Manufacturer**: Valtir LLC (discontinued)
- **Accepted for use on NHS Route**: No
- **Guardrail Type**: MGS & Type 5
- **Test Level**: NCHRP-350 TL-3
- **Characteristics**:
  - Type E anchor assembly, tangent, redirective, gating end terminal
  - 46’-10 ½” length with offset between 0’ to 2’
  - Rectangular impact head
  - Impact head feeder guide chute is open along traffic-side with 1 vertical strut
  - Rectangular holes in 1st rail allow for attachment of the tabs of the cable anchor bracket
  - Ground strut assembly between posts 1 & 2
  - BLON at post 3

101.3.3 Other End Treatment Types

Other non-proprietary end treatments include Type A Anchor Assembly, Type T Anchor Assembly, Type 8 Buried-In-Backlslope Anchor Assembly, and the Thrie-Beam Bullnose at Bridge Piers.

Type A Anchor Assembly



Figure 51 - Type A Anchor Assembly image

The Type A anchor assembly (twisted turned-down end) is a non-proprietary, non-redirective end terminal. It is 25’ long and may be used as an approach or trailing guardrail end treatment where a Type B or Type E anchor assembly is not feasible in any of the following situations:

1. On non-NHS arterials, collectors and local roads with a design average daily traffic volume of 2000 vpd or less.
2. On non-NHS roadway outside the clear zone.
3. On non-NHS roadway with an operating speed of less than 50 mph.

See SCD MGS-4.1 and PIS GR-4.1 for additional details.

MASH

Type T Anchor Assembly



Figure 52 - Type T Anchor Assembly (Wood Posts) image per Roadside Safety Pooled Fund Program website

The Type T anchor assembly is a non-proprietary, non-redirective end terminal that may be used on any roadway in any of the following situations:

1. On trailing ends of guardrail runs outside the clear zone of opposing traffic. Since the LON point is at the rear of this device, no portion of the Type T can be included within the guardrail length of need.
2. In guardrail runs where directional changes are made using a radius of less than 25' (see Figure 19 and Figure 20).
3. On the ends of guardrail runs on drive approaches (see **Figure 19**).

The Type T is 12.5' long. There are two designs that are considered equivalent from a crashworthiness perspective: the wood post system & the steel post system. See SCD MGS-4.2 and PIS GR-4.2 for additional details.

MASH

“MGS” Buried-In-Backslope



Figure 53 - Buried-In Backslope image per TTI Roadside Safety Pooled Fund Program website

The “MGS” buried-in-backslope anchor assembly is a flared, redirective, non-gating, non-proprietary, end terminal that meets MASH TL-3 criteria. The length of this terminal varies depending upon field conditions. It is installed with 4:1 or flatter foreslopes and backslopes as steep as 1:1. Where backslopes are flatter than 2:1 a 75’ minimum length of guardrail must be provided upstream between the warranting feature and the intersection of the guardrail with the ditch flowline. This anchor assembly may be used as an approach end treatment for guardrail on any roadway. See SCD MGS-4.5.

MASH

Thrie-Beam Bullnose (Steel-Post)



Figure 54 – Steel Post Bullnose image per Midwest Roadside Safety Pooled Fund Program website

The steel-post thrie-beam bullnose is a non-proprietary end terminal, typically used to shield bridge piers within the median. Posts 1 & 2 on each side nearest to the nose of the terminal are rectangular wood posts, and the remainder of the system is composed of steel posts. This terminal meets MASH TL-3 criteria. See SCD MGS-6.3 for additional details.

RETIRED

Type 8 Buried-In-Backslope



Figure 55 - Type 8 Buried-In Backslope image per Task Force 13 website

The buried-in-backslope anchor assembly is a flared, redirective, non-gating, non-proprietary, end terminal. The length of this terminal varies depending upon field conditions. Its construction is similar to guardrail except the buried-in-backslope terminal uses 8.0' long posts and a rubrail. It is installed with 4:1 or flatter foreslopes and backslopes as steep as 1:1. Where backslopes are 2:1 or flatter a 75' minimum length of guardrail must be provided upstream between the warranting feature and the intersection of the guardrail with the ditch flowline. This anchor assembly may be used as an approach end treatment for guardrail on any roadway. See SCD MGS-4.5 dated 1/18/2013 and PIS GR-4.5 for additional details.

RETIRED

Thrie-Beam Bullnose (Wood-Post)



Figure 56 - Thrie-Beam Bullnose image per Task Force 13 website

The wood-post thrie-beam bullnose is a non-proprietary end terminal used to shield bridge piers within the median. See SCD GR-6.3 for additional details.

101.4 Impact Attenuators

Impact Attenuators, also known as crash cushions, are generally used to shield motorists from rigid structures like bridge piers and end of concrete barriers. Since impact attenuators can be installed in two sided situations, they are well suited for median or gore applications.

Lettings after Jan 1st, 2023, require Mash 2016 crash tested Impact Attenuators for new, permanent installations. Where no ODOT approved MASH crash tested devices meets the necessary design width, an ODOT approved NCHRP-350 crash tested device may be used. NCHRP-350 Impact Attenuators may be repaired. For each ODOT Type system, all products and product configurations listed in that Type are considered equal.

101.4.1 Type 1 Impact Attenuator

Type 1 impact attenuators are redirective, gating, proprietary median guardrail terminal and crash cushion. Type 1's can be installed on any roadway in unidirectional and bidirectional configurations, but they must have at least 10' of clearance on both sides of the device. A maximum flare of 20:1 is permissible. Generally Type 1 Impact Attenuators are used in wider medians to safely end barrier design guardrail runs.

All systems are sacrificial, meaning they absorb impact kinetic energy by deforming the steel rail elements and/or breaking wood posts. Most of these systems are not reusable after an impact and must be replaced with new parts.

