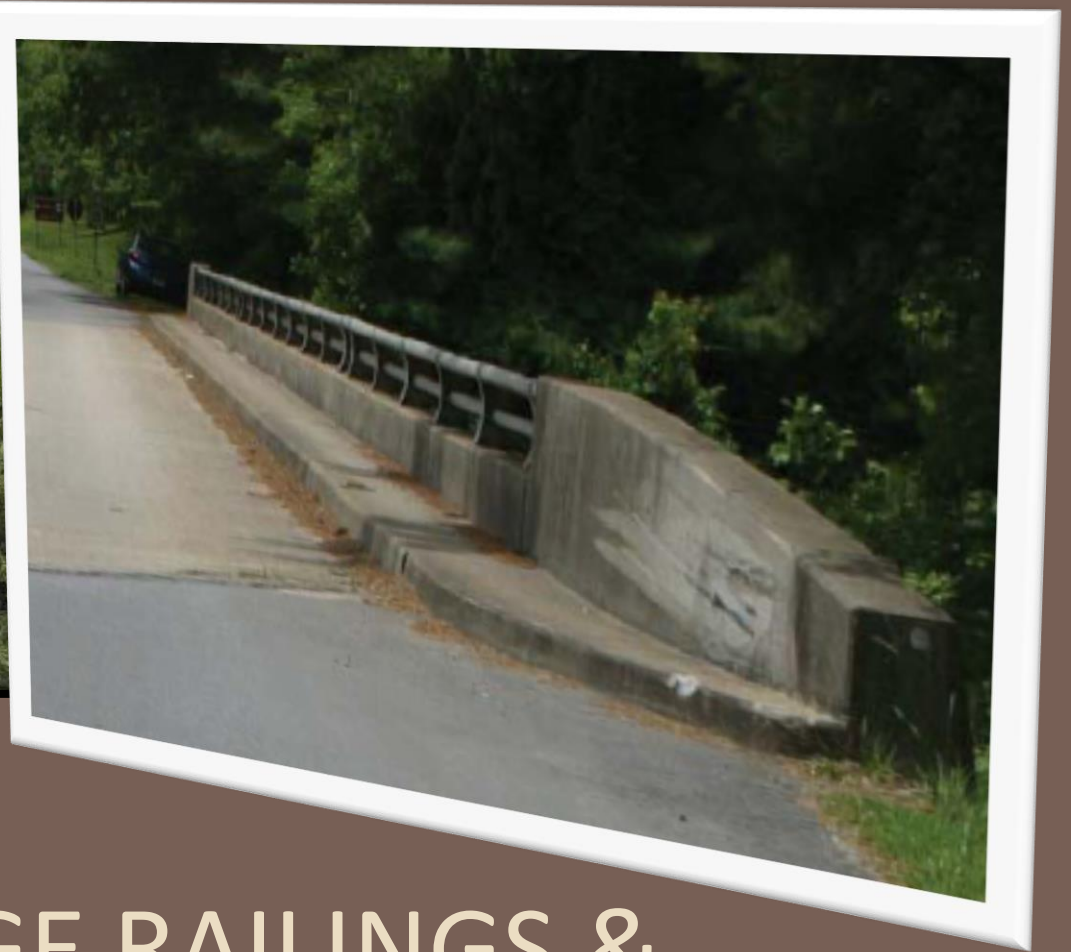


LTAP Transportation Technology Transfer Center



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*Spokesperson Decade of Action
for Road Safety 2011-2020*



BRIDGE RAILINGS & TRANSITIONS

Module 6

Bridge Railings

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- Longitudinal barrier intended to prevent a vehicle from running off the edge of a bridge or culvert
- Differ from roadside barriers in that bridge railings are an integral part of the structure
- Usually designed to have NO deflection when struck by an errant vehicle



Bridge Railings

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- Materials
 - ▣ Concrete
 - ▣ Metal [steel and aluminum]
 - ▣ Timber
- Height: prevents a vehicle from rolling over the railing
- Shape of face
 - ▣ A vertical face may be desirable whenever heavy vehicle roll over is a concern



32" New Jersey Shape Concrete Barrier



Foothills Parkway Aluminum Bridge Rail



Timber Rail 3 Bridge Rail

Factors to Consider When Installing a Railing

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- ❑ Protection of the occupants of a vehicle in collision with the railing
- ❑ Protection of other vehicles near the collision
- ❑ Protection of persons and property on roadways and other areas underneath the structure
- ❑ Possible future rail upgrading
- ❑ Railing cost effectiveness
- ❑ Appearance and view from passing vehicles

1. Performance Requirements



- Resist applied static loads w/o exceeding allowable stress
- FHWA requires all railings on the National Highway System to be a crash-tested design

AASHTO Standard Specifications for Highway Bridges
AASHTO LRFD Bridge Design Specifications

Structural Adequacy of Bridge Rails

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- A structurally adequate bridge rail:
 - ▣ Sustains the impact of the design vehicle without allowing it to penetrate the bridge rail
 - ▣ Safely redirect vehicles
 - ▣ Retains structural integrity and does not require any mayor repair after a crash
- Flexible barrier systems are not considered adequate for bridge railings

Functional Adequacy of Bridge Rails

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- A functionally adequate bridge rail:
 - Prevents vehicle from vaulting over the rail
 - Prevents vehicle from snagging, and stopping or decelerating abruptly (causing rollover or redirection of the vehicle into the rail on the other side of the bridge)
 - Does not penetrate the vehicle's passenger compartment

2. Warrants for Railings



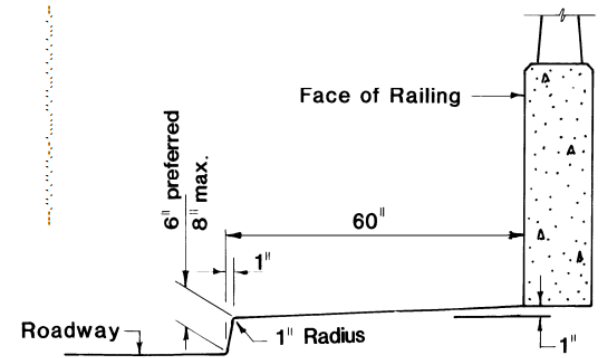
- All structures require some type of railing
 - ▣ Preferably TL-3 or better
 - ▣ Effective height
 - ▣ Low-speed, low-volume may not need to meet full AASHTO standards
- Rigid railing
 - ▣ Approach guardrail
 - ▣ Transition section
- Additional shield for pedestrians or cyclists

