ROADSIDE DELINEATION
AND SAFETY SYSTEMS

Presented by
Nazir Lalani P.E.
Traffex Engineers Inc.
N_lalani@hotmail.com

RELATIONSHIP OF ELEMENTS

Source: FHWA
ROAD SIDE DELINEATION

EDGELINES REQUIRED ON

- Interstate freeways
- State highways
- Rural multi-lane divided highways
- Recommended on other classes of highway as visual reference
EDGELINES IMPORTANCE

- Foggy areas
- Unlit highways
- Curved section of highway
- Pavement width transitions

RIGHT EDGELINE

- 4” solid white (Wider lines permitted in MUTCD)
- 12’ from centerline or lane line
- Edge of pavement
- Dropped at flared intersections
Edge lines essential where no lighting provided

**LEFT EDGELINE**

- 4” yellow
- In combination with reflective markers
- Some States using double yellow lines for HOV lanes
- HOV lane crash rates reduced by installing physical barriers
Left edge lines/HOV lane markings in S. CA

Source: Urban Transportation Monitor
**DELINEATORS**

- On shoulders
- On curved sections
- Along pavement width transitions
- On median barriers

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**Table 3D-1. Approximate Spacing for Delineators on Horizontal Curves**

<table>
<thead>
<tr>
<th>Radius (R) of Curve (meters)</th>
<th>Approximate Spacing (S) on Curve (meters)</th>
<th>Radius (R) of Curve (feet)</th>
<th>Approximate Spacing (S) on Curve (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>6</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>35</td>
<td>9</td>
<td>115</td>
<td>25</td>
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<td>55</td>
<td>11</td>
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<td>95</td>
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<td>125</td>
<td>18</td>
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<td>245</td>
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<td>800</td>
<td>80</td>
</tr>
<tr>
<td>275</td>
<td>27</td>
<td>900</td>
<td>85</td>
</tr>
<tr>
<td>305</td>
<td>29</td>
<td>1,000</td>
<td>90</td>
</tr>
</tbody>
</table>

Distances in feet were rounded to the nearest 5 feet. Spacing for specific radii may be interpolated from table. The minimum spacing shall be 0.1 m (20 ft). The spacing on curves should not exceed 60 m (200 ft). In advance of or beyond a curve, and proceeding away from the end of the curve, the spacing of the first delineator is 25, the second 30, and the third 35, but not to exceed 60 m (200 ft). S refers to the delineator spacing for specific radii computed from the formula \( S = 1.771 \sqrt{R} \) for metric units and \( S = 5.8 \sqrt{R} \) for English units.

**Source:** MUTCD
Tall delineators in snow country

Chevrons on a curve should be spaced so two are visible. Prefer three visible on each approach.
Chevrons at T intersections in Utah
Converging Pavement Markings Successful in Reducing Speed

Source: Urban Transportation Monitor

RECOMMEND STRATEGIES
(not already covered)

- Lighting on curve
- Dynamic curve warning system
- Skid resistance surfaces using open graded asphalt friction courses
- Provide 45 degree fillet at pavement drop off
- Backfill dirt shoulder to reduce drop off
- Automatic deicing systems

RECOMMEND STRATEGIES
(not already covered)

- Modify horizontal alignment
- Increasing horizontal curve radius
- Improving/restoring super elevation
- Eliminating compound curves
- Eliminating back to back reverse curves
- Widening travel lanes/shoulders
CHANNELIZERS

- In-pavement
- Prohibit or discourage illegal movements
- Supplement pavement markings
- Warn drivers of hazards in roadway

Channelizers used to reduce U-turn crashes
For objects in the roadway:
Type 1 or 3

For objects adjacent to the roadway:
Type 2 or 3

Where roadway ends:
OM-1, OM-2, OM-3
(Typically with Type 3 Barricade)

*Source: MUTCD*
DELINEATION IMPORTANT FOR

- Narrow bridges
- Transition from divided to undivided highways
- Stop sign controlled approaches to divided highways
- Wild life crossings

Drivers become confused at night at the transitions.
Clear guidance is necessary.