MASH

MATT



Figure 57 – MATT image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Valtir LLC
- **Test Level**: MASH 2016 TL-1, TL-2, and TL-3
- **Characteristics**:
  - Type 1 impact attenuator, redirective, gating crash cushion
  - Median Attenuating Trend Terminal (MATT)
  - 34'-4 ½" length
  - 2'-5" width at impact head
  - Square impact head with rounded corners, flanges on all sides, and angle braces on top and bottom flanges
  - Longitudinal slots on double-sided w-beam rail elements
  - Ground strut assembly between posts 1 & 2
  - BLON at post 3

NCHRP 350

CAT 350



Figure 58 – CAT 350 image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Valtir LLC
- **Test Level**: NCHRP-350 TL-3
- **Characteristics**:
  - Type 1 impact attenuator, redirective, gating crash cushion
  - Cushion Attenuating Terminal (CAT)
  - 31'-3" length
  - 29" width
  - Curved nose plate
  - Longitudinal slots on double-sided w-beam rail elements
  - Ground strut assembly between posts 1 & 2
  - BLON at post 4

NCHRP 350

FLEAT-MT



Figure 59 – FLEAT-MT image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Road Systems, Inc.
- **Test Level**: NCHRP-350 TL-3
- **Characteristics**:
  - Type 1 impact attenuator, redirective, gating crash cushion
  - FLared Energy Absorbing Terminal - Median Terminal (FLEAT-MT)
  - 37'-6" length with straight flare between posts 1-4 with 2' offset
  - 2 rectangular impact heads, staggered
  - Square bar welded to top of each impact head, angled along traffic-side edge
  - Impact head feeder guide chute is open along traffic-side with 2 vertical struts
  - Ground strut assembly between posts 1 & 2
  - BLON at post 3

RETIRED

Brakemaster 350



Figure 60 – Brakemaster 350 image

- Manufacturer Website: N/A
- **Manufacturer**: Valtir LLC (discontinued)
- **Test Level**: NCHRP-350 TL-3
- **Characteristics**:
  - Type 1 impact attenuator, redirective, gating crash cushion
  - 32’-8” length
  - Steel nose assembly
  - Double-sided w-beam rail elements
  - Tensioning (brake) cable upstream of post 1
  - Posts 3-5 are on surface mounted skids (not embedded)

101.4.2 Type 2 Impact Attenuator

Type 2 impact attenuators are reusable, redirective, non-gating proprietary systems that can be installed on any roadway in unidirectional and bidirectional configurations. Some of the major components of these crash cushions can be reused after an impact.

Type 2 attenuators are ideal to protect the ends of rigid objects like concrete barrier ends. Some other uses could be for connection to guardrail runs in diverging gores or narrow medians.

MASH

QuadGuard M10



Figure 61 – QuadGuard M10 image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Valtir LLC
- **Test Level**: MASH 2016 TL-2 & TL-3
- **Characteristics**:
  - Type 2 impact attenuator, reusable, redirective, non-gating crash cushion
  - 13' length of TL-2, 22' length for TL-3
  - 24" width
  - Steel nose
  - Double-sided quad-beam rail elements
  - Monorail base runs length of system and bolted to pad
  - Energy absorbing cartridge between bulkheads

MASH

QuadGuard M Wide



Figure 62 – QuadGuard M Wide image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Valtir LLC
- **Test Level**: MASH 2016 TL-3
- **Characteristics**:
  - Type 2 impact attenuator, reusable, redirective, non-gating crash cushion
  - 22' length
  - 69" width
  - Steel nose
  - Double-sided quad-beam rail elements
  - Monorail base runs length of system and bolted to pad
  - Energy absorbing cartridge between bulkheads

MASH

TAU-M



Figure 63 – TAU-M image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Lindsay
- **Test Level**: MASH 2016 TL-2 & TL-3
- **Characteristics**:
  - Type 2 impact attenuator, reusable, redirective, non-gating crash cushion
  - 14'-2" length for TL-2, 22'-9" length for TL-3
  - 30" wide
  - Steel nose
  - Double-sided thrie-beam rail elements
  - System is bolted to pad at the leading and trailing ends of the system
  - Barrel shaped energy absorbing cartridge between bulkheads

MASH

Delta



Figure 64 – Delta image per manufacture's website

- Manufacturer Website
- **Manufacturer**: TrafFix Devices
- **Test Level**: MASH 2016 TL-2 & TL-3
- **Characteristics**:
  - Type 2 impact attenuator, reusable, redirective, non-gating crash cushion
  - 13' length for TL-2, 21' length for TL-3
  - 30" width
  - Plastic nose
  - Series of thrie-beam fender panels supported by diaphragms

MASH

NOVUS 100



Figure 65 – NOVUS 100 image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Valtir LLC
- **Test Level**: MASH 2016 TL-3
- **Characteristics**:
  - Type 2 impact attenuator, reusable, redirective, non-gating crash cushion
  - 21' length for TL-3
  - 26" width
  - Series of steel diaphragms and side panels mounted to a base track
  - 33 anchors required
  - New units arrive fully assembled

NCHRP 350

QuadGuard



Figure 66 – QuadGuard image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Valtir LLC
- **Test Level**: NCHRP-350 TL-1, TL-2, & TL-3
- **Characteristics**:
  - Type 2 impact attenuator, reusable, redirective, non-gating crash cushion
  - Varying lengths up to 21'
  - 2' to 10'-6" width
  - Plastic nose
  - Double-sided quad-beam rail elements
  - Monorail base runs length of system and bolted to pad
  - Energy absorbing cartridge between bulkheads

NCHRP 350

TAU-II



Figure 67 – TAU-II image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Lindsay
- **Test Level**: NCHRP-350 TL-1, TL-2, & TL-3
- **Characteristics**:
  - Type 2 impact attenuator, reusable, redirective, non-gating crash cushion
  - Varying lengths
  - Maximum 102" width
  - Curved plastic nose
  - Double-sided thrie-beam rail elements
  - System is bolted to pad at the leading and trailing ends of the system
  - Barrel shaped energy absorbing cartridge between bulkheads

NCHRP 350

TRACC

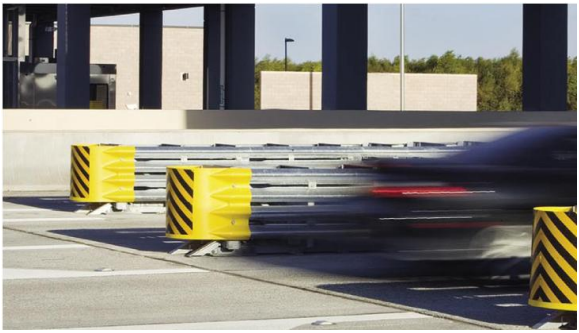


Figure 68 – TRACC image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Valtir LLC
- **Test Level**: NCHRP-350 TL-2 & TL-3
- **Characteristics**:
  - Type 2 impact attenuator, reusable, redirective, non-gating crash cushion
  - TRACC Family includes TRACC (21' length, 24" or 30" width, TL-3), ShorTRACC (14' length, 24" or 30" width, TL-2), FasTRACC (25'-8" length, 24" or 30" width, TL-3+), and WideTRACC (21' minimum length, 31"-58" width, TL-3+)
  - Base with rip plates bolted to pad
  - Curved plastic nose
  - Double-sided quad-beam rail elements

101.4.3 Type 3 Impact Attenuator

Type 3 impact attenuators are low-maintenance/self-restoring crash cushions typically considered for use at locations where high frequencies of impacts is expected. Maintenance is required with these units after impacts to restore full capacity for design impact conditions.

Type 3 impact attenuators should be specified in lieu of Type 2 impact attenuators when a higher than normal impact frequency would be expected.

