Session 5: Design Principles
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Session 5 Learning Outcomes

At the end of this session, you will be able to:
Understand the design principles affecting an optimal barrier installation.
MDT Range of Treatments

1. Eliminate obstacles or design proposed features free of obstacles (such as slope flattening to avoid barrier warrants, removing rock outcroppings, and removing point obstacles);
2. Relocate the obstacle;
3. Where applicable, make the obstacle breakaway (such as sign posts and luminaire supports);
4. Shield the obstacle with a roadside barrier, which is also considered an obstacle and should only be used when other alternatives cannot be achieved; or
5. Delineate the obstacle.

Barriers Must Be Less of a Hazard
Guardrail Placement

Place AS FAR AWAY as Possible

without affecting function

Barrier Design Principles

1. Deflection
2. Slope in Front of Barrier
3. Guardrail and Curb
4. Soil Backing for Fill Locations
5. Flare Rate
Principle 1: Deflection

Adequate room must be left behind the barrier to allow for lateral deflection in an impact.

- If the barrier is shielding a vertical rigid object, the distance between the barrier and the object should be sufficient to avoid the vehicle impacting or snagging on the object.
- Note that, even for rigid barriers with no lateral deflection, large vehicles may roll behind the top of the barrier even if the barrier itself does not deflect.

Deflection Distance / Working Width

Ref: AASHTO ROADSIDE DESIGN GUIDE, 4th EDITION – Figure 5-33
<table>
<thead>
<tr>
<th>Barrier Type</th>
<th>Dynamic Deflection Distances (Test Level 3)</th>
<th>Barrier Width</th>
<th>Min. Dist. From Face Rail to Obstacle</th>
</tr>
</thead>
<tbody>
<tr>
<td>“W” Beam – Wood Posts</td>
<td>4’</td>
<td>1’-7”</td>
<td>5.6’</td>
</tr>
<tr>
<td>“W” Beam – Steel Posts</td>
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</tr>
<tr>
<td>Stiffened “W” Beam – Point Obstacle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3’-1 ½” Post Spacing – Single Rail</td>
<td>2’</td>
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</tr>
<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1’-6 ¾” Post Spacing – Double Rail</td>
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<td>1’-7”</td>
<td>2.7’</td>
</tr>
<tr>
<td>Nested “W” Beam – 25’-0” Span</td>
<td>5’</td>
<td>1’-7”</td>
<td>7.3’</td>
</tr>
<tr>
<td>Metal Guardrail – 7’ Posts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posts spaced at 3’-1½” with 2:1 slopes and without widening</td>
<td>3’</td>
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<td>4.6’</td>
</tr>
<tr>
<td>Low Tension Cable Guardrail</td>
<td>7’-10”</td>
<td>4” or 5”</td>
<td>12.0’</td>
</tr>
<tr>
<td>Box Beam Guardrail</td>
<td>3’-9”</td>
<td>9”</td>
<td>4.5’</td>
</tr>
<tr>
<td>Concrete Barrier Rail</td>
<td>4’-6”</td>
<td>2’-0”</td>
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</tr>
<tr>
<td>Anchored Concrete Barrier Rail</td>
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Deflection

Deflection – MDT Detailed Drawings
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Session 5: Design Principles

Deflection – MDT Detailed Drawings

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September 2016
Deflection – MDT Concrete (CBR)

This is NOT Rigid barrier
Must consider deflection
Deflection – MDT Concrete (CBR)

Rigid (structural) CBR

Zone of Intrusion – Truck Lean-over
Zone of Intrusion (almost)

2. Barrier-Mounted Obstacles. If trucks or buses impact the CBR, their high center of gravity may result in a vehicular roll angle which possibly will allow the truck or bus to impact obstacles on top of the CBR (e.g., luminaire supports). If practical, move these devices to the outside and make them breakaway, or provide additional distance between the barrier and obstacle by using a flared/divided median barrier.

Principle 2: Slope in Front of Barrier

Any barrier may be placed anywhere on a 10H:1V or flatter slope.
Principle 2: Slope in Front of Barrier

Video Clip

NCHRP 350 TL-3 MGS on 8:1 Slope

Video Clip

Vehicle is contained and redirected but shows some instability
9.4.3.7 Placement on Slopes

Slopes in front of a barrier should be 10:1 or flatter. This also applies to the areas in front of the flared section of guardrail and to the area approaching the terminal ends. See the MDT Detailed Drawings.
Cable barrier may be placed anywhere on a 10:1 or flatter slope.

