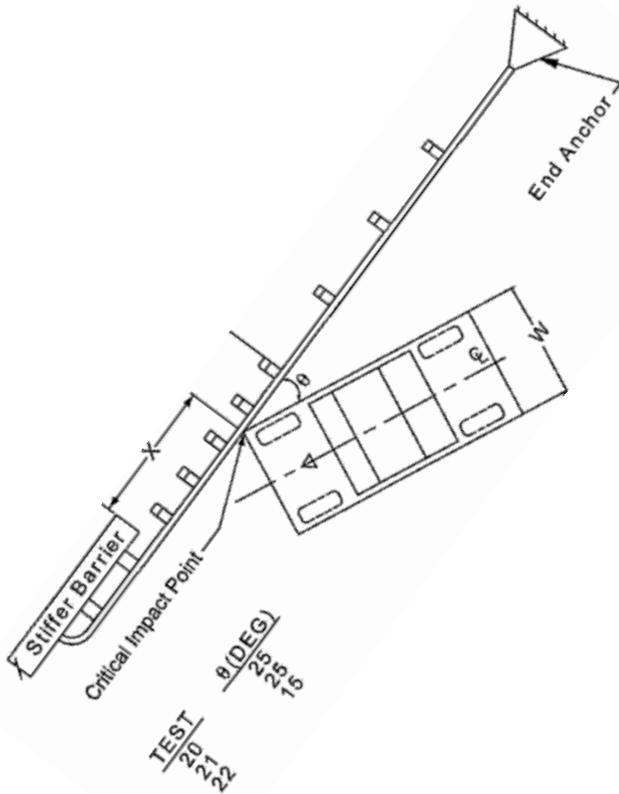




FHWA FAST Act Guardrail Training Highway Barrier Design Training

Participant Notebook

September 20th, 2018



DISCLAIMER

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INTRODUCTION

Today's program is the second part of a three day program established under the latest US Highway funding law with the objective of improving the safety of our nation's highways through improved roadside barrier installations. The objective of today's training is to assist Montana Department of Transportation (MDT) by providing their personnel and consultant designers with the appropriate information needed to enhance the probability of optimal barrier designs.

Today's program provides the State with the following deliverables:

- The PowerPoint presentations and the accompanying notebook on Highway Barrier Design Training
- MDT Barrier Design Sheet
- Highway Barrier Pocket Guide
- 4 – Technical Briefs
 - Midwest Guardrail System (MGS)
 - Transitioning MGS Guardrail to Existing Bridge Railing
 - Maintenance of High Tension Cable
 - Drive-By Inspections of Barrier Systems

The deliverables are prepared by ARTBA/KLS Engineering, LLC, under direct supervision by Mr. William P Longstreet of FHWA's Office of Safety Roadway Departure Technology Transfer Team, with review by appropriate MDT staff. The following are responsible for providing this material:

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Target Audience

The target audience for this training includes design engineers and staff, as well as consultants working for MDT and local agencies, having direct responsibilities for designing and/or specifying traffic barriers (including transitions), terminals, and crash cushions in Montana.

Course Goal and Outcomes

The overall course goal is to make design engineers aware of decisions that could improve the roadside safety of Montana roads and issues that will affect the barriers' capability to function as intended. Specifically, participants should have a better understanding of the following:

- The clear zone concept.
- When roadside and median barriers are warranted.
- Optimal design of barrier installations.
- Selection of the most appropriate end treatments per site conditions.

Course Contents

This one-day course consists of seven sessions (listed below):

- Session 1:** Introduction and Pre-Assessment – Includes a brief overview of the run off the road (ROR) problem as it exists in Montana and tests the participants' pre-training familiarity with barrier design principles.
- Session 2:** Clear Zone and Guidelines for Barrier Need – Explains the clear zone concept and examines the sometimes difficult decision of when a barrier is warranted to shield a hazard(s).
- Session 3:** Testing Requirements and Performance Characteristics of Common Barrier Systems – Identifies how selected safety barriers are tested and function under controlled crash tests.
- Session 4:** Testing Requirements and Performance Characteristics of Terminals and Crash Cushions – Identifies how selected terminals and crash cushions are tested and function under controlled crash tests.
- Session 5:** Design Principles – Provides guidance concerning selecting the barrier type and creating an optimal design based on the five design principles.

Session 6: Length of Need and Special Situations – Explains what Length of Need is based on and how it is calculated, and identifies design options to use in special situations.

Session 7: Design Workshop – Tests the participants’ post-training knowledge of barrier design principles by providing an opportunity for attendees to demonstrate the overall effectiveness of the training in a workshop

Suggestion for Participants

The one day invested in this training course will be more valuable if you ask questions and share your experiences. Please turn your cell phones off during the class. If you are uncomfortable with the lighting, heating or air conditioning or other features of the facility please let the instructor know.