MASH

REACT M



Figure 69 – REACT M image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Valtir LLC
- **Test Level**: MASH 2016 TL-3
- **Characteristics**:
  - Type 3 impact attenuator, self-restoring crash cushion
  - 22' – 2 ¾" length
  - 38-3/4" cylinder width
  - HDPE cylinders with redirective cables on outside

MASH

Smart Cushion



Figure 70 – Smart Cushion image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Hill & Smith Inc.
- **Test Level**: MASH 2016 TL-2 & TL-3
- **Characteristics**:
  - Type 3 impact attenuator, self-restoring crash cushion
  - 13'-6" length for TL-2, 21'-6" length for TL-3
  - 24" width
  - Metal nose
  - Double-sided quad-beam rail elements
  - System includes a hydraulic cylinder and steel cable assembly visible within the bays

MASH

QuadGuard Elite M10



Figure 71 – QuadGuard Elite M10
image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Valtir LLC
- **Test Level**: MASH 2016 TL-3
- **Characteristics**:
  - Type 3 impact attenuator, self-restoring crash cushion
  - 27'-2" system length
  - 24" width
  - Flex-Belt Nose
  - Quad-beam panels
  - System includes HDPE cylinders

MASH

QuadGuard Elite M10 Wide



Figure 72 – QuadGuard Elite M10 Wide
image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Valtir LLC
- **Test Level**: MASH 2016 TL-3
- **Characteristics**:
  - Type 3 impact attenuator, self-restoring crash cushion
  - 27'-1" system length
  - 69" width
  - Flex-Belt Nose
  - Quad-beam panels

NCHRP 350

HEART



Figure 73 – Heart image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Valtir LLC
- **Test Level**: NCHRP-350 TL-3
- **Characteristics**:
  - Type 3 impact attenuator, self-restoring crash cushion
  - 26' length
  - 25" to 27" width at the diaphragms with a maximum width of 36" between diaphragms 2 and 3
  - HMW/HDPE wave shaped side panels and rounded nose connected to steel diaphragms mounted on tubular steel tracks

NCHRP 350

QuadGuard ELITE



Figure 74 – QuadGuard ELITE image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Valtir LLC
- **Test Level**: NCHRP-350 TL-2 & TL-3
- **Characteristics**:
  - Type 3 impact attenuator, self-restoring crash cushion
  - 26'-9" length
  - 24", 30", 36", 69", and 90" widths
  - Flex-belt nose
  - Double-sided quad-beam rail elements
  - Monorail base runs length of system and bolted to pad
  - Energy absorbing open HDPE cylinders between bulkheads

NCHRP 350

REACT 350

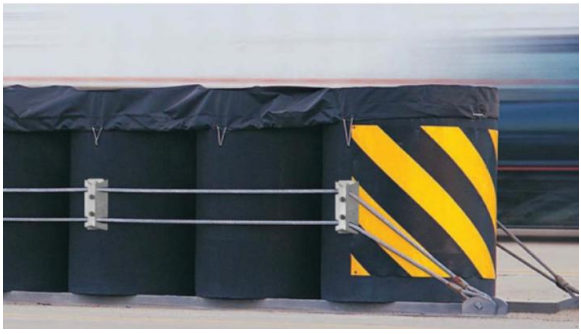


Figure 75 – REACT 350 image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Valtir LLC
- **Test Level**: NCHRP-350 TL-1, TL-2, and TL-3
- **Characteristics**:
  - Type 3 impact attenuator, self-restoring crash cushion
  - 28'-9" length with concrete backup structure, 30'-3" length for self-contained backup structure
  - 36″ width
  - HMW/HDPE cylinders with redirective cables on outside

101.5 Sand Barrels

Sand barrel arrays are proprietary sand-filled modules of varying sizes arranged in a pattern designed to protect wide hazards. Sand barrel arrays are appropriate in limited situations for the protection of wide hazards when no other product is acceptable. Because each product is different a specific design layout is required for each location based on the design speed and width of the hazard being shielded. All arrays installed on the NHS must meet NCHRP Report 350 Test Level 3 criteria.

Lettings after Jan 1st, 2023 require Mash crash tested Sand Barrels for new, permanent installations. NCHRP-350 Sand Barrels may be repaired.

MASH

Big Sandy



Figure 76 – Big Sandy image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Traffix Devices Inc.
- **Test Level**: MASH 2016 TL-3

MASH

CrashGard



Figure 77 – CrashGard image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Plastic Safety Systems, Inc.
- **Test Level**: MASH 2016 TL-3

MASH

Energite III



Figure 78 – Energite III image per manufacture's website

- Manufacturer Website
- **Manufacturer**: Valtir LLC
- **Test Level**: MASH 2016 TL-3

RETIRED

Fitch Universal Module System



Figure 79 – Fitch Universal Module System image per manufacture's website

- Manufacturer Website: N/A
- **Manufacturer**: Valtir LLC (discontinued)
- **Test Level**: NCHRP-350 TL-3

101.6 Bridge Terminal Assemblies

When a less rigid barrier is to be connected to a more rigid barrier, a stiffening transition is needed to make the connection. A transition from a more rigid barrier to a less rigid barrier doesn't require any stiffening unless the barrier can be struck from the opposite direction. Even when the difference in strength is not an issue, a transition is frequently required simply to connect two barrier systems that have different hardware components. Transitions in Ohio are called Bridge Terminal Assemblies because they are typically required where guardrail is warranted in conjunction with bridge parapets/railings. They are also used to connect guardrail to concrete barrier and other similar fixed objects.

MASH

Type 1 Bridge Terminal Assembly



Figure 80 - Type 1 Bridge Terminal Assembly to Concrete Barrier image



Figure 81 - Type 1 Bridge Terminal Assembly to TST image

- The Bridge Terminal Assembly, Type 1 is commonly used to connect guardrail to a concrete barrier, concrete bridge parapet, or twin steel tube bridge rail.
- It uses blocked-out, nested, thrie-beam guardrail panels attached to a vertical concrete surface to transition to the guardrail.
- The addition of a curb under the stiffer thrie-beam transition panel enables the assembly to meet TL-3 when connecting to the concrete

barrier or parapet. Curb is not required when connecting to twin steel tube bridge rail.

- It is generally installed at the following locations:
  1. At the approach end of a rigid object.
  2. At the trailing end of a rigid object if it is located within the clear zone of opposing traffic.
  3. To connect Type MGS Guardrail to Twin Steel Tube Bridge Rail
- Where designs require the upstream guardrail to be used in conjunction with curb for drainage purposes, the section 25 ft. immediately prior to this transition assembly should be without curb.
- A barrier design is commonly used to connect barrier design guardrail or a Type 1 Impact Attenuator to a concrete median barrier. It uses blocked-out, nested, thrie-beam, guardrail panels attached to a vertical face on both sides of the barrier to transition to the guardrail or attenuator.
- See SCD MGS-3.1, PIS GR-3.1, PIS GR-3.5, and PIS GR-3.6 for additional details.

