AASHTO’s Roadside Design Guide:
Topography, Signs, Poles and Barriers

May 23rd, 2014

Instructor:
Ivette Cruzado, PhD
American Association of State Highway and Transportation Officials

• “nonprofit, nonpartisan association representing highway and transportation departments in the 50 states, the District of Columbia, and Puerto Rico.”

• Represents all five transportation modes
  1. air
  2. highways
  3. public transportation
  4. rail
  5. water
AASHTO

• Goal: “foster the development, operation, and maintenance of an integrated national transportation system.”

• AASHTO serves as a liaison between state departments of transportation and the Federal government.

• AASHTO is an international leader in setting technical standards for all phases of highway system development. Standards are issued for design, construction of highways and bridges, materials, and many other technical areas.
Roadside Design Guide

- Chapter 1 – Introduction
- Chapter 2 – Benefits and Economics
- Chapter 3 – Topography and Drainage
- Chapter 4 – Signs, Trees and Poles
- Chapter 5 – Roadside Barriers
- Chapter 6 – Median Barriers
- Chapter 7 – Bridges
- Chapter 8 – End Treatments
- Chapter 9 – Work Zones
- Chapter 10 – Urban Environments
- Chapter 11 – Mailboxes
AASHTO’s Roadside Design Guide: Chapter 1: Introduction to Roadside Safety

May 23rd, 2014
I. Cruzado
1.0 History of Roadside Safety

• Highway Design – 1940s & 1950s
  – Horizontal and Vertical Alignment
  – Sight Distance

• Roadside Design – 1970s
  – Projects 25-30 years of service
  – Now: candidates for reconstruction
1.1 Benefits of Roadside Safety

Roadside Design Definition

The design of the area between the outside shoulder edge and the right-of-way limits.
1.1 Benefits of Roadside Safety

Benefits

• 30% of crashes are categorized as single vehicle run-off-road
• Statistics on Fatalities
• Number of Total Fatalities versus Fatality Rate per Vehicle Miles Traveled (VMT)
1.1 Benefits of Roadside Safety

![Bar chart showing the total number of fatalities from 1997 to 2011. The chart shows a decrease in fatalities from 1997 to 2011.]

5/23/2014
1.1 Benefits of Roadside Safety

Vehicle Miles Traveled (Billions)

<table>
<thead>
<tr>
<th>Year</th>
<th>Miles Traveled</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>2,400</td>
</tr>
<tr>
<td>1998</td>
<td>2,500</td>
</tr>
<tr>
<td>1999</td>
<td>2,600</td>
</tr>
<tr>
<td>2000</td>
<td>2,700</td>
</tr>
<tr>
<td>2001</td>
<td>2,800</td>
</tr>
<tr>
<td>2002</td>
<td>2,900</td>
</tr>
<tr>
<td>2003</td>
<td>3,000</td>
</tr>
<tr>
<td>2004</td>
<td>3,100</td>
</tr>
<tr>
<td>2005</td>
<td>3,200</td>
</tr>
<tr>
<td>2006</td>
<td>3,300</td>
</tr>
<tr>
<td>2007</td>
<td>3,400</td>
</tr>
<tr>
<td>2008</td>
<td>3,500</td>
</tr>
<tr>
<td>2009</td>
<td>3,600</td>
</tr>
<tr>
<td>2010</td>
<td>3,700</td>
</tr>
<tr>
<td>2011</td>
<td>3,800</td>
</tr>
</tbody>
</table>

5/23/2014
1.1 Benefits of Roadside Safety

Fatality Rate (per billion VMT)

- 1997
- 1998
- 1999
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011

5/23/2014
1.1 Benefits of Roadside Safety

Reasons for the reduction in fatality rate:

• Safer vehicles
• Safer highways
• Better Driveways
• Better Emergency Response
1.2 Strategic Plan for Improving Roadside Safety