Cable barrier may be placed on slopes of 6:1, but not in the area from 1 ft. to 8 ft. from the ditch bottom.

Ref: AASHTO ROADSIDE DESIGN GUIDE, 4th EDITION – 6.6.1.1, Pg. 6-18
Location of Cable in Swales

*Video Clip*

CABLE SHOULD NOT BE PLACED BETWEEN 1' AND 8' BEYOND THE BOTTOM OF A DITCH.

Ref: AASHTO ROADSIDE DESIGN GUIDE, 4th EDITION – 6.6.1.1, Pg. 6-18

Location of Cable in Swales

Slope in Front of Cable Barrier

- Cable barrier may be placed on **4:1** slopes with a maximum offset of 4 ft. from the shoulder.

![Diagram showing 4:1 slope with cable barrier]

*Figure 6.1. Underride criteria for V-shaped medians.* (NCHRP Report 711)

*Figure 6.2. Override criteria for V-shaped medians steeper than 6H:1V slope.* (NCHRP Report 711)

Ref: AASHTO ROADSIDE DESIGN GUIDE, 4th EDITION – 6.6.1.1, Pg. 6-18
Barrier in Sloped Median

Which Side of the Median Should the Cable Barrier be Placed?

Principle 3: Guardrail and Curbs
Curbs may function to channelize traffic, to control drainage, improve delineation, control access, and reduce erosion.

Curbs are not adequate to prevent a vehicle from leaving the roadway; they are not a barrier.

Use of any guardrail/curb combination where high-speed, high-angle impacts are likely should be discouraged.
9.4.3.6 Placement in Conjunction With Curbs

For rural (outside the boundaries of urban areas) roadways and urban roadways where the design speed is greater than 45 miles per hour, do not place curbs in front of roadside barriers. Where curbs are used in conjunction with roadside barriers on low-speed facilities, the face of the barrier should be in line with the face of the curb (i.e., at the gutter line). Do not use curbs higher than 4 inches with a barrier on new construction facilities. Existing curb installations higher than 4 inches may remain if the installation otherwise meets MDT criteria. Measure the height of the barrier from the pavement surface (e.g., where curbs are on bridges). A weak post system, such as cable or box-beam guardrail, cannot be used in conjunction with curbing.
MGS Guardrail and Curbs

Guardrail and Curbs

NORMAL FINISHED SHOULDER

EDGE OF TRAFFIC LANE

4" [100] HIGH CURB FLUSH WITH GUARDRAIL FACE WHEN SPECIFIED (SEE DTL DWG. NO. 603-28 AND 609-05)

TYPICAL INSTALLATION

DETAILED DRAWING
REFERENCE DWG. NO.
STANDARD SPEC.
SECTION 606-05A 606-05A
METAL GUARDRAIL - WOOD POSTS (MG6)

MONTANA DEPARTMENT OF TRANSPORTATION

Session 5 5-36
Box Beam and Curbs

Not allowed by MDT guidance

MGS and Curbs

Successfully tested to MASH placed 6” behind a 6” high curb at TL-3 – 12” block only

Special Use: Not in MDT Detailed Drawings
Session 5
Terminals and Curbs

2” maximum height recommended

CURRENTLY UNDER STUDY –
DO NOT BURY BEARING PLATE
MASH TL-2 MGS 6 ft. behind curb

Principle 4: Soil Backing For Fill Locations
Soil Backing Recommendation

Historical Guidance

1. Slope can be as steep as 2:1 with 2-ft. backing in strong soil with 6 ft. posts.

2. Backing can be less than 2 ft. with 2:1 slope in strong soil with 7 ft. posts. NCHRP 350 requires half post spacing – ONLY applies to "Old" system

Ref: AASHTO Roadside Design Guide, 4th Edition – Figure 5.33, Pg. 5-41

Soil Backing – MDT

PREFERRED INSTALLATION

TYPICAL INSTALLATION

REFERENCE: DWG. NO.
STANDARD SPEC. 606-05A
SECTION 606, 704
EFFECTIVE: SEPTEMBER 2014
MONTANA, DEPARTMENT OF TRANSPORTATION
Soil Backing – Good

If posts are in structural pavement, it's a problem.