MASH

Type 2 Bridge Terminal Assembly



Figure 82 - Type 2 Bridge Terminal Assembly image

- The Bridge Terminal Assembly, Type 2 is commonly used to connect guardrail to the trailing end of a concrete barrier or bridge parapet located outside the clear zone of opposing traffic.
- It uses standard w-beam guardrail panels attached to a vertical face on the concrete barrier to transition to the guardrail.
- When used as a trailing end assembly, it can be used on the NHS.
- See SCD MGS-3.2 and PIS GR-3.2 for additional details.

MASH

Type TST-2 Bridge Terminal Assembly



Figure 83 - Type TST-2 Bridge Terminal Assembly image

- The Bridge Terminal Assembly, Type TST-2 is used to connect MGS guardrail to TST-2-21 bridge railing.
- See SCD MGS-3.3 for additional details.

RETIRED

Type 3 Bridge Terminal Assembly

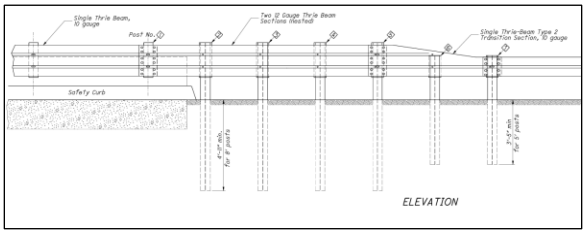


Figure 84 - PIS GR-3.3 Barrier image

- The Bridge Terminal Assembly, Type 3 was commonly used to connect Type 5 guardrail to the approach and trailing ends of thrie-beam bridge railings and has since been retired.
- See PIS GR-3.3 for additional details.

RETIRED

Type 4 Bridge Terminal Assembly



Figure 85 - Type 4 Bridge Terminal Assembly image

- The Bridge Terminal Assembly, Type 4 was used to connect Type 5 guardrail to the approach and trailing ends of bridges having tubular backup bridge railing and has since been retired.
- It was also used to transition between Type 5 guardrail and Type 5 guardrail with Tubular Backup.
- See PIS GR-3.4 for additional details.

101.7 Concrete Barrier End Treatment

The end of a concrete barrier may be a hazard if not treated properly. Since a rigid barrier generally does not require end anchorage to develop its strength, the simplest means of providing impact protection for the barrier end may be to terminate the barrier beyond the clear zone. When this approach is used, the flare rate used to offset the barrier should not exceed the flare rates recommended in *L&D Vol 1* Figure 602-1. However, when the end of a concrete barrier is located within the clear zone, a terminal is necessary to protect a vehicle's occupants in an end-on impact.

Acceptable end treatments include the following:

1. Transition to guardrail using a bridge terminal assembly and terminate the end of the guardrail run with an anchor assembly.
2. Use an impact attenuator.
3. Terminate the concrete barrier directly into a cut backslope.
4. Use a tapered end section only when the barrier is terminated outside the clear zone, or when the barrier is on a non-NHS road with a design speed less than or equal to 40 mph (NCHRP Report 350 TL-2) and space is limited by right-of-way constraints or presence of other roadside features that preclude the use of an approved end treatment.

102 Maintenance of Roadside Safety Devices

Keep barrier systems in reasonable working condition so they are able to function as designed. Some deterioration occurs as a result of crash damage and environmental degradation. Much of this wear can be considered cosmetic and may not measurably affect barrier performance. However, some kinds of damage may significantly degrade performance. Repair to these types of damage should be made in a reasonable time frame. It is important to assess, prioritize, and schedule identified damaged barrier sites.

While it is not practical to quantitatively define "in a timely manner", each identified damaged barrier site must be assessed, prioritized and scheduled for repairs based upon risk exposure (highway type, extent of barrier/terminal damage, potential for being restruck within the repair time window, etc.).

102.1 General Maintenance Guidelines

The following are General Guidelines for maintenance:

- Delineate the area of damage to warn the motorists as soon as practical after the discovery/notification of the impact. For some

types of damage, such as a ruptured rail or an end treatment left in a condition such that it does not function and/or is not crashworthy, schedule repair as soon as practical. To temporarily mitigate a blunt rail end condition, one option is to unbolt the rail from several posts and drop the leading end to the ground. This will avoid exposing a blunt end condition until the installation can be repaired.

- Review damaged guardrail as soon as reasonable to determine the scope of repair based on individual site conditions.
- If damage to non-standard barrier requires reconstructing a significant portion of the run, consider upgrading the entire run to current standards.
- If a significant length of substandard height guardrail is damaged or deteriorated and the whole system is not being upgraded, repair the damaged or deteriorated length to the latest standard for that system.

When barrier is damaged to the point where repairs are needed, several questions should be asked before the damaged hardware is simply replaced in-kind:

- Is the barrier warranted or could it be removed?

- Does the barrier meet current design standards or should it be upgraded?
- Is the guardrail end treatment an acceptable crash-tested design?
- If crashworthy, is the guardrail end treatment the most appropriate type for the location?

102.2 Maintenance of Flexible Cable Systems

Cable guardrail systems are designed to contain and redirect a striking vehicle while minimizing the forces on the vehicle and its occupants. Proper maintenance as listed below includes checking that the cables are properly tensioned and at the correct height:

- Perform routine tension checks, even in the absence of a strike. Tension checks are particularly important during the first few years following installation.
- Check for missing or damaged posts. Damaged posts can present a spearing concern should a secondary impact occur. Remove damaged or bent over posts to eliminate the spearing potential.
- Check the cable height and repair to meet manufacturer's specifications.
- Inspect cable for kinks or broken strands.
- Check that cables are attached to the anchors, and that the anchors are flush with the ground surface.

- In the event of a crash resulting in a vehicle becoming entangled in the cable, keep the cable intact. Only cut the cable when there is a life-or-death situation. Alternatives to cutting the cable include:
  - Removing the vehicle by towing it in the opposite direction from which it hit the system.
  - Loosening the cables at the turnbuckles.
  - Releasing at anchoring points.
  - Cutting the turnbuckle, which is referred to cutting the cable. Remove the adjacent posts on either side of the turnbuckle. Ensure personnel are clear of the cable; cut the center of the turnbuckle, as shown in Figure 86.