- In 2008 23.1% of crashes occurred in the roadside
- Fatalities with fixed objects are 19-23% of all fatalities
- Trees are the most common object struck, followed by utility poles
1.2 Strategic Plan for Improving Roadside Safety

- Building: 12%
- Wall: 8%
- Bridge Pier: 8%
- Fence: 6%
- Culvert: 3%
- Highway Sign Support: 3%
- Ditch: 3%
- Embankment: 3%
- Other: 3%
- Traffic Barrier: 2%
- Utility Pole: 2%
- Tree: 2%
- Other: 2%
1.2 Strategic Plan for Improving Roadside Safety

Why would a vehicle leave the highway?
1.2 Strategic Plan for Improving Roadside Safety

Why would a vehicle leave the highway?
• Driver fatigue, inattention
• Excessive speed
• Driver under the influence
• Crash Avoidance
• Bad pavement conditions
• Vehicle failure
• Poor visibility

5/23/2014
1.2 Strategic Plan for Improving Roadside Safety

1998 AASHTO’s Strategic Highway Safety Plan

• Provide strategies for keeping vehicles on the roadway

• Minimize the consequences when it does leave the road
1.2 Strategic Plan for Improving Roadside Safety

The Forgiving Roadside Concept

• Roadside free of fixed objects
• Stable, flattened slopes
Cheo Feliciano
July 3, 1935 – April 17, 2014

Photo: http://lacallerevista.com/
April 17, 2014
4:35 a.m
Route 176
Cupey
1.2 Strategic Plan for Improving Roadside Safety

The Forgiving Roadside Concept: What to do with an obstacle in order of preference:

• Remove it
• Redesign it
• Relocate it
• Reduce severity with breakaway devices
• Shield it
• Delineate it
AASHTO’s Roadside Design Guide: Chapter 3: Roadside Topography and Drainage Features

May 23rd, 2014
I. Cruzado
3.0 Overview

• Clear Roadside Concept
• Roadside Geometry:
  – Embankment and ditches
  – curbs, culverts and drop inlets

Idea: enhance safety without compromising the purpose of these elements
3.1 Clear-Zone Concept

Clear Roadside Concept – AASHTO (1974)

- Provide a wide recovery area
- Width of 30 feet (9 meters) permits 80% of runaway vehicles to recover
EXAMPLE #1
1:6 SLOPE
(FILL SLOPE)
100 km/h
5000 V.P.D.

ANSWER:
CLEAR ZONE
WIDTH = 9 m

EXAMPLE #2
1:6 SLOPE
(CUT SLOPE)
100 km/h
750 V.P.D.

ANSWER:
CLEAR ZONE
WIDTH = 6 m

*SEE SECTION 3.B.4. FOR DISCUSSION ON VARIABLE SLOPE DETERMINATION*
3.2 Roadside Geometry

- Foreslopes
- Backslopes
- Transverse Slopes
- Drainage Channels
3.3 Application of the Clear-Zone Concept

- **Foreslopes**
- **Backslopes**
- **Transverse Slopes**
- **Drainage Channels**

- Recoverable are 1V:4H or flatter
- Non-recoverable are between 1V:3H
- Critical are steeper than 1V:3H
3.3 Application of the Clear-Zone Concept

Roadside Geometry:
• Foreslopes
• Backslopes
• Transverse Slopes
• Drainage Channels

• Could be traversable if they are 3V:1H or flatter
3.3 Application of the Clear-Zone Concept

Roadside Geometry:
  - Foreslopes
  - Backslopes
  - Transverse Slopes
  - Drainage Channels

- Created by median crossovers, driveways, or intersecting roads
- 1V:6H or flatter for high-speed roads
- 1V:10H is desirable

5/23/2014
3.3 Application of the Clear-Zone Concept

Roadside Geometry:

- Foreslopes
- Backslopes
- Transverse Slopes
- Drainage Channels
3.4 Drainage Features