Source: Caltrans Traffic Manual
Driver leaves the road and hits a rock. Injuries render driver a quadriplegic. Taper is half what it should be based on \( L = W \times S \). Driver sues agency. Wins a jury verdict of $5 million.

Source: MUTCD

Pavement width transitions - source of major lawsuits

One-way signing for divided highways

Source: MUTCD
Providing visual cues essential to preventing wrong way crashes.
WILDLIFE CONFLICTS

THE PROBLEM
(2003 Data)

- 6.3 million total crashes; 2.9 million injuries, 42,600 fatalities
- 1.6 million crashes involving trees, animals, debris
- From 1999 to 2003, fatal crashes involving animals increased by 38% from 152 to 210
- 60% involved drivers with no seatbelts on
- Vehicle-deer collisions estimated at 1.5 million per year
- 2.2 million wild acres being developed each year
THE PROBLEM

- 3.9 million miles of public roads in the US
- Millions of animals killed every year on nation’s roads
- Roads adversely impact wildlife, resulting in loss of biodiversity & extinction of populations

IMPACT TO ROAD USERS

- 2003 data show 210 deaths involving animals
- Deer populations have dramatically increased
- 2.2 million wild acres are developed each year
- 2004 data show 52 moose-vehicle crashes in Massachusetts
**Functional Groups**

- **Large Mammal**
- **Medium Mammal**
- **Reptile**
- **Amphibian**

**Large Mammals**

- Prefer larger structures, i.e. bridges
- Supported by Recent Research

**Graph**

- **Large Mammal Use of Various Structure Types**

- **Average number of uses per structure type**
  - **Box**
  - **Bridge**
  - **Pipe**
Accessibility Problems

Fencing & Funneling

Source: FHWA/USDOT 2002

Source: www.lakejacksonturtles.org
Warning system for Pelicans on Bridge to South Padre Island

Effective Design Elements
Roadway Design

- Non-vegetated landscape
- Fencing
- Lighting
- Signage
- Speed reduction strategies

Fencings should have been provided here!
Source: Urban Transportation Monitor
TRAFFIC SAFETY SYSTEMS

Reduce severity/prevent crashes

http://www.wildlifeaccidents.ca/reports.htm
THE PROBLEM

Source: FHWA

THE PROBLEM

Source: Insurance Institute for Highway Safety
Trees 29%; Guard Rail 9%
(Trees wider than 4 inches are fixed objects)

RECOMMEND STRATEGIES (not already covered)

- Remove trees
- Delineate trees
- Modify clear zone in vicinity of tree
- Implement vegetation and mowing control guidelines
- Shield trees

Utility Poles – 9%

Several hits

RECOMMEND STRATEGIES

- Keep vehicles on roadway
- Remove/relocate pole
- Alter pole (Breakaway Design)
- Protect drivers from pole (guard rail)
- Avoid introducing new hazardous poles
- Delineate pole or improve driver visibility of pole
Embankments – 11%

PREVENTING CRASHES
AASHTO CLEAR ZONES FOR FIXED OBJECTS

- Freeways: 30’ from edge of traveled way
- Conventional highways (no curbs): 20’ from edge of traveled way
- Local: 10’ from edge of traveled way
- Roads in urban areas: 18” beyond curb face

Truck hit support column south of Dallas in 2002
Pavement Grooves

GROOVED SHOULDERS & CENTER LINES

- Shoulders/center lines/ freeway end
- Prevent drifting off road crashes
- Discourage illegal crossing of centerlines
- Prevent head-on crashes
**RUMBLE STRIP TYPES**

- Milled-in: cutting or grinding
- Rolled: steel wheel roller over hot asphalt
- Formed: Added to fresh concrete shoulder with a corrugated form pressed onto the surface
- Raised: RPMs or extruded pavement marking material placed as raised bars
GROOVED RUMBLE DESIGN

- Depth: 1”
- Width: 2 – 2.5”
- Length perpendicular to travel lane: 16 – 35”
- In groups of 5 – 7 depressions, 50’ apart