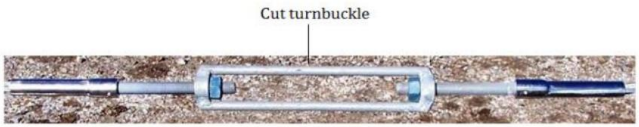


Figure 86 - Turnbuckle Cut Location image

102.3 Maintenance of Semi Rigid Barrier

The types of guardrail damage listed below may result in inadequate structural and substandard redirective performance:

- Vertical tears in the W-beam rail that begin at the top or bottom edge. These are likely to result in rail separation in a subsequent crash.
- Holes in the rail resulting from damage or deterioration that reaches the top or bottom

of a rail or one hole with a section greater than 1” or several holes with a dimension less than 1” within a 12.5’ length of rail.

- More than 2 missing or ineffective splice bolts.
- More than 9” of lateral deflection over a 25’ length of rail.
- Top rail height more than 2.5” or 3” lower or higher than the original rail height of Type 5 and MGS guardrail systems, respectively.
- Rail flattening that increases the W-beam section width from its original 12”.
- Rotted wood posts.
- Missing blockouts.
- Eroded/improper grading in front of and behind rail installations.

Maintain guardrail as constructed. Refer to the plans and design standards for proper installation.

102.4 Maintenance of Guardrail End Treatments

The following types of guardrail end treatment damage may result in inadequate performance if hit:

- Broken or damaged end posts.
- Missing or very slack rail-to-end post cables.
- Missing cable bearing plate at end posts.
- Impact head not properly aligned with W-beam rail elements.
- W-beam rail element not properly seated in the impact head.

Maintain guardrail end treatments as constructed. Refer to the plans, design standards, and manufacturers' manuals for proper installation.

102.5 Maintenance of Impact Attenuators

The following types of impact attenuator damage may result in inadequate performance if hit:

- Devise twisted from side impacts
- Cracked, damaged, or unseated cylinders/cartridges
- Loosened, broken, or pulled out anchors
- Cables are not attached or tensioned
- Loose or rusted bolts
- Unnested side panels

Maintain impact attenuators as constructed. Refer to the plans, design standards, and manufacturers' manuals for proper installation.

102.6 National Guidelines for W-Beam System Maintenance

The following pages consist of excerpts from NCHRP Report 656, *Criteria for the Restoration of Longitudinal Barrier*. Note that the types and degree of damage to the barrier itself and end treatments is prioritized as High, Medium, or Low. Use these rankings, along with the perceived likelihood of a second impact — at the crash-testing criteria of high speed, high angle — in the same location to set repair priorities.

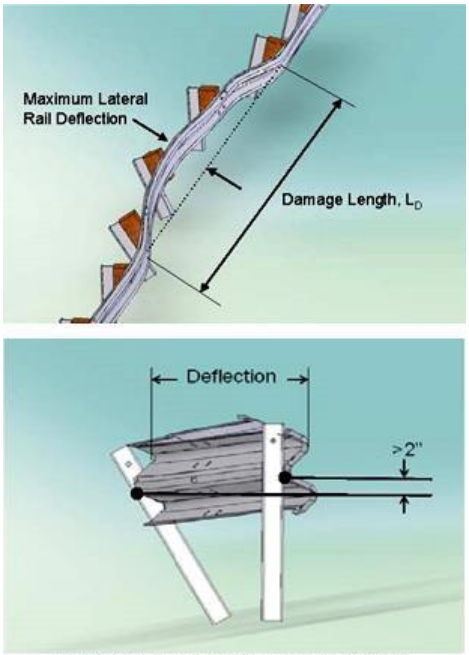
Note: These evaluations were based on analysis of the Type 5 system, not the MGS, under NCHRP 350 testing. For example, MGS will still function with one post missing as long as 50' of guardrail (which may include the anchor) is available both upstream and downstream of the omitted post to maintain tension and strength in the system.

Repair Priority Scheme

Priority Level	Description
High	A second impact results in unacceptable safety performance including barrier penetration and/or vehicle rollover.
Medium	A second impact results in degraded but not unacceptable safety performance.
Low	A second impact results in no discernible difference in performance from an undamaged barrier.

W-beam Barrier Repair Threshold

Damage Mode: Post and Rail Deflection

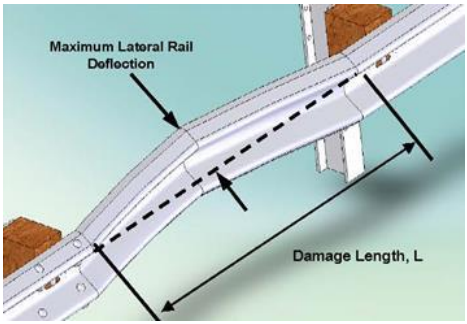


(Weak Post W-Beam Shown Only for Clarity.
Each measurement taken at rail middle fold)

Relative Priority	Repair Threshold
High	One or more of the following thresholds: • More than 9” of lateral deflection anywhere over a 25’ length of rail. • Top of rail height 2” or more lower than original top of rail height.
Medium	6” -9” lateral deflection anywhere over a 25’ length of rail.
Low	Less than 6” of lateral deflection over 25’ length of rail.

W-beam Barrier Repair Threshold

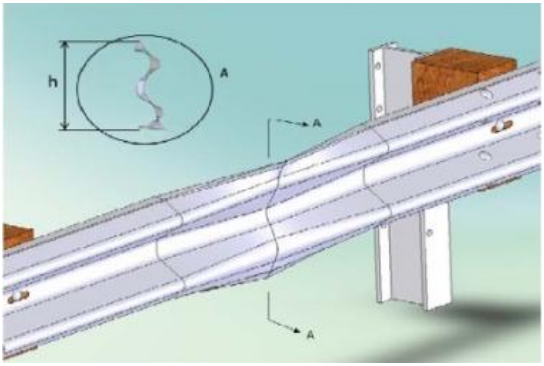
Damage Mode: Rail Deflection Only



Relative Priority	Repair Threshold
Medium	6” – 9” of lateral deflection between any two adjacent posts. Note: For deflection over 9”, use post/rail deflection guidelines.
Low	Less than 6” of lateral deflection between any two adjacent posts.

W-beam Barrier Repair Threshold

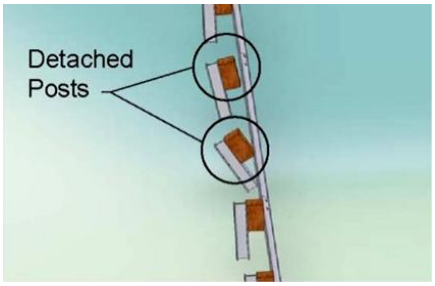
Damage Mode: Rail Flattening



Relative Priority	Repair Threshold
Medium	One of more of the following thresholds: • Rail cross-section height, h, more than 17” (such as may occur if rail is flattened). • Rail cross-section height, h, less than 9” (such as a dent to top edge).
Low	Rail cross-section height, h, between 9” and 17”.