Features:
• Curbs
• Cross-Drainage
• Parallel
• Drop Inlets

Order of preference:
• Eliminate if non-essential
• Design it so they can traversable
• Shield it
3.4 Drainage Features

Features:

- Curbs
- Cross-Drainage
- Parallel
- Drop Inlets

Source: FHWA website
3.4 Drainage Features

Features:

• Curbs
• Cross-Drainage
• Parallel
• Drop Inlets

Source: [www.jjdrainage.com](http://www.jjdrainage.com)
3.4 Drainage Features

Features:

• Curbs
• Cross-Drainage
• Parallel
• Drop Inlets

Source: [www.jjdrainage.com](http://www.jjdrainage.com)
3.4 Drainage Features

Features:

• Curbs
• Cross-Drainage
• Parallel
• Drop Inlets

Source: FHWA website
US-DOT & FHWA

Maintenance of Drainage Features for Safety
US-DOT & FHWA
Maintenance of Drainage Features for Safety
US-DOT & FHWA
Maintenance of Drainage Features for Safety
US-DOT & FHWA
Maintenance of Drainage Features for Safety

5/23/2014
Some pictures
Questions and Comments

May 23rd, 2014
I. Cruzado
Chapter 4

Sign, Signal, and Luminaire Supports, Utility Poles, Trees, and Similar Roadside Features

• Idea: we do not want obstacles near the road, but we need some fixed objects near the road
• What to do?
Chapter 4: Overview

Statistics

• Since 1999, 19% to 22% of fatalities are crashes with fixed objects

• 48% of these are with trees, 12% with utility poles, 6% with signs and lighting supports

• Design guidelines are available
Chapter 4: Overview

The 6 options still apply:
1. Remove
2. Redesign
3. Relocate
4. Reduce impact severity
5. Shield
6. Delineate
4.1 Acceptance Criteria for Breakaway Supports

• Breakaway Support = design to yield when impacted by a vehicle

• Types of release mechanism:
  – slip plane
  – plastic hinge
  – fracture element
  – or any combination of these
Wood Support - Breakaway

• Holes are needed if post is greater than 4X4 inches
• Example: drill two 3-inch holes perpendicular to the roadway to weaken the cross section for a 6X8 inch wood post.

Source: FHWA website
Slip Base – Steel
4.1 Acceptance Criteria for Breakaway Supports

Breakaway Support Criteria:

- Fail in a predictable when impacted by 1800 lb vehicle at 35 mph and 60 mph
- Maximum stub height: 10 cm (4 in.)

http://www.youtube.com/watch?v=9S9fH2czel4

The point of initial impact on a full-scale crash test is the front of the vehicle, either at the center or at the quarter point of the bumper
4.2 Design and Location

Sign, luminaire, and other supports should be:

• structurally adequate to support the device mounted on them

• structurally adequate to resist ice and wind loads

MUTCD states that if located in the clear zone – it should be shielded or breakaway
4.2 Design and Location

Sign, luminaire, and other supports:

- Should not be placed where are going to get damaged, such as ditches (erosion)
- If is not needed, remove it
- If needed, place it where is less likely to be hit
- If you can, place it behind a barrier or on an existing structure
- If not, make it breakaway
4.2 Design and Location

Sign, luminaire, and other supports:

• Sometimes we do want it to be fixed: in urban areas where there is pedestrian activity

• However:
  – pedestrian activity – daylight hours
  – run-off-road crashes – evening and early morning hours

• Example: bus stops
4.2 Design and Location

Sign, luminaire, and other supports, if on slopes:

Figure 3.1 Roadside Design Guide, AASHTO, 2011
4.2 Design and Location

Sign, luminaire, and other supports, if electrical:

• Must have electrical disconnects to reduce the risk of fire and electrical hazards

• It should disconnect as close to the pole base as possible
4.2 Design and Location

Sign, luminaire, and other supports:

• Designed to be impacted at bumper height
• It should disconnect as close to the pole base as possible
• Not located in places where a vehicle can airborne (ditches and steep slopes)
• Type of soil can also affect the mechanism
Source: Hollistone Reporter website
4.3 Sign Supports

Three categories

• Overhead Signs
• Large Roadside Signs
• Small Roadside Signs
4.3.1 Overhead Sign Supports

- They are fixed (not breakaway)
- Should be located behind barriers or mounted on structures
- If located within the clear zone: shielded with a crashworthy barrier
4.3.2 Large Roadside Signs

- Greater than 5 m² (50 ft²)
- Typically have two or more breakaway support posts

Source: www.hawaiihighways.com
4.3.2 Large Roadside Signs

Some criteria:

• Hinge at least 2 m (7 ft) over the ground
• No supplementary signs below the hinge
• The breakaway mechanism should be fracture or slip base-type

Source: www.hawaiihighways.com
• ADD FIGURE 4-3
4.3.3 Small Roadside Sign Supports

- Supported by one or more posts
- Panel area no greater than 5 m² (50 ft²)
- Mechanisms are either base-bending, fracture, or slip-base design

Source: www.ratestogo.com
4.3.3 Small Roadside Sign Supports

Base-bending or yielding signs are usually:

- U-channel steel posts
- Perforated square steel tubes
- Thin-walled aluminum tubes
- Thin-walled fiberglass tubes
U-channel

• It should bend, break or pull out of the ground when hit.
• The post should be driven into the ground no more than 3.5 feet
• Should not be in concrete.

Source: FHWA website
U-channel Treatments

Source: FHWA website
Square Steel Tube

• Considered breakaway if they are 2 ¼ inches or less in size
• Ground preferred over concrete
• A broken or damaged post is easier to remove if it is not driven or set into the ground more than three feet.

Source: FHWA website
Square Steel Tube Treatments

Source: FHWA website
4.4 Multiple Post Support for Signs

- All breakaway supports with a clear distance less than 2.1 m (7 ft) are considered to act together.
- A vehicle can hit two posts within a 2.1 m (7ft) spacing between them.
4.5 Luminaire Supports

• Either breakaway or fixed
• Breakaway can be:
  – frangible base
  – slip base
  – frangible coupler
Frangible Coupling (Coupler)

Source: http://guides.roadsafellc.com
Frangible Base

Source: www.millerberndmfg.com
Slip Base

Source: www.ingaleps.com.au
4.5.1 Breakaway Luminaire Supports

The rule is:

• When impacted, should fall near the path of the vehicle

• The mast should rotate so it points away from the roadway when resting on the ground

• Height should not exceed 18.5 m (60 ft)
4.5.2 High-Level Lighting Supports

- Fixed-base supports that do not yield or break away
- They should be outside of the clear zone; if not, they should be shielded with a crashworthy barrier.
4.6 Traffic Signal Supports

• Also fixed
• The support post should be placed as far away from the roadway as practicable
4.7 Supports for Miscellaneous Devices

Railroad Crossing Warning Sign – decide between highway and railroad officials

Fire Hydrants – at least one with stem and coupling design that shuts off water when impacted

Mailboxes - Chapter 11
Car hits fire hydrant, powerful water suspends it in the air
4.8 Utility Poles