Guidelines for the Application of Different Types of Rails

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- Traffic railing is used when a bridge is for the exclusive use of vehicle traffic
- A combination barrier in conjunction with a raised curb and sidewalk is used only on low speed highways (< 45 mph)
- On high speed highways, the pedestrian or bicycle path should have both an outboard pedestrian or bicycle railing and an inboard combination railing



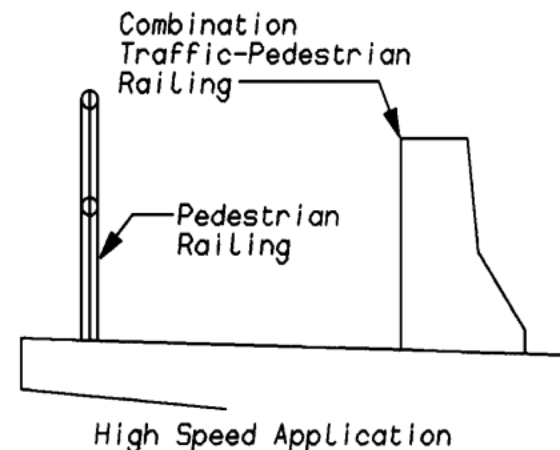
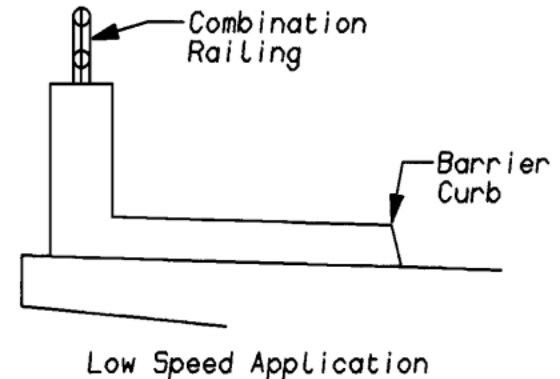
Typical Raised Sidewalk

Ref. AASHTO Bridge Design Specifications, 2012

Pedestrian Walkways



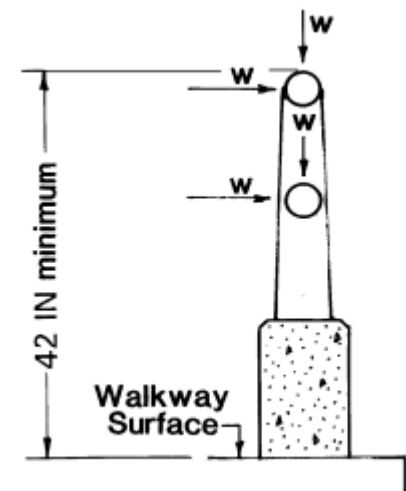
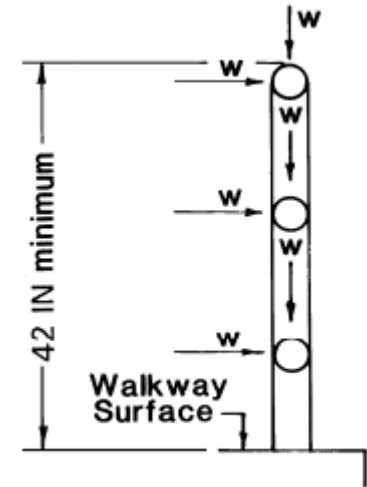
- A pedestrian walkway may be separated from an adjacent roadway by a barrier curb, traffic railing, or combination railing.
- On high speed urban expressways where a pedestrian walkway is provided, the walkway area shall be separated from the adjacent roadway by a traffic railing or combination railing.



Pedestrian Railings



- Minimum height: 1.07 m (42 in)
- Composed of horizontal and/or vertical elements
 - ▣ Clear opening between elements shall not allow a 150 mm (6 in) diameter sphere pass through
- When both horizontal and vertical elements are used
 - ▣ 150 mm (6 in) openings apply for the lower 685 mm (27 in) of the rail
 - ▣ 200 mm (8 in) openings apply to the upper portion of the rail

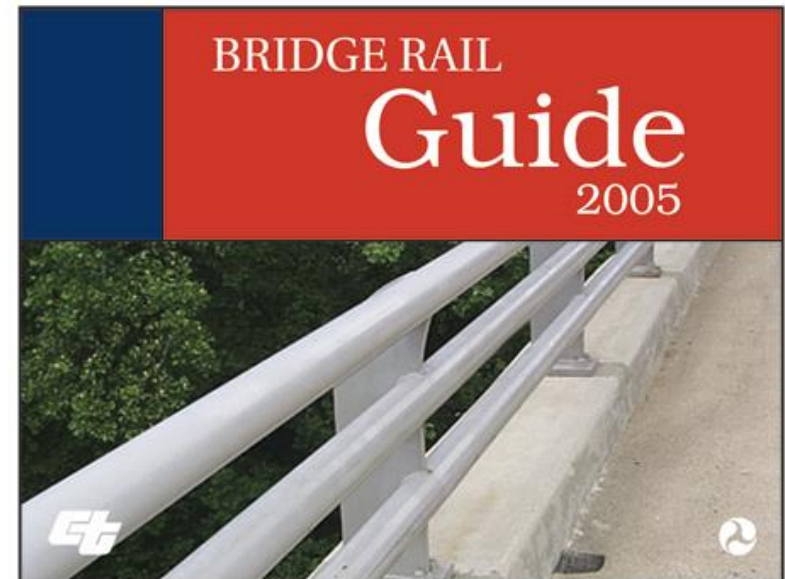


Bridge Rail Guide (2005)

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- Document created by Caltrans and FHWA
- More than 90 crash tested bridge railings
 - ▣ Railing Details
 - ▣ Location
 - ▣ NCHRP-350 Test Level



Rail Sections in the Bridge Rail Guide

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1. W-Beam Bridge Rail
2. Thrie-Beam Bridge Rail
3. Metal Tube Bridge Rail
4. Vertical Concrete Parapet
5. F-Shape Concrete Barrier
6. Timber Bridge Rail