Soil Backing – ????
Soil Backing – MDT – Long Wood Post

6" x 8" x 14" (155 x 205 x 350) wood block (H1000)-

2'-1" (635)

7'-6" (2290)

4'-10" (1470)

W-Beam (H800-0)-

5/8" dia x 1'-6" (416 x 191) Guardrail bolt (FB04)-

Wood block (see detail)-

Post holes (see detail)-

Wood post (post meeting same specs as pole02)-

Detail Drawing

REFERENCE: GIG. NO.
606-11A

MATERIAL: TYPE 2 WOOD

DRAWN: SEPTEMBER 2014

I.T. Department of Transportation

Federal Highway Administration

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Page 5-47
MGS shielding a 2H:1V Slope – at Hinge

- **On 2H:1V slope**
  - Standard steel posts.
  - Standard 6’-3” post spacing.

**Break-line of 2H:1V Slope**

*Not in MDT Detailed Drawings - Use only with appropriate approval*
Soil Backing – MDT – Long Steel Post

REFLECTOR
S/8 "DIA. x 10" CDS x 243 GUARDRAIL BOLT 163234 ROOTED HOLE BLOCK (SEE DETAIL) POST HOLES (SEE DETAIL)

M x 6.3 612 x 12.6 kips/m 6.3 x 6.3 x 6.3 POST MOUNTING SAME SPECS AS FOR (#)

STEEL POST AND MOUNTING DETAIL


DETAILED DRAWING
REFERENCE Dwg. NO.
STANDARD SPEC.
SECTION 606 606-11B
METAL GUARDRAIL - LONG POSTS - STEEL (MGS.)
EFFECTIVE: SEPTEMBER 2014

MTDN MONTANA DEPARTMENT OF TRANSPORTATION

Session 5

U.S. Department of Transportation
Federal Highway Administration
MGS With Posts on a 2:1 Slope

MGS with face of rail at slope break point of 2:1 slope

**Posts**
- 8’ long W6x9 posts tested
- Not recommended with Wood posts at this time
- 6’-3” post spacing

**Blocks**
- 8” block tested
- 12” block acceptable
- Not recommended without blocks at this time
**Flare Rate**

*Flared barriers* are those that are not parallel to the edge of the traveled way. They are used to:

- Locate terminals farther from the roadway.
- Lessen driver reaction to a roadside obstacle.
- Reduce total length of rail needed.
- Reduce nuisance hits.
- When tying to a bridge rail from a farther offset (in advance of transition)
Trade offs and restrictions of flared barriers:

- Flare increases the angle at which the barrier can be hit.
- Flare may increase the angle of redirection after an impact.
- Flared barriers can only be placed on 10:1 or flatter slopes.
- Maximum flare rate varies with design speed.

<table>
<thead>
<tr>
<th>Design Speed</th>
<th>Flare Rate for Barrier Inside Shy Line</th>
<th>Flare Rate for Barrier at or Beyond Shy Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>km/h</td>
<td>[mph]</td>
<td>A</td>
</tr>
<tr>
<td>110</td>
<td>[70]</td>
<td>36:1</td>
</tr>
<tr>
<td>100</td>
<td>[60]</td>
<td>26:1</td>
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<tr>
<td>90</td>
<td>[55]</td>
<td>24:1</td>
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<td>80</td>
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<td>60</td>
<td>[40]</td>
<td>16:1</td>
</tr>
<tr>
<td>50</td>
<td>[30]</td>
<td>13:1</td>
</tr>
</tbody>
</table>

Notes:
- A = Suggested maximum flare rate for rigid barrier system.
- B = Suggested maximum flare rate for semi-rigid barrier system.
- Flatter flare rates for the MGS installations also are acceptable. The MGS should be installed using the flare rates shown or flatter for semi-rigid barriers beyond the shy line when installed in rock formations.
Flare at Bridge Approach Narrow
Bridge Shoulder

PRE-ASSESSMENT PHOTO
Must satisfy flare rate criteria
Review Learning Outcomes

Understand the design principles affecting an optimal barrier installation.