• 12% of fatalities with fixed objects involved utility poles
• High number of poles and their proximity to the roadway
• Power and telephone lines could be buried; since they are privately owned, they are not under the direct control of highway agencies
<table>
<thead>
<tr>
<th>Objectives</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>A1 Remove poles in hazardous locations</td>
</tr>
<tr>
<td>A2</td>
<td>A2 Relocate poles further away or to less vulnerable location</td>
</tr>
<tr>
<td>A3</td>
<td>A3 Use breakaway poles</td>
</tr>
<tr>
<td>A4</td>
<td>A4 Shield drivers from poles</td>
</tr>
<tr>
<td>A5</td>
<td>A5 Improve drivers' abilities to see poles</td>
</tr>
<tr>
<td>A6</td>
<td>A6 Apply traffic calming techniques to reduce speeds</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>B1 Develop, revise, and implement policies to prevent placing or replacing poles within the recovery area</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>C1 Place utilities underground</td>
</tr>
<tr>
<td>C2</td>
<td>C2 Relocate poles further away or to less vulnerable location</td>
</tr>
<tr>
<td>C3</td>
<td>C3 Decrease the number of poles</td>
</tr>
</tbody>
</table>
4.9 Trees

- Number of deaths is approximately 4,550 persons per year

Source: FHWA
4.9 Trees

On-roadway treatments:
• Pavement markings
• Rumble strips
• Signs
• Delineators
• Roadway improvements

Off-roadway treatments
• Remove it
• Shield it
What’s new

Source: radarsign.com
Questions & Comments

Remember
• Remove
• Redesign
• Relocate
• Reduce impact
• Shield
• Delineate
AASHTO’s Roadside Design Guide
Part 3
Chapter 5: Roadside Barriers &
Chapter 8: End Treatments

May 23rd, 2014
Ivette Cruzado, PhD
5.0 Overview

Roadside Barrier (definition)

“Longitudinal barrier used to shield motorists from natural or man-made obstacles located along either side of the traveled way”
5.0 Overview

Roadside Barrier (extra)
It could also be used to shield pedestrians and cyclists from vehicles.
5.1 Performance Requirements

Primary purpose: reduce the probability of an errant vehicle to hit a fixed object that is less forgiving than the barrier itself; this could be achieved by containing and redirecting the vehicle.
5.1 Performance Requirements

MASH – for evaluating the crashworthiness

- or NCHRP 350

Since January 1st, 2011: newly tested or revised system should be evaluated using MASH
5.1 Performance Requirements

Six test levels for longitudinal barriers:

- **TL-1, TL-2, and TL-3:** a 2,420-lb passenger car and a 5,000-lb pickup truck impacting at 25 degrees, at speeds of 50 km/h, 70 km/h, and 100 km/h, respectively (31, 44, and 62 mph).
- **TL-4** adds an 22,000-lb single-unit truck at 15 degrees and 90 km/h (56 mph) to TL-3
- **For TL-5** is a tractor/van trailer at 80 km/h (50 mph)
- **And for TL-6** is a 79,930-lb tractor/tank trailer at 50 mph
5.2 Barrier Recommendations

• Only install if it will reduce the severity of a potential crash

• A benefit-cost analysis should be made; costs with and without the barrier are used to evaluate three options:
  1. remove or reduce the area of concern
  2. install an appropriate barrier
  3. leave the area of concern unshielded
5.2 Barrier Recommendations

• If is decided to shield the area of concern, highway conditions can be labeled as:
  1. embankments, or
  2. roadside obstacles
5.2.1 Roadside Geometry and Terrain Features

• Factors that decide: embankment height and side slope
• Many charts have been developed
• Highway agencies can create their own chart
• Additional factors to considered: environmental impacts, cost for additional right of way, and the cost of utility adjustments.
5.2.2 Roadside Obstacles

- Either man-made (culvert inlets) or natural (trees)
- There is a list to guide you
<table>
<thead>
<tr>
<th>Obstacle</th>
<th>Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge piers</td>
<td>Shielding generally needed</td>
</tr>
<tr>
<td>Culverts</td>
<td>Judgment decision based on size, shape, and location</td>
</tr>
<tr>
<td>Retaining Walls</td>
<td>Judgment decision based on smoothness of wall and anticipated angle of impact</td>
</tr>
<tr>
<td>Sign/luminaire supports</td>
<td>Shield if not breakaway</td>
</tr>
<tr>
<td>Traffic signals</td>
<td>Isolated, rural, high-speed may need to be shielded</td>
</tr>
<tr>
<td>Trees</td>
<td>Judgment decision based on site-specific circumstances</td>
</tr>
</tbody>
</table>
5.2.3 Bystanders, Pedestrians, and Bicyclists