3. Railing Types



- ❑ TL-1: few crash-tested
- ❑ TL-2: Thrie-beam railing
 - ❑ IMounting height of 22-in
 - ❑ Low volume secondary roads
 - ❑ Railing transition not needed
 - ❑ Post attachment yield on impact



TL2:

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3. Railing Types



- TL-3: Wyoming Two-tube railing
 - ▣ Two horizontal rails
 - ▣ Flush with 6-in curb
 - ▣ Mounting height of 29-in (top rail)
 - ▣ Modification with stronger rails successful at TL-4



TL2 vs. TL3:

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TL3: Steel Post and Beam Railing

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3. Railing Types



- TL-4
 - ▣ Reinforced concrete railings w/ 32-in height
 - ▣ Massachusetts S3 steel railing
 - ▣ Wyoming Two-tube railing
 - ▣ BR27C: structural tube over concrete parapet
- TL5: Reinforced concrete railings w/ 42-in height
- TL-6: Texas Type Tank Truck railing



Massachusetts S3

BR27C

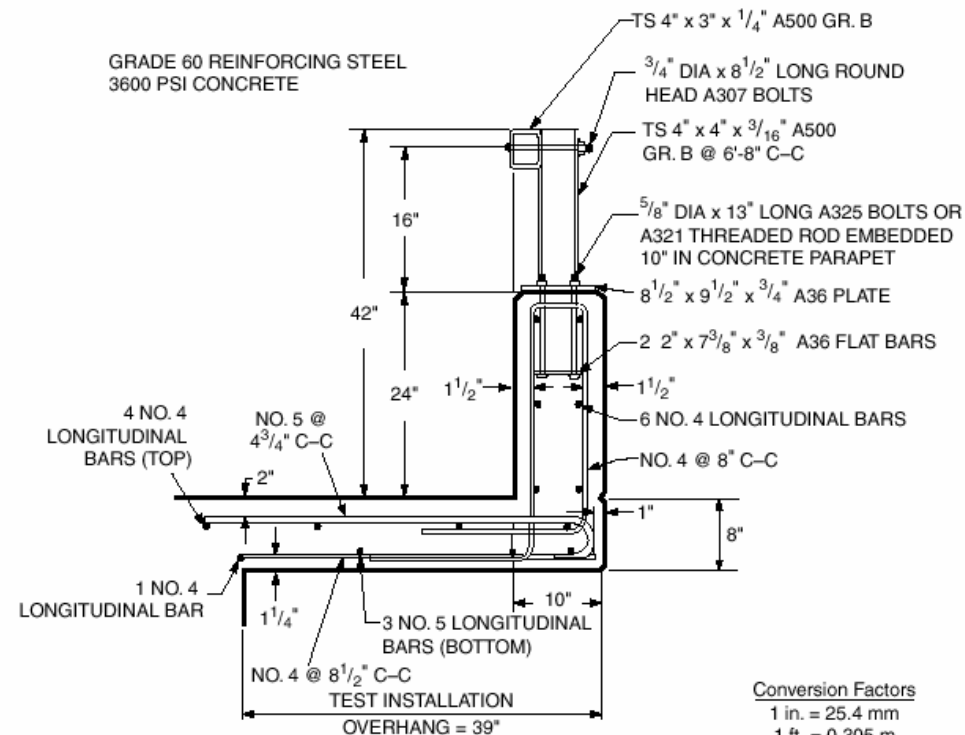


FIGURE 7.4 BR27C on sidewalk

TL4: Reinforced Concrete Railing

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TL5: 42" Concrete Safety Shape

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TL6: Texas Tank Trailer Railing

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4. Selection Guidelines



1. Railing Performance - Crash tested to meet NCHRP Report 350 criteria
2. Compatibility of approach roadside barrier and bridge railing
 - ▣ Differences in strength, height and deflection characteristics require a transition section.
3. Costs
 - ▣ Initial Construction Costs: Increases as the systems rigidity and strength increases
 - ▣ Maintenance costs: Decreases as the strength of the railing increases
 - ▣ Costs resulting from vehicle impacts (Damages to vehicles and injury costs to motorists)
4. Field Experience - Crash and performance history
5. Aesthetics - Scenic areas and park roads

5. Placement Recommendations



- Full and continuous shoulder that maintains clearance to roadside obstructions
- Provide flare rates when railing is inside shy line distance
- Avoid 8-in or higher curbs in front of railings
- Railing requires special termination