W-beam Barrier Repair Threshold

Damage Mode: Posts Separated from Rail



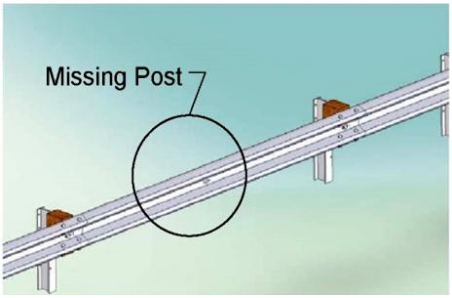
Note:

1. If the blockout is not firmly attached to the post, use the missing blockout guidelines.
2. Damage should also be evaluated against post/rail deflection guidelines.

Relative Priority	Repair Threshold
Medium	One or more of the following thresholds: • 2 or more posts with blockout attached with post-rail separation less than 3”. • 1 or more post with post-rail separation which exceeds 3”.
Low	1 post with blockout attached with post-rail separation less than 3”.

W-beam Barrier Repair Threshold

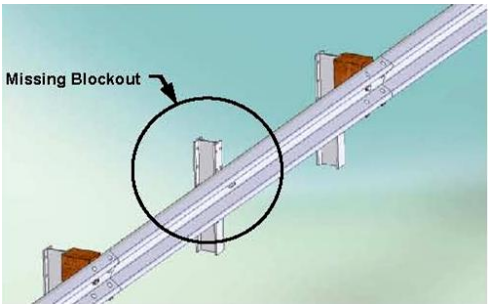
Damage Mode: Missing/Broken Posts



Relative Priority	Repair Threshold
High	One or more posts: • Missing • Cracked across the grain • Broken • Rotten • With metal tears

W-beam Barrier Repair Threshold

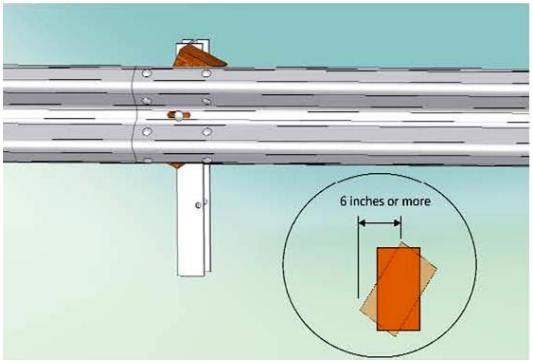
Damage Mode: Missing Blockout



Relative Priority	Repair Threshold
Medium	Any blockouts • Missing • Cracked across the grain • Cracked from top or bottom blockout through post bolt hole • Rotted

W-beam Barrier Repair Threshold

Damage Mode: Twisted Blockout

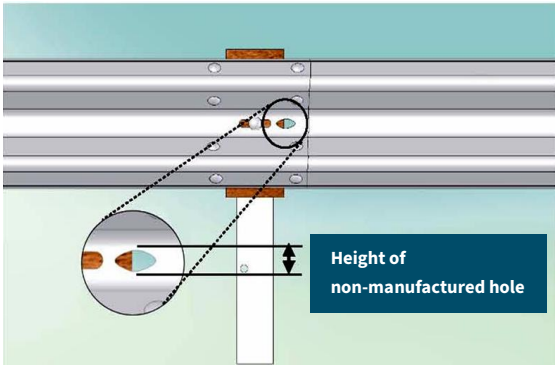


Relative Priority	Repair Threshold
Low	Any misaligned blockouts, top edge of block 6” or more from bottom edge. Note: Repairs of twisted blockout are relatively quick and inexpensive

W-beam Barrier Repair Threshold

Damage Mode: Non-Manufactured holes

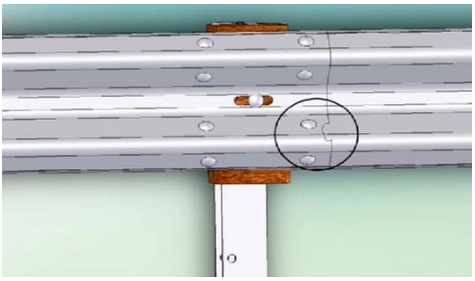
(such as crash induced holes, lug-nut damage, or holes rusted-through the rail)



Relative Priority	Repair Threshold
High	One or more of the following thresholds: • More than 2 holes less than 1" in height in a 12.5' length of rail. • Any holes greater than 1" height. • Any hole which intersects either the top or bottom edge of the rail.
Medium	1-2 holes less than 1" in height in a 12.5' length of rail.

W-beam Barrier Repair Threshold

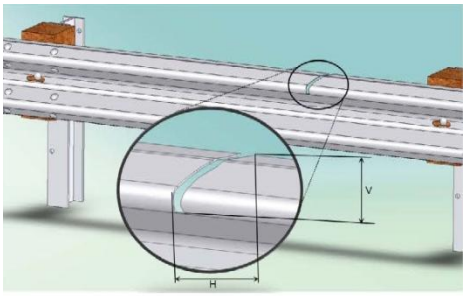
Damage Mode: Damage at Rail Splice



Relative Priority	Repair Threshold
High	More than 1 splice bolt: • Missing • Damaged • Visibly missing any underlying rail • Torn through rail
Medium	1 splice bolt: • Missing • Damaged • Visibly missing any underlying rail • Torn through rail

W-beam Barrier Repair Threshold

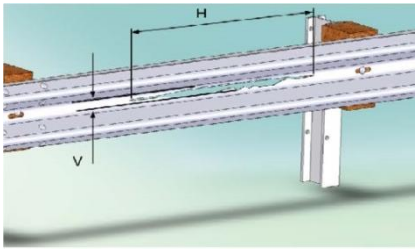
Damage Mode: Vertical Tear



Relative Priority	Repair Threshold
High	Any length vertical (transverse) tear

W-beam Barrier Repair Threshold

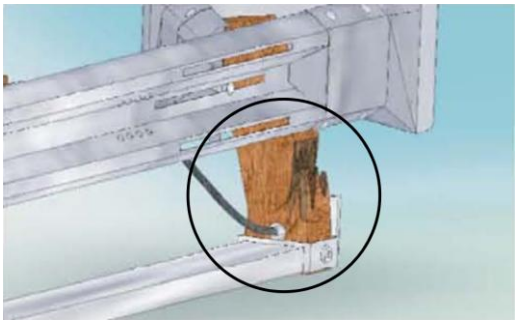
Damage Mode: Horizontal Tear



Relative Priority	Repair Threshold
Medium	Horizontal (longitudinal) tears greater than 12” long or greater than 0.5” wide. Note: for horizontal tears less than 12” in length or less than 0.5” in height, use the non-manufactured holes guidelines.