• Currently there are no criteria
• For low-speed streets (25 mph) a sidewalk with a raised curb is enough
• Over 25 mph, a buffer space can be added between the sidewalk and the roadway
5.2.4 Motorcycles and Barrier Design

- There is no systematic approach because motorcycle crashes are random.
- Some European countries are adding a lower rubrail.

5.3 Test Level Selection Factors

How do I know which level should I install?

- Percentage of heavy vehicles
- Route of hazardous materials
- Adverse geometrics (sharp curve)
- Severe consequences (multi-level interchange ramp)
5.4 Structural and Safety Characteristics of Roadside Barriers

• Definition
5.4.1 Standard Section of Roadside Barrier

- Can either be flexible, semi-rigid, or rigid, depending on how it deflects
- Flexible are more “forgiving” to the car
- Rigid.., not so forgiving but they sure can last!
Flexible

Low-tension cable (and high-tension too)

**PROS**: low initial cost, effective containing and redirection of vehicle in various conditions.

**CONS**: A lot of cable to replace after an impact and it needs a lot of clear area behind it.

Source: [www.wsdot.wa.gov](http://www.wsdot.wa.gov)
Armorwire cable barrier crash test

http://www.youtube.com/watch?v=-zGJYVe-qms
Flexible

W-Beam Weak Post

Posts are 3’ X 5.7” and are spaced 12.5’
It failed the TL-3
Lateral deflection can be reduced by closer post spacing.
Semi-Rigid

Box Beam (Weak Post)

- TL-3
- Dynamic lateral deflection was 1.15m (45 inches)
Semi-Rigid

Blocked-Out W-Beam (Strong Post)

- Most common barrier
- Wood posts and wood blockouts or steel posts
- Steel blockouts are no good for TL-3 (but TL-2 is okay)
Semi-Rigid

Gregory Mini Spacer

• Standard strong posts and W-beam rail with or without blockouts.
• Mini Spacer fastener helps the vehicle to remain in contact with the rail for containment and redirection

Source: www.gregorycorp.com
Semi-Rigid

Midwest Guardrail System (MGS)

- non-proprietary steel or wood posts
- increased mounting height
- extra blockout depth

Source: FHWA website
Semi-Rigid

NU-Guard 31 W-Beam  Trinity T-39 Thrie Beam

Source: [www.eberliron.com](http://www.eberliron.com)  Source: [www.highwayguardrail.com](http://www.highwayguardrail.com)
Rigid

TL-4 and TL-5 depending on the dimensions

• New Jersey
• F-Shape
• Vertical Concrete
• Single Slope

If 32 inches tall, then TL-4
If 42 inches tall, then TL-5
Rigid

• New Jersey

• F-Shape

Source: www.capeconcrete.com

Source: www.deltabloc.co.za
Rigid

• New Jersey

• F-Shape

Source: http://www.jjhooks.com/profiles.shtml
Rigid

- Vertical
- Constant or Single Slope

Source: www.hardstaffgroup.co.uk

Source: www.concretesafety.com
5.4.2 Long-Span Guardrail Systems

• Effective to shield low-fill culverts
• Spacing is 25 ft
• Two-beams nested

Photo not available
5.4.3 Transition Designs

• Mostly for bridges
• That’s another chapter
5.5 Selection Guidelines

• I need a barrier.... which one?
• Preferred one will offer my desired degree of shielding at the lowest cost
• Also you may consider:
  – route classification, speed, traffic volume and composition
  – roadway alignment
  – deflection space available
  – impact frequency
  – construction and maintenance issues
5.5.1 Barrier Performance Capability