RUMBLE STRIP LOCATION

- Outside the edge line of the travel lane
- Offset by 4 – 12”
- Some states offset by as much as 30”
- For more information refer to FHWA Technical Advisory T 5040.35, December 20, 2001
Shoulder rumble strip detail from WADOT

Source: Urban Transportation Monitor
Milled more effective than rolled in

Grooved centerline
Centerline Rumble Detail from WA DOT

Rumble Strip Profile

Centerline Groove Detail from Jefferson County Colorado
JEFFERSON COUNTY STUDY

- 22-29% of crashes crossed center line on rural mountainous roads
- Cost of installation – $0.30 per linear foot
- No impact on bicycle related crashes
- Crashes reduced by 25%
- 18 miles of road took one week to complete
RMP RUMBLE STRIPS

- Warn drivers
- Ahead of stop signs/school zones
- Avoid in residential areas
- End of freeway or highway

Freeway termination warnings on H2
RECOMMEND STRATEGIES
(not already covered)

- Provide lighting
- 45 degree fillet at pavement drop off
- Skid resistance surfaces using open graded asphalt friction courses
- Widen clear zones
- Enhanced pavement markings
- Delineate roadside objects
- Flatten shoulders/ditches
Runaway Truck Escape Ramps

RUNAWAY TRUCK CRASHES

NHTSA Study:
- 2,450 runaway truck incidents per year
- Total cost - $37 million
- 2,150 used ramps – $1 million
- 300 not using ramps - $36 million
ESCAPE RAMPS

- Downhill grades exceeding 1.25 miles in length (California warrant)

- Aggregate size to drag trucks to a stop - large enough to allow truck removal

- NCHRP 178: Truck Escape Ramps; Synthesis of Highway Practices, 1992
Runaway truck ramp aggregate size

Left-side runaway truck ramp on Interstate 80
Shorter runaway ramp with crash cushions

Very short runaway ramp in China
Severe Grades by State

<table>
<thead>
<tr>
<th>Location</th>
<th>Percent Grade</th>
<th>Length (miles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pennsylvania</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I-376</td>
<td>5</td>
<td>1.8</td>
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<tr>
<td>I-279</td>
<td>5.5</td>
<td>1.7</td>
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<tr>
<td>Stoop's Ferry Rd.</td>
<td>10.5</td>
<td>0.45</td>
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<tr>
<td>Hulton Rd.</td>
<td>10</td>
<td>0.3</td>
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<tr>
<td>Idaho</td>
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<tr>
<td>Lewiston Hill</td>
<td>6.7</td>
<td>7</td>
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<tr>
<td>Whitebird Hill</td>
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<tr>
<td>Oregon</td>
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<td>Siskiyou Summit</td>
<td>5-6.4</td>
<td>7</td>
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<tr>
<td>California</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I-80</td>
<td>5-6</td>
<td>40</td>
</tr>
</tbody>
</table>

Source: USA Roads Road Management and Engineering Journal, 1997: Truck Escape Ramps, Determining the Need and Location
Figure 12: Relationship of entry velocity and deceleration rate (18, Fig. 36).

Depth is 18-30” of material

<table>
<thead>
<tr>
<th>Surfacing Material</th>
<th>&quot;R&quot; Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portland cement concrete</td>
<td>0.010</td>
</tr>
<tr>
<td>Asphalt concrete</td>
<td>0.012</td>
</tr>
<tr>
<td>Gravel compacted</td>
<td>0.015</td>
</tr>
<tr>
<td>Earth, sandy, loose</td>
<td>0.037</td>
</tr>
<tr>
<td>Crushed aggregate, loose</td>
<td>0.050</td>
</tr>
<tr>
<td>Gravel, loose</td>
<td>0.100</td>
</tr>
<tr>
<td>Sand</td>
<td>0.150</td>
</tr>
<tr>
<td>Pea gravel</td>
<td>0.250</td>
</tr>
</tbody>
</table>

Source: NCHRP 178
REDUCING SEVERITY

REDUCE CRASH SEVERITY

- Guard rail
- Median barrier
- Crash cushions
- Yielding supports
Guard rail post spacing typically 12’
Height to top of rail is 27-28”
Comparative risk warrants for embankments:
(Fill height, slope, traffic volumes, alignment are all factors in considering guardrail installation)

Location where guard rail warranted
W-Beam strong post guardrail like this meets test for 4,400 lb 60 mph pickup at 24 degrees – the force here was greater!