End Terminal Repair Threshold

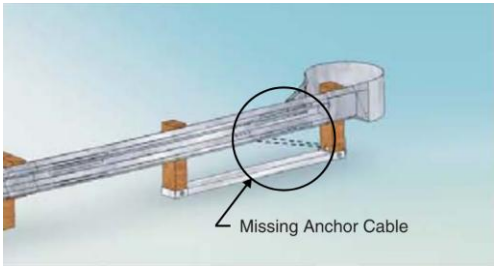
Damage Mode: Damage End Post



Relative Priority	Repair Threshold
High	Not functional (sheared, rotted, cracked across the grain)

End Terminal Repair Threshold

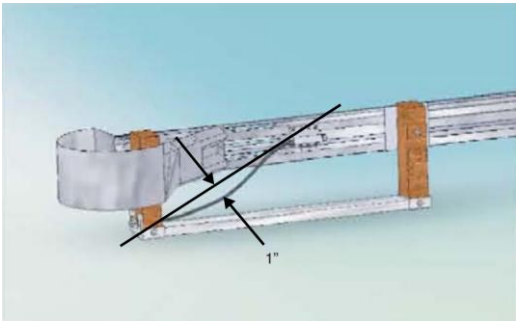
Damage Mode: Anchor Cable



Relative Priority	Repair Threshold
High	Missing

End Terminal Repair Threshold

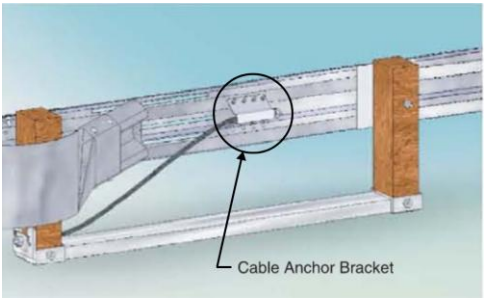
Damage Mode: Anchor Cable



Relative Priority	Repair Threshold
Medium	More than 1” of movement when pushed down by hand

End Terminal Repair Threshold

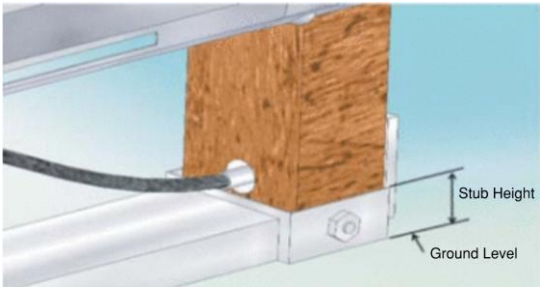
Damage Mode: Cable Anchor Bracket



Relative Priority	Repair Threshold
Medium	Loose or not firmly seated in rail

End Terminal Repair Threshold

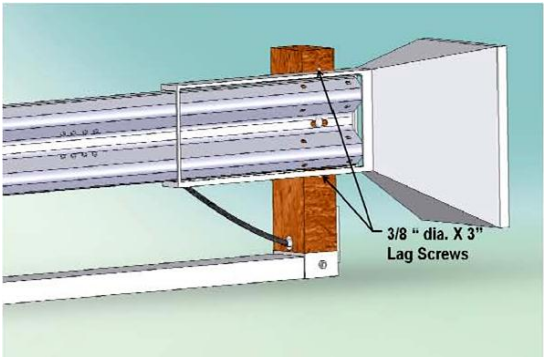
Damage Mode: Stub Height



Relative Priority	Repair Threshold
Medium	Height which exceeds 4”

End Terminal Repair Threshold

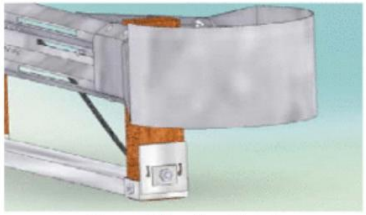
Damage Mode: Lag Screws (Energy Absorbing Terminals Only)



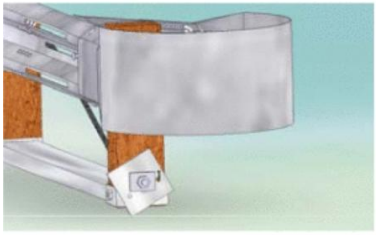
Relative Priority	Repair Threshold
High	Missing or failed lag Screws

End Terminal Repair Threshold

Damage Mode: Bearing Plate



(Correct Bearing Plate)

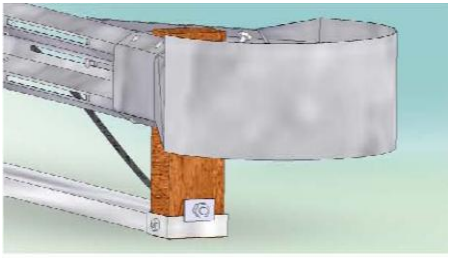


(Misaligned Bearing Plate)

Relative Priority	Repair Threshold
Medium	Loose or Misaligned

End Terminal Repair Threshold

Damage Mode: Bearing Plate



Relative Priority	Repair Threshold
High	Missing Bearing Plate

Note: Although not included in NCHRP 656, improper seating of the rail in an extruder head end treatment as shown in **Figure 87** will not allow the end treatment to function properly in a crash and could penetrate a vehicle during an impact. When identified, correct this condition at the earliest opportunity.



Figure 87 - Improper seating of rail into head image

Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ADT	Average Daily Traffic
BLON	Beginning Length of Need
CMC	Cross Median Crashes
FHWA	Federal Highway Administration
LON	Length of Need
L&D Vol 1	Location & Design Manual, Volume 1 – Roadway Design
MASH	Manual for Assessing Safety Hardware
MGS	Midwest Guardrail System
NCHRP	National Cooperative Highway Research Program
NHS	National Highway System
PIS	Plan Insert Sheet
SCD	Standard Construction Drawing
TL	Test Level
VPD	Vehicles Per Day

Glossary

Barricade—A device which provides a visual indicator of a hazardous location or the desired path a motorist should take. It is not intended to contain or redirect an errant vehicle.

Barrier—A device which provides a physical limitation through which a vehicle would not normally pass. It is intended to contain or redirect an errant vehicle.

Breakaway—A design feature which allows a device such as a sign, luminaire, or traffic signal support to yield or separate upon impact The release mechanism may be a slip plane, plastic hinges, fracture elements, or a combination of these.

Bridge Railing—A longitudinal barrier whose primary function is to prevent an errant vehicle form going over the side of the bridge structure.

Clearance—Lateral distance from edge of traveled way to a roadside object or feature.

Clear Zone—The unobstructed, traversable area provided beyond the edge of the through traveled way for the recovery of errant vehicles. The clear zone includes shoulders, bike lanes,

and auxiliary lanes, except those auxiliary lanes that function like through lanes.