6. Upgrade of Railings

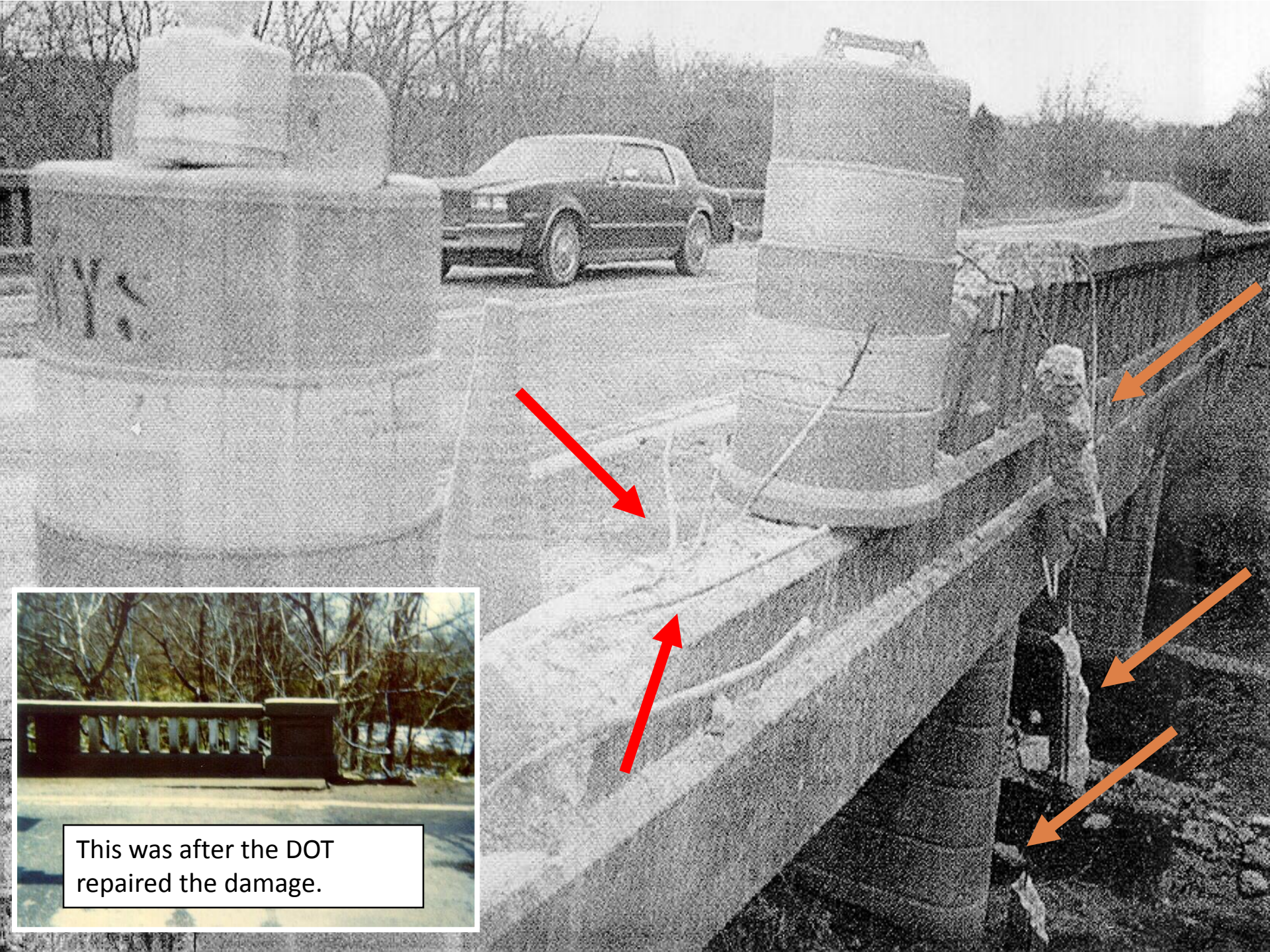


- Inadequate railing strength
 - ▣ Designed before 1964
 - ▣ Contain and redirect car impact at 60-mph and 25 degrees
- Snagging potential (open faced)
- Presence of curb or walkway
- Adequate approach rail to bridge rail transition









This was after the DOT repaired the damage.

Use of Safety Walk & Potential for Snagging

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Another Potential Danger a Curb can Pose

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APPROACH GUARDRAIL & TRANSITION

7. Transitions



- Semi-rigid approach barrier joins a rigid bridge railing
- Gradual stiffening of approach barrier
- Connection must be as strong as the approach barrier
- Length should be 10 to 12 times the difference in the lateral deflection

Transitions

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♥ Bobby



Lack of Connection Between Bridge Railing and W-beam Guardrail

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W-beam Transition Segment

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W-beam w/ Rubrail Transition Segment

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Thrie-beam Guardrail Transition

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Thrie-beam Guardrail Transition

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W-beam Transition Segment and End Treatment

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Adequate Structural Connection

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Block Outs and Rubrails

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Adequate Length to Gradually Increase Stiffness

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Nested Guardrail Beam Elements

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8. Approach Guardrail



- Considered the most important safety feature at a bridge or large culvert
- Frequently require greater length than the bridge rail
- Standard guardrail systems must be modified:
 - ▣ Adequate connection to bridge rail
 - ▣ Crash-worthy transition between the semi rigid approach and the rigid bridge
 - ▣ Crash-worthy end terminal

Warrants for Approach Guardrail

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- Approach guardrail systems should be provided for high speed rural areas
- The approach railing includes the transition and a crashworthy end terminal

Bridges in Urban Areas or with Sidewalks



- Approach guardrail and crashworthy terminals might not be possible to install
- Consider
 - ▣ Extending the bridge rail to prevent encroachment onto the side of the bridge
 - ▣ Provide a barrier curb
 - ▣ Restrict speed
 - ▣ Adding signing of intersections
 - ▣ Provide recovery area

Structurally Adequate Approach Guardrails

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- W-Beam on wood posts with wood block-outs
- W-Beam on steel posts with wood block-outs
- Thrie Beam on wood posts with wood block-outs



Functionally Adequate Approach Guardrails

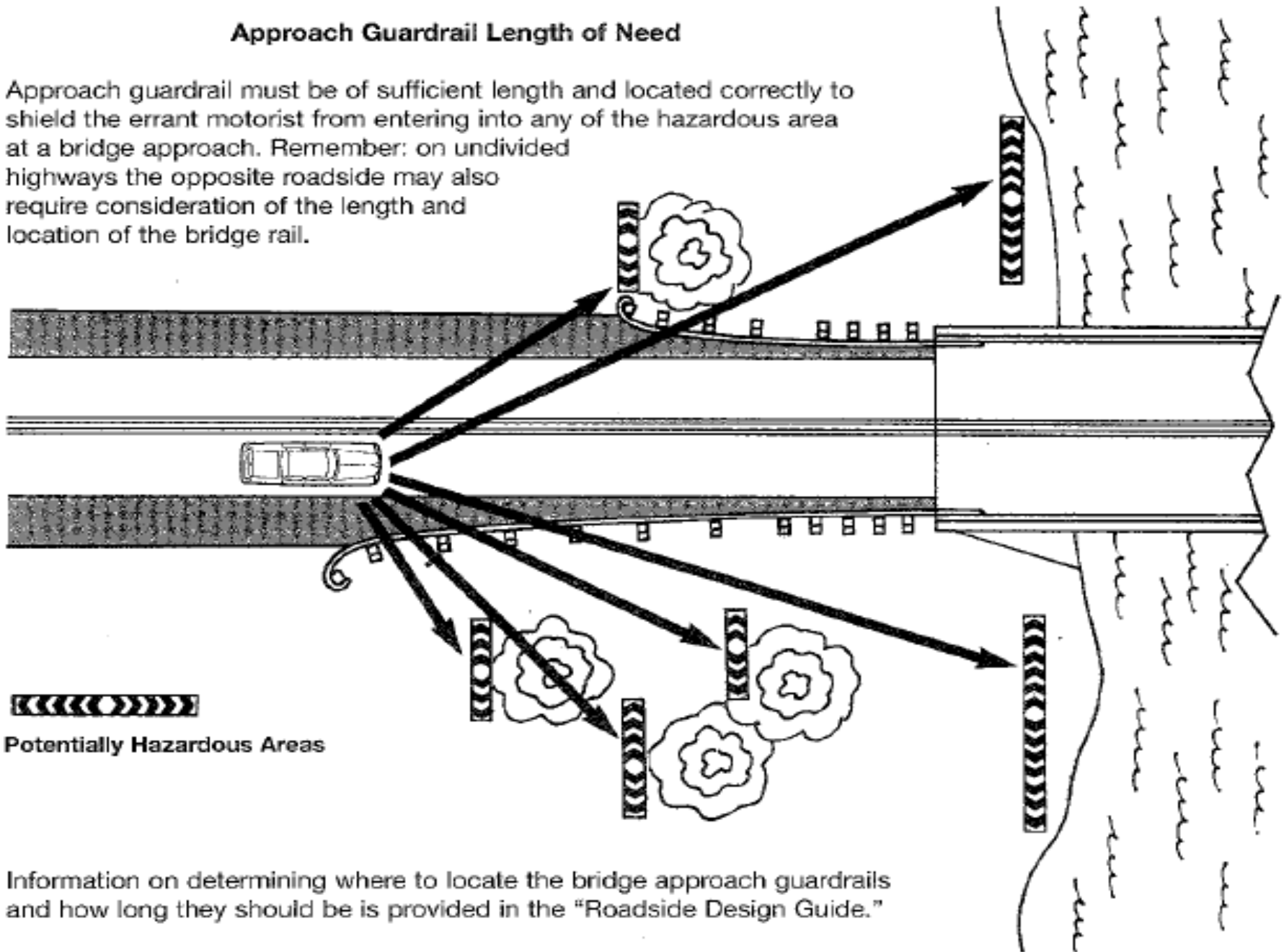
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- Sufficient length to ensure the car doesn't go around the approach guardrail and end up in the hazardous area
- Redirects the impacting car along the bridge rail in a stable manner
 - ▣ Not into traffic or opposing bridge rail
 - ▣ No rollover
 - ▣ No abrupt stops