Resources

Montana Department of Transportation (MDT)

- Standard Specifications
https://www.mdt.mt.gov/business/contracting/standard_specs.shtml
- Detailed Drawings
https://www.mdt.mt.gov/business/contracting/detailed_drawings.shtml
- Road Design Manual
<https://www.mdt.mt.gov/other/webdata/external/cadd/RDM/50-RDM-COMPLETE.pdf>
- Qualified Product List
<https://www.mdt.mt.gov/business/contracting/qpl.shtml>
- Guidelines for Pavement Projects (3R)
<https://www.mdt.mt.gov/publications/docs/GUIDELINES-FOR-PAVEMENT-PROJECTS.PDF>
- MASH Design Guidance (W-beam)
https://www.mdt.mt.gov/other/webdata/external/cadd/design_memos/2018-02-08_MASH_wbeam_guidance.pdf

Federal Highway Administration (FHWA) <https://www.fhwa.dot.gov/>

- FHWA Hardware Policy and Guidance
http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/
- FHWA Longitudinal Barriers
http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/barriers/
- FHWA Resource Charts
http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/resource_charts/
- W-Beam Guardrail Repair Guide
https://safety.fhwa.dot.gov/local_rural/training/fhwasa08002/

American Association of State Highway and Transportation Officials (AASHTO)

<https://www.transportation.org/>

- AASHTO, Roadside Design Guide, 2011
- AASHTO, Manual for Assessing Safety Hardware, 2016 (MASH16)

AASHTO Task Force 13 website <https://www.tf13.org/>

- Guide to Standardized Highway Barrier Hardware

TERMINOLOGY

Several terms will be used throughout the course; to ensure no misunderstanding, they are defined here:

Effective barrier: barrier that will satisfactorily perform as tested; i.e. containing and redirecting an impacting vehicle with crashworthy performance criteria

Hazard: an area of concern such as a terrain feature or an obstacle that should be considered for mitigation

Warranting hazard: a hazard that by itself would be determined to be shielded

Secondary hazard: a hazard that by itself would not normally be shielded (such as a typical tree or utility pole)

Head-on versus End-on impact: a head-on impact is essentially at zero degrees to the line of barrier; an end-on impact is hitting the end of the barrier at ANY angle.

Upstream versus Downstream: the upstream point is what the travelling vehicle comes to first; the downstream is as the vehicle is leaving

GLOSSARY – Ref: AASHTO Roadside Design Guide (2011)

Adjacent Grading—Adjacent grading refers to the area on which the terminal is installed and the area immediately behind it.

Advance Grading—Advance grading refers to the area over which a vehicle may travel before any contact with a barrier terminal is made.

Anchorage—A device which anchors a flexible or semi-rigid barrier to the ground so as to develop the barrier's tensile strength during an impact. Anchorages differ from terminals in that they are not considered crashworthy.

Area of Concern—An object or roadside condition that may warrant safety treatment.

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.

Bi-directional—For the purposes of classifying crash cushions, bi-directional describes the capability of a crash cushion to safely operate the median of a divided highway or an undivided roadway, where it will be exposed to impacts from two different directions of traffic. A bi-directional crash cushion is considered. A bi-directional crash cushion is also a uni-directional crash cushion. A crash cushion is considered to be bi-directional when it has been qualified through a reverse-direction crash test.

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 from going over the side of the bridge structure.

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

Clear Runout Area—The area at the toe of a non-recoverable slope available for safe use by an errant vehicle.

Clear Zone—The total roadside border area, starting at the edge of the traveled way, available for safe use by errant vehicles. This area may consist of a shoulder, a recoverable slope, a non-recoverable slope, and/or a clear run-out area. The desired width is dependent upon traffic volumes, speeds and roadside geometry.

Conservation of Momentum Principle—A concept of crash cushion design which involves the dissipation of the kinetic energy of an impacting vehicle by transferring the vehicles momentum to the variable masses of materials in the crash cushion, such as sand contained in sand barrels.

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.

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.

Frangible—A structure quality or feature that makes the structure readily or easily broken upon impact.

Fuse Plate—The plate which provides structural reinforcement to the sign post hinge to resist wind loads but which will release or fracture upon impact of a vehicle with the post.

Glare Screen—A device used to shield a driver's eye from the headlights of an oncoming vehicle.

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—Total length of a longitudinal barrier needed to shield an area of concern

Length of Need (LON) Point—That point on the terminal or longitudinal barrier at which it will contain and redirected an impacting vehicle along the face of the terminal barrier.