Cost-effective—An item or action taken that is economical in terms of tangible benefits produced for the money spent.

Crash Cushion—Device that prevents an errant vehicle from impacting a fixed object by gradually decelerating the vehicle to a safe stop or by redirecting the vehicle away from the obstacle.

Crash Tests—vehicular impact tests by which the structural and safety performance of roadside barriers and other highway appearances may be determined. Three evaluation criteria are considered, namely (1) structural adequacy, (2) impact severity, and (3) vehicular post-impact trajectory.

Crashworthy—A feature that has been proven acceptable for use under specified conditions either through crash testing or in-service performance.

Design Speed—A selected speed used to determine the various geometric design features of the roadway. The assumed design speed should be a logical one with respect to the topography, anticipated operating speed, the

adjacent land use, and the functional classification of the highway.

Drainage Feature—Roadside items whose primary purpose is to provide adequate roadway drainage such as curbs, culverts, ditches, and drop inlets.

End Treatment—The designed modification of the end of a roadside or median barrier.

Energy-Absorbing Terminals—Terminals that can stop vehicles in relatively short distances in direct end-on impacts (usually 50 ft. or less depending on type of terminal).

Flare—The variable offset distance of a barrier to move it farther from the traveled way; generally in reference to the upstream end of the barrier.

Hinge—The weakened section of a sign post designed to allow the post to rotate upward when impacted by a vehicle.

Impact Angle—For a longitudinal barrier, it is the angle between a tangent to the face of the barrier and tangent to the vehicle's path at impact. For a crash cushion, it is the angle between the axis of symmetry of the crash cushion and a tangent to the vehicles path of impact.

Impact Attenuator—See Crash Cushion.

Length of Need (LON)—Total length of a longitudinal barrier needed to shield an area of concern.

Longitudinal barriers—A barrier whose primary function is to prevent penetration and to safely redirect an errant vehicle away from a roadside or median obstacle.

Median—The portion of a divided highway separating the traveled ways for traffic in opposite directions.

Median Barrier—A longitudinal barrier used to prevent an errant vehicle from crossing the median.

Non-Energy-Absorbing Systems— Systems that will allow an unbraked vehicle to travel 150 ft. or more behind and parallel to guardrail installations or along the top of the barrier when struck head-on at high speeds.

Non-Recoverable Slope—A slope which is considered traversable but on which an errant vehicle will continue to the bottom. Embankment slopes between 3H:1V and 4H:1V may be considered traversable but non-recoverable if they are smooth and free of fixed objects.

Offset—Lateral distance from the edge of traveled way to a roadside object or feature.

Operating Speed—The highest speed at which reasonably prudent drivers can be expected to operate vehicles on a section of highway under low traffic densities and good weather. This speed may be higher or lower than posted or legislated speed limits or nominal design speeds where alignment, surface, roadside development, or other features affect vehicle operations.

Operational Barrier—One that has performed satisfactorily in full-scale crash tests and has demonstrated satisfactory in-service performance.

Recoverable Slope—A slope on which a motorist may, to a greater or lesser extent, retain, or regain control of a vehicle. Slopes flatter than 4H:1V are generally considered recoverable.

Recovery Area—Generally synonymous with clear zone.

Roadside—That area between the outside shoulder edge and the right-of-way limits. The area between roadways of a divided highway may also be considered roadside.

Roadside Barrier—A longitudinal barrier used to shield roadside obstacles or no-traversable terrain features. It may occasionally be used to protect pedestrians or "bystanders" from vehicle traffic.

Roadside Signs—Roadside signs can be divided into 3 main categories: overhead signs, large roadside signs, and small roadside signs. Large roadside signs may be defined as those greater than or equal to $50ft^2$ in area. Small roadside signs may be defined as those less than $50ft^2$ in area.

Roadway—The portion of a highway, including shoulders for vehicular use.

Shielding—The introduction of a barrier or crash cushion between the vehicle and an obstacle or area of concern to reduce the severity of impacts of errant vehicles.

Shy Distance—The distance from the edge of the traveled way beyond which a roadside object will not be perceived as an obstacle by the typical driver to the extent that the driver will change the vehicle's placement or speed.

Slope—The relative steepness of the terrain expressed as a ratio or percentage. Slopes may be categorized as positive (backslopes) or negative

(foreslopes) or as a parallel or cross slope (in relation to the direction of traffic).

Test Level— A set of conditions, defined in terms of vehicular type and mass, vehicular impact speed, and vehicular impact angle that quantifies the impact severity of a matrix test.

Traffic Barrier—A device used to prevent a vehicle from striking a more severe obstacle or feature located on the roadside or in the median or to prevent crossover median accidents. As defined herein, there are four classes of traffic barriers, namely; roadside barriers, median barriers, bridge railings, and crash cushions.

Transition—A section of barrier between two different barriers, or more commonly, where a roadside barrier connects to a bridge railing or to a rigid object such as a bridge pier. The transition should produce a gradual stiffening of the approach rail so vehicular pocketing, snagging, or penetration at the connection can be minimized.

Traveled Way—The portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

Traversable Slope—A slope from which a motorist will be unlikely to steer back to the roadway but may be able to slow and stop safely.

Slopes between 3H:1V and 4H:1V generally fall into this category.

Warrants—The criteria by which the need for a safety treatment improvement can be determined.

Resources

Ohio Department of Transportation:

- ODOT Bridge Maintenance Manual
- ODOT Construction and Material Specifications
- ODOT Location & Design Manual, Volume 1 – Roadway Design
- ODOT Office of Maintenance Operations, Volume II: Maintenance Activities Manual (ODOT internal link)
- ODOT Ohio Strategic Highway Safety Plan
- ODOT Quality Standards for Temporary Traffic Control Devices & Acceptable Delineation Methods for Vehicles
- ODOT Roadway Approved Products List
- ODOT Standard Construction Drawings

Federal Highway Administration (FHWA):

- FHWA Reduce Crash Severity
- FHWA W-beam Guardrail Repair Guide
- NHTSA FARS

American Association of State Highway and Transportation Officials (AASHTO):

- AASHTO Guidelines for Geometric Design of Low-Volume Roads, 2019
- AASHTO Manual for Assessing Safety Hardware (MASH), 2009 & 2016
- AASHTO Roadside Design Guide, 2011
- Task Force 13

Pooled Fund Programs:

- Midwest Roadside Safety Facility (MWRSF)
- Roadside Safety Pooled Fund Program

National Cooperative Highway Research Program (NCHRP):

- NCHRP Report 350
- NCHRP Report 656
- NCHRP Research Projects

Road Safe LLC:

- Bridge Rail Guide

NOTES