Approach Guardrail Length of Need

Approach guardrail must be of sufficient length and located correctly to shield the errant motorist from entering into any of the hazardous area at a bridge approach. Remember: on undivided highways the opposite roadside may also require consideration of the length and location of the bridge rail.



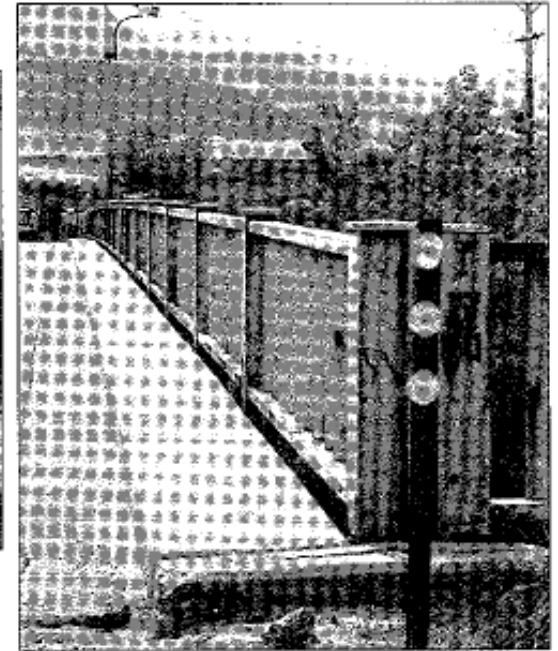
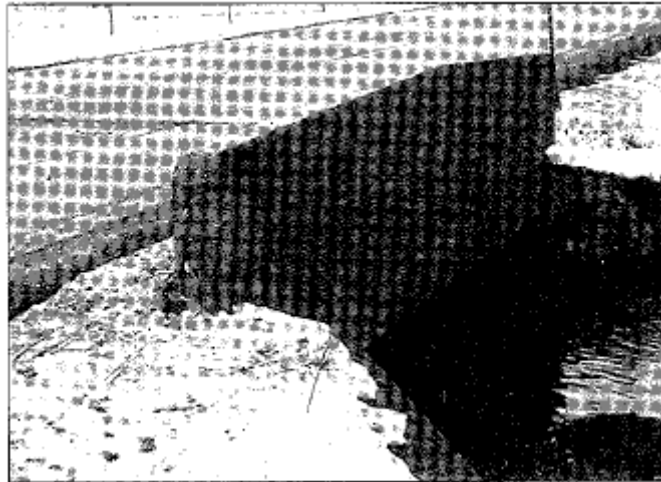
Information on determining where to locate the bridge approach guardrails and how long they should be is provided in the "Roadside Design Guide."

Where is Approach Guardrail Needed?

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- Rigid objects more than 4 in high have the potential to abruptly stop a car

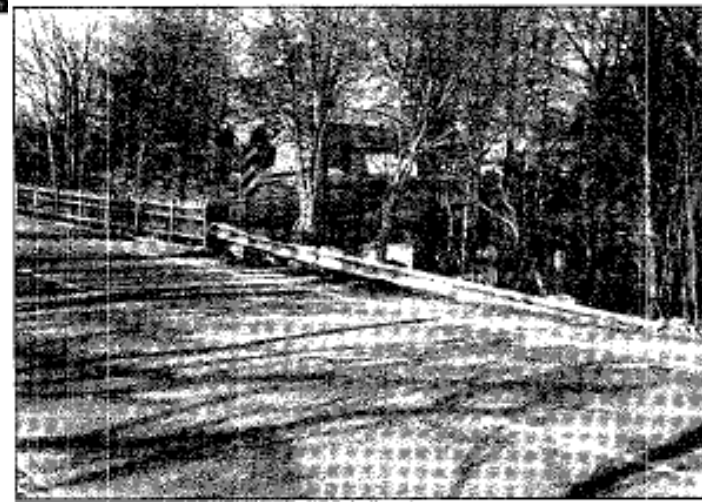
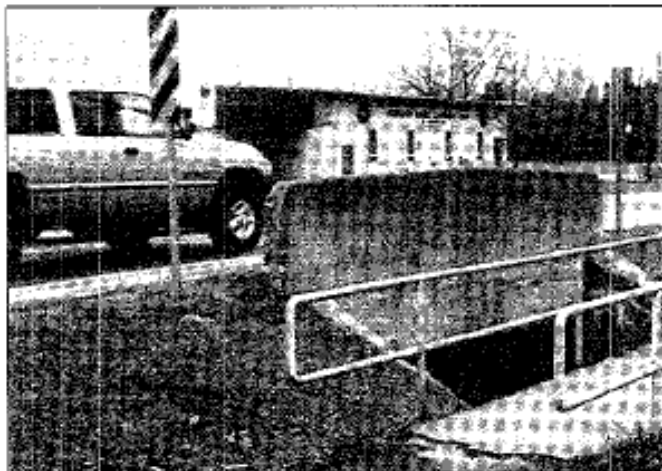


Where is Approach Guardrail Needed?

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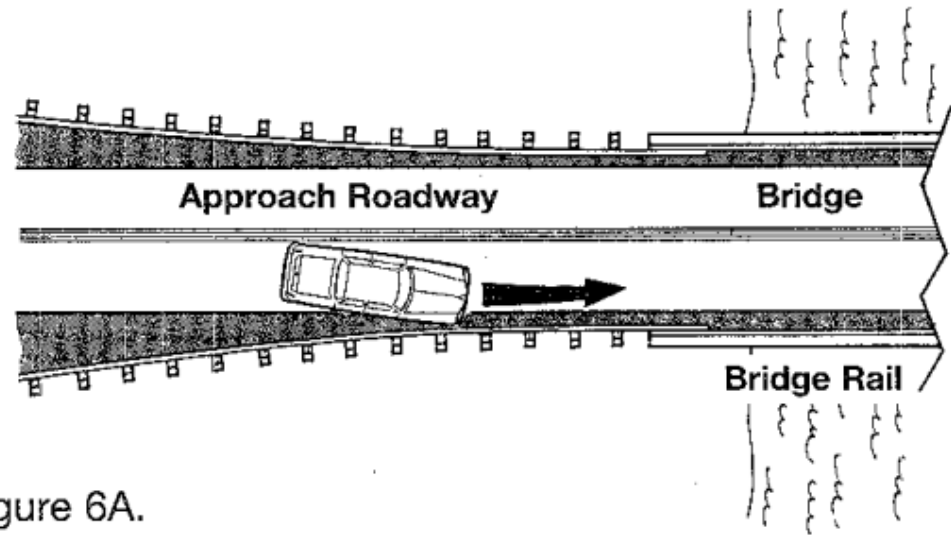
- Hazardous area behind bridge rail



Approach Guardrail Alignment

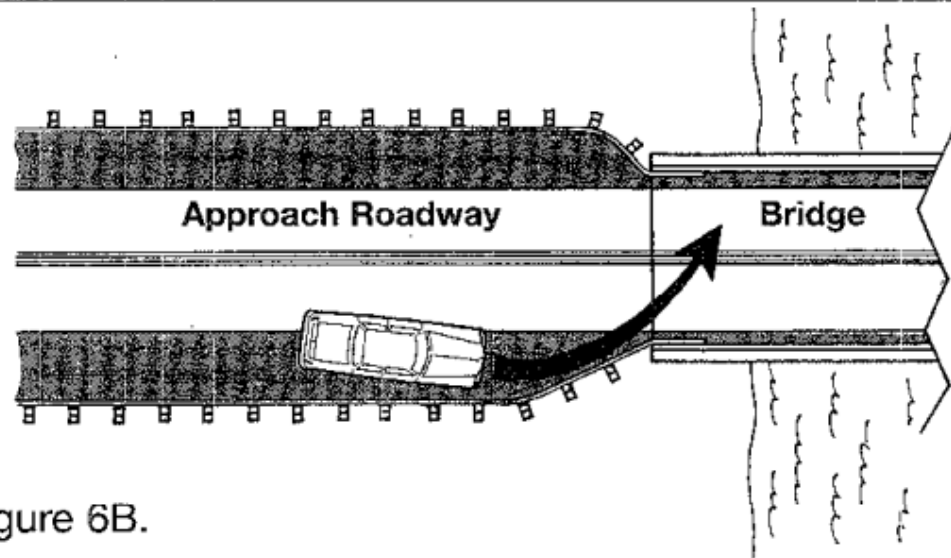
Good Alignment

Guardrail *should not* deflect and pocket. Car is redirected along guardrail in or adjacent to its lane.



Poor Alignment

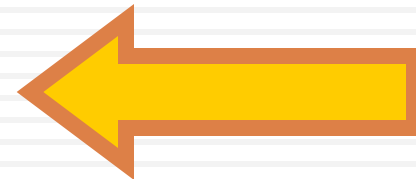
Guardrail that is curved in to connect to the bridge rail or is not sufficiently supported in the transition area can form a pocket on impact. The pocket can abruptly stop a car or redirect into the opposite lane of traffic.



Module 6 Review

1. Which bridge railing deficiency do you think is most serious:

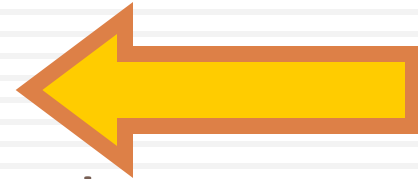
- a. Inadequate strength
- b. Safety curb
- c. Snagging potential



Module 6 Review

2. Which transition deficiency is likely to be the most critical:

- a. No connection to bridge rail
- b. Single metal beam rail (no nested elements)
- c. No reduced post spacing





Temporary Barriers



Truck Mounted Attenuators

Work Zone Safety



- ❑ More severe crashes
- ❑ Crashes with fixed-objects
- ❑ Near half of the crashes occur in darkness
- ❑ Forgiving roadside concept should be applied also to work zones

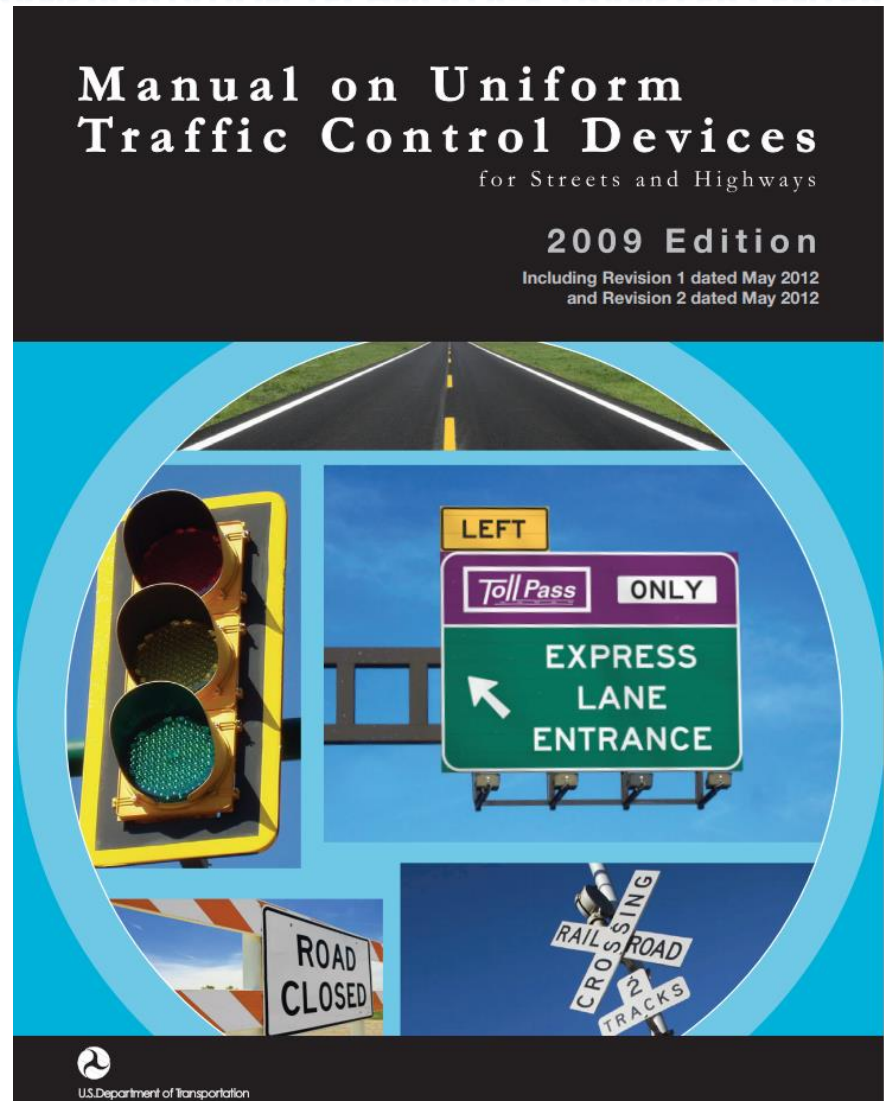
Work zone clear zone: unobstructed relatively flat area impacted by construction that extends outward from the edge of traveled way

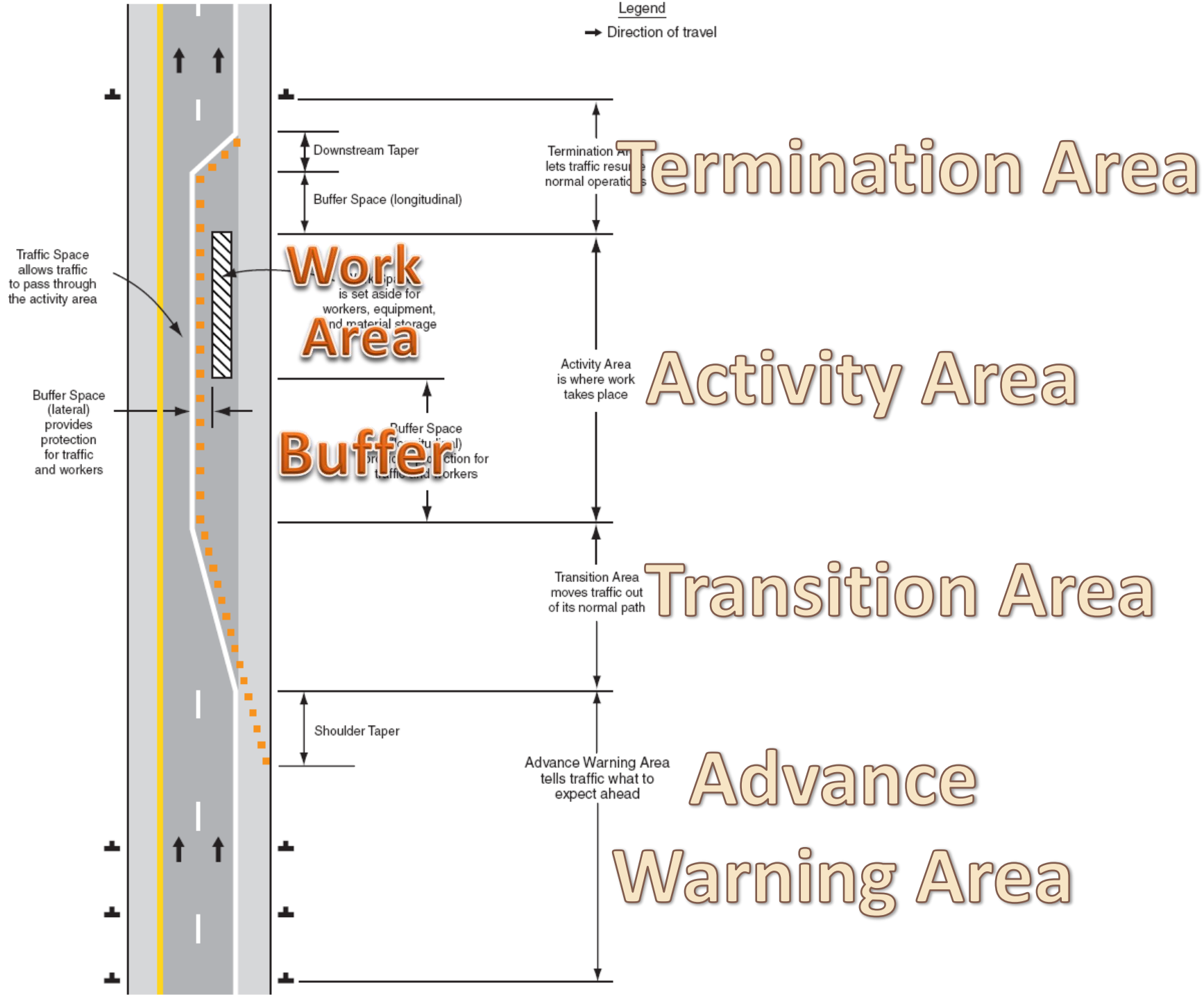
Manual on Uniform Traffic Control Devices Part 6

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- Requirements for the size, color, shape, and legend of signs
- Covers the design and placement of traffic control devices in work zones





Primary Work Zone Concerns

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- ❑ Channelization devices
- ❑ Temporary barriers
- ❑ Portable sign stands
- ❑ Crash cushions and Truck Mounted Attenuators (TMAs)
- ❑ Pavement-edge drop-offs

Channelizing Devices

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- ☐ Cones
- ☐ Tubular Markers
- ☐ Vertical Panels
- ☐ Drums
- ☐ Barricades

WZ Category 1 Devices

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- Low-mass, single-piece traffic cones, tubular markers, single-piece drums, & delineators
- Plastic drums w/ Type A or C warning lights moved from Category 2 to Category 1
- Self-certification allowed

Sandless
Drum



Channelizer Cones



Tube Delineators



Plastic Drums with Warning Lights

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WZ Category 2 Devices

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- Vertical panels, Type I, II, or III barricades, portable sign stands
- Category 1 devices w/ attachments (< 45 kg (100 lbs) up to 100 kg)
- Must be crash tested by approved agency

Cone w/ vertical panel and light



Type 2/3

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Type II



Type III

MiDOT's Type III w/ 12' wood panels
Pass @ 90 deg & Failure @ 0 deg



Portable Sign Stands



- X - Footprint, H-, & Inverted T Bases
- Panel Height From Ground to Panel Bottom
 - ▣ 12" Minimum
 - ▣ 14-24"
 - ▣ 5' and 7' Heights
- Panels (3'x3' and 4'x4')
 - ▣ -Mostly Vinyl Rollups
 - ▣ -Rigid Available (I.E., Plastic, Aluminum, Wood)
 - ▣ -New Systems Will Allow for More Rigid Panels

X-stands w/ vinyl roll-ups

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5/8" indentation
10" diameter pattern



MiDOT's combination sign w/ wood panels
Pass @ 0 deg & Failure @ 90 deg





Pass @ 0 deg



Failure @ 90 deg



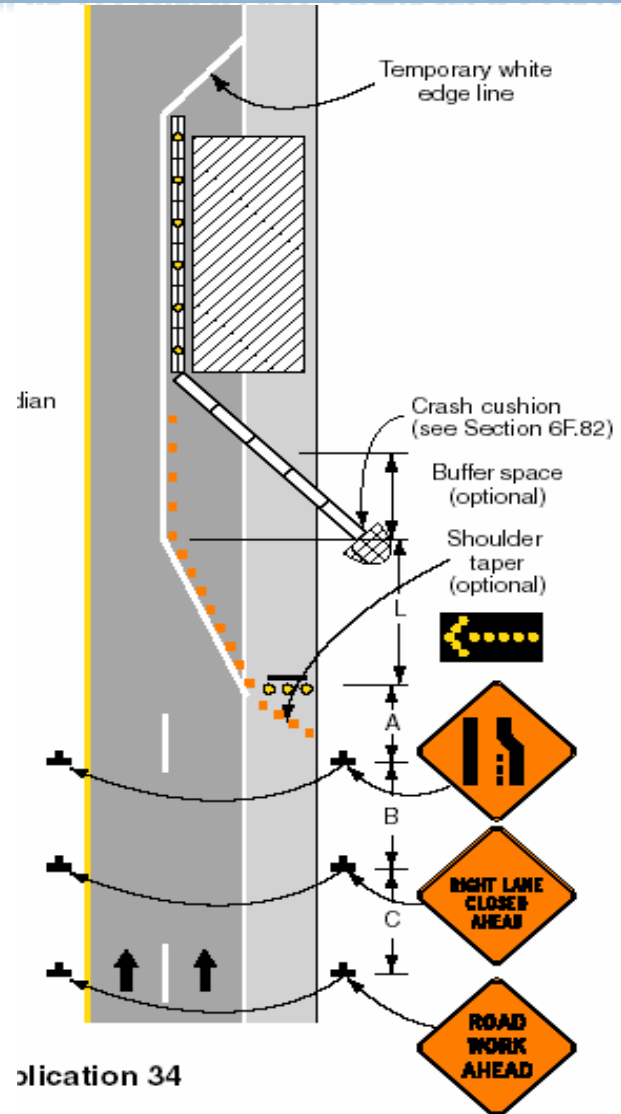
Example of Windshield Penetration



WZ Category 3 Devices



- Temporary barriers
 - ▣ Barrier joints must provide tensile & moment capacity
 - ▣ New units must meet NCHRP 350 by Oct 2002
- Crash cushions & TMA's
 - ▣ Can be tested to TL-2 or TL-3
 - ▣ Must be crash tested by approved agency



Uses for Temporary Longitudinal Barriers

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- Prevent Access to Work Zone
- Provide Positive Protection for Workers
- Separate Two-Way Traffic
- Protect Falsework

Table 9.1 Example Clear Zone Widths For Work Zones

WORK ZONE SPEED (KM/H)	WIDTHS (METERS)	WORK ZONE SPEED (MPH)	WIDTHS (FEET)
100-greater	9	60-greater	30
70-90	6.1	45-55	20
60	4.6	40	15
55 or less	3	35 or less	10

Clear Zone Distances in Work Zones

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***Engineering judgment
should be exercised in
the application of clear
zones in work zones***





Temporary Work Zone Barriers



Table 9-2. Temporary Longitudinal Barriers

Barrier Type	PCB	Quickchange®	Low Profile	Water-Filled/Steel
Structural Adequacy	Varies depending on type of joint	TL-3*	TL-2*	TL-2 and 3*
Deflection	0–1.5 m [0–5 ft]	1.5 m [5 ft]	127 mm [5 in.]	3.8–6.9 m [12.5–22.6 ft]
Uses	<p>Two-lane, two-way operation</p> <p>Shielding obstacles and falsework</p> <p>Shielding pavement edge drop-offs</p>	Shielding for changeable lanes	Work sites in urban and suburban areas where sight distance is an issue	<p>Shielding where high portability is desired; i.e