Level of Performance—The degree to which a longitudinal barrier, including bridge railing, is designed for containment and redirection of different types of vehicles.

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.

Low Maintenance/Self Restoring Crash Cushions—Crash Cushions that either suffer very little, if any damage, upon impact and are easily pulled back into their full operating condition, or they partially rebound after an impact and may only need an inspection to ensure that no parts have been damaged, misaligned, or otherwise disabled.

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

Multidirectional—The capability of the fracture mechanism of a breakaway support or the plates of a split-base support to work when struck from any direction. These are also referred to as omni-directional.

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

Non-Recoverable Slope—A slope which is considered traversable but on which an errant vehicle will continue to the bottom of the slope. 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.

Omni-directional—See Multidirectional.

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.

Performance Level—See Level of 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.

Reusable Crash Cushions—Reusable crash cushions have some major components that may be able to survive most impacts intact and can be salvaged when the unit is being repaired.

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 50ft² in area. Small roadside signs may be defined as those less than 50ft² in area.

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

Rounding—The introduction of a vertical curve between two transverse slopes to minimize the abrupt slope change and to maximize vehicle stability and maneuverability.

Runout Distance Grading—Refers to the area into which a vehicle may travel after impacting a terminal ahead of its LON point.

Sacrificial Crash Cushions—Sacrificial crash cushions are crashworthy roadside safety devices designed for a single impact. These system’s major components are destroyed in impacts and must be replaced, but many of the other parts of the system can be reused.

Severity Index—A severity index (SI) is a number from zero to ten used to categorize accidents by the probability of their resulting in property damage, personal injury, or a fatality, or any combination of these possible outcomes. The resultant number can then be translated into an accident cost and the relative effectiveness of alternate safety treatments can be estimated.

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.

Slip Base—A structural element at or near the bottom of a post or pole which will allow release of the post from its base upon impact while resisting wind loads.

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).

Staged Attenuation Device—A crash cushion that is designed to be progressively stiffer as an impacting vehicle deforms or penetrates it.

Temporary Barrier—Temporary barriers are used to prevent vehicular access into construction or maintenance work zones and to redirect an impacting vehicle so as to minimize damage to the vehicle and injury to the occupants while providing worker protection.

Terminal—A terminal is essentially a crashworthy anchorage, a device used to anchor a flexible or semi-rigid barrier to the ground. Being crashworthy, terminals are normally used at the end of a barrier that is located within the clear zone or that is likely to be impacted by errant vehicles.

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.

Through 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.

Uni-directional—For the purposes of classifying crash cushions, uni-directional describes the capability of a crash cushion to operate in a location where it will be exposed to traffic impacts from only one direction. Such locations may include gore areas, or roadside locations on a divided highway. A crash cushion is considered to be uni-directional unless it has been qualified as bi-directional through a reverse-direction crash test.

Vehicle—A motorized unit for use in transporting passengers or freight, ranging from an 820-kg [1,800-lb] automobile to a 36000-kg [80,000-lb] van-type tractor trailer.

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

Work-Energy Principle—“A concept of crash cushion design which involves the reduction of an impacting vehicle’s kinetic energy to zero, the condition of a stopped vehicle, through the conversion of kinetic energy into other forms of energy.”

Working Width—The distance between the traffic face of the test article before the impact and the maximum lateral position of any major part of the system or vehicle after the impact.

Zone of Intrusion (ZOI)—The region measured above and behind the face of a barrier system where an impacting vehicle or any major part of the system may extend during an impact.

Acronyms

AASHTO – American Association of State Highway Transportation Officials

ADT – Average Daily Traffic

AML – Authorized Material List

BIB – Buried In Backslope

CIP – Critical Impact Point

CM – Countermeasure

CRZ – Clear Recovery Zone

FARS – Fatal Analysis Reporting System

FAST Act – Fixing America's Surface Transportation Act

FHWA – Federal Highway Administration

HTC – High Tension Cable

LON – Length of Need

MASH – Manual for Assessing Safety Hardware

MBGR – Metal Beam Guardrail

MDT – Montana Department of Transportation

MGS – Midwest Guardrail System

NCHRP – National Cooperative Highway Research Program

NHTSA – National Highway Transportation Safety Administration

OTS – Office of Traffic Safety

PE – Preliminary Engineering

RDG – Roadside Design Guide

ROW – Right of Way

SHSP – Strategic Highway Safety Plan

SPWB – Strong Post W-Beam

TL – Test Level

TTI – Texas Transportation Institute

VMT – Vehicle Miles Traveled

WZ – Work Zone