• What level of performance?
  – TL-3 are the most common
  – TL-2 for 45mph or less
  – TL-4 for poor geometry, high volumes/speeds, and significant percentage of heavy vehicles
5.5.2 Barrier Deflection Characteristics

- How much available distance beyond the barrier?
- Table 5-6

<table>
<thead>
<tr>
<th>Post Spacing (inches)</th>
<th>Beam Description</th>
<th>Maximum Deflection (inches) - Field Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>Single W-Beam</td>
<td>29.7</td>
</tr>
<tr>
<td>38</td>
<td>Single W-Beam</td>
<td>23.5</td>
</tr>
<tr>
<td>75</td>
<td>Double W-Beam</td>
<td>35.5</td>
</tr>
<tr>
<td>38</td>
<td>Double W-Beam</td>
<td>19.6</td>
</tr>
</tbody>
</table>
5.5.3 Site Conditions

• Consider flexible or semi-rigid if barrier placed on a slope steeper than 1V:10H
• No barrier should be placed on any slope steeper than 1V:6H (unless tested)
5.5.4 Compatibility

• Use only a few different systems; advantages:
  – It has been proven efficient over the years
  – Better understanding of the design details
  – Construction and maintenance personnel are familiar with the system
  – Familiarity with parts and inventory
  – End treatments and transition sections can be standardized
Other considerations

• Costs – a system with low installation usually requires a lot of maintenance effort after impact
• If frequent crashes in high traffic volumes, use rigid systems; this is the case of urban freeways
• Aesthetics – not the controlling factor
• Environmental factors – steel may deteriorate in corrosive environments
5.6 Placement Recommendations

• The layout of the barrier should consider:
  – lateral offset from the edge of the traveled way
  – barrier to obstacle separation
  – terrain effects
  – flare rate
  – length-of-need
  – grading for terminals
5.6.1 Barrier Offset

- Shy-line offset – distance from edge of traveled way up to an object that will not be perceived as an obstacle
- Motorists will not change speeds
- Place barrier beyond the shy-line offset

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Shy-Line Offset (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>4</td>
</tr>
<tr>
<td>40</td>
<td>5</td>
</tr>
<tr>
<td>45</td>
<td>6</td>
</tr>
<tr>
<td>50</td>
<td>6.5</td>
</tr>
<tr>
<td>55</td>
<td>7</td>
</tr>
<tr>
<td>60</td>
<td>8</td>
</tr>
<tr>
<td>70</td>
<td>9</td>
</tr>
<tr>
<td>75</td>
<td>10</td>
</tr>
<tr>
<td>80</td>
<td>12</td>
</tr>
</tbody>
</table>
5.6.1 Barrier Offset

• If non-traversable slope behind the barrier – at least 2 ft

• Consider deflection of barrier for the distance between the barrier and the obstacle
5.6.2 Terrain Effects

Terrain between the traveled way and the barrier:

• Curbs – the MGS and the Trinity T-31 have been approved

• Slopes – vehicle may go over the barrier or impact it too low.
5.6.3 Flare Rate

- Flare – the part that is not parallel to the roadway
- Minimize driver’s reaction to an obstacle by gradually introducing the barrier

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Flare Rate*</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>13:1</td>
</tr>
<tr>
<td>40</td>
<td>16:1</td>
</tr>
<tr>
<td>45</td>
<td>18:1</td>
</tr>
<tr>
<td>50</td>
<td>21:1</td>
</tr>
<tr>
<td>55</td>
<td>24:1</td>
</tr>
<tr>
<td>60</td>
<td>26:1</td>
</tr>
<tr>
<td>70</td>
<td>30:1</td>
</tr>
</tbody>
</table>

*For barrier inside the shy-line
5.6.4 Length-of-Need

- Length of Need (X)
- Lateral Extent of the Area of Concern (L_A or L_H)
- Runout Length (L_R)
5.6.4 Length-of-Need