Whatever is installed has to do the job or the consequence can be
Guard rail should not be too low
No maintenance renders guard rail ineffective

Inadequate warning of lane drop
 Crunch!!

MEDIAN BARRIER

- Thrie beam
- Jersey wall
- Temporary Rail (Emergency remedial measure for medians)
- Temporary rail for construction
CROSSOVER CRASHES IN WISCONSIN

- 741 of 15,194 crashes involved median crossovers on divided facilities

- Median crossover crashes involving 2 vehicles (65%); 3 vehicles (25%)

- Wet conditions: 19% for all crashes, 32% for median crossovers

Wide median with no center barrier wider than 40’
Median barrier warrant

Median Barrier

Source: Regan J. McKendry, E.I.T. and David A. Noyce Ph.D., P.E.
“Quantifying the Safety Effects of Median Crossover Crashes”
MEDIAN BARRIER

- Thrie beam
- Jersey wall
- Temporary Rail (Emergency remedial measure for medians)
- Temporary rail for construction

Some DOTs will not use guardrail in medians

Modified thrie-beam rail with deep steel block-outs redirected a 60 mph 32,000 lb intercity bus at 14 degree impact
New Jersey Safety Shaped Wall: 32” (42”) ht., 26” (32”) width redirects intercity buses and tractor trailers

Cable Median Barrier Study
Cable Median Barrier

Temporary rail protecting construction workers
Rail too close to travel lanes – 2’ set back!

Rail not designed for truck movements
Dangers of not placing Rail correctly

Moveable barrier used in construction zones and for reversible lanes
Moveable Median Barrier on Tappan Zee Bridge Creates Additional Peak Period Capacity

The moveable median barrier on the Tappan Zee Bridge in New York was installed in a way that improved traffic capacity and efficiency. The barrier was designed to adapt to traffic needs, allowing for smoother flow during peak periods. The installation involved careful planning and coordination with traffic management systems to ensure safety and efficiency.

TRB Publishes List of Available Transit Bibliographies

The Transportation Research Board (TRB) has published a list of available transit bibliographies. These resources are valuable for researchers and practitioners in the field of transit planning and management.

NCHRP Report 537: Recommended Guidelines for Curb and Curb Barrier Installations

NCHRP Report 537 provides recommended guidelines for curb and curb barrier installations. It offers guidance on design, installation, and maintenance to ensure safety and efficiency in traffic management.

Source: Urban Transportation Monitor
BARRIER END TREATMENTS AND CRASH CUSHIONS

Spearing Problem
W-beam guard rail end terminal

W-beam guard rail anchored in back slope
Variety of sand filled plastic barrel systems

Energy absorbing barrier end treatments (QuadGuard Family)
Reversible energy absorbing crash terminal
(REACT 350)

BREAKAWAY SUPPORTS

- Drilled wooden posts
- Breakaway street light poles
- Breakaway sign poles
- Traffic signals not breakaway
Breakaway Pole:
Total mass less than 1,000 lbs;
Maximum height less than 60 feet

Breakaway street light pole
Should not be used in pedestrian areas
Reported reckless driver hits hydrant

From staff reports

A reckless driver reportedly struck a fire hydrant at a four-way stop at Loma Vista Drive and La Colonia Drive in Thousand Oaks on Monday morning.

The driver, who was traveling at high speed, crashed into the hydrant, causing a water main to break and flood the area. The driver was taken to the hospital with minor injuries.

Sources of Information:

Source: Ventura County Star
AASHTO Roadside Design Guide

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM REPORT 350

- More stringent than NCHRP 230
- Permanent Devices
- Work Zone Devices
QUESTIONS ?