- Table for Runout Length ($L_R$) based on ADT and design speed
- Formula for Length-of-Need
- Charts for adjustments given a series of factors
5.6.5 Grading for Terminals

- Ends of barriers should be treated with crashworthy terminals
- This is Chapter 8
8.0 Overview

For vehicle impacting the end of a roadside barrier there are end treatments:

• Anchorage – to the ground (not crashworthy)
• Terminals – crashworthy anchorages
• Crash cushions – impact attenuators
Before

• No treatment – “Fish Tail”

Source: www.crashforensics.com
The problem

Source: www.crashforensics.com
Solution

• Let’s bury it!
The Problem

• Flying cars!!!

Source: http://www.youtube.com/watch?v=wxeHUwHU2ug
8.1 Performance Requirements

- MASH – includes the evaluation of end treatments
- To be crashworthy, a vehicle should not spear, vault, or rollover
8.2 Anchorage Design Concepts

- Needed for flexible and semi-rigid systems
- Anchor at both ends
- When a vehicle impacts a barrier, tension is developed
- Anchorage transfers the tension forces to the ground
8.3 Terminal Design Concepts

• A terminal is essential if the end of barrier can be hit by a motorist

• Factors to consider when selecting a terminal:
  – compatibility with the barrier system
  – performance characteristics
  – site-grading considerations
Terminals for W-Beam

• Buried-in-backslope Terminal
• Flared Terminal
• Tangent Terminal
• Height Terminal
Terminals for W-Beam

- Buried-in-backslope

Source: FHWA website
Terminals for W-Beam

Flared – Eccentric Loader Terminal (ELT)

Source: www.amgmetals.com
Terminals for W-Beam

Flared – Modified Eccentric Loader Terminal (MELT)

Source: FHWA website
Terminals for W-Beam

Flared Energy-Absorbing Terminal (FLEAT)

Source: www.armtec.com
Terminals for W-Beam

Flared – Slotted Rail Terminal (SRT-350)

Source: www.highwayguardrail.com
## Up until now

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Test Level</th>
<th>System Designation</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buried</td>
<td>TL-3</td>
<td>Not posted</td>
<td>Generic</td>
</tr>
<tr>
<td>ELT</td>
<td>TL-3</td>
<td>Not posted</td>
<td>Generic</td>
</tr>
<tr>
<td>MELT</td>
<td>TL-2</td>
<td>SEW05</td>
<td>Generic</td>
</tr>
<tr>
<td>FLEAT</td>
<td>TL-2 and 3</td>
<td>SEW14a to b</td>
<td>Road Systems</td>
</tr>
<tr>
<td>SRT-350</td>
<td>TL-3</td>
<td>SEW11 and 12</td>
<td>Trinity Highway Products</td>
</tr>
</tbody>
</table>
Terminals for W-Beam

Tangent– Extruder Terminal (ET-Plus)

Source: www.highwayguardrail.com
Terminals for W-Beam

Tangent– Sequential Kinking Terminal (SKT-350)

Source: www.roadsystems.com
Terminals for W-Beam

- Height Terminals – for higher mounting heights
  - FLEAT
  - SRT-350
  - ET-Plus
Also

- Terminals for box-beam and cable rails
- Terminals for guardrails in the median

Bursting Energy Absorbing Terminal (BEAT)
Source: www.roadsystems.com
8.4 Crash Cushions

- Reduce the severity of the impact
- Gradually decelerates a vehicle to a stop if hit head-on
- Redirects a vehicle away if hit on the side
- Ideal for locations where the fixed object cannot be removed or made breakaway and a longitudinal barrier is not appropriate
- Very frequent in median barriers
Crash Cushions

Source: www.impactabsorption.com
Crash Cushions

Source: www.impactabsorption.com
And now... Pictures!
Questions & Comments

Remember
- Remove
- Redesign
- Relocate
- Reduce impact
- Shield
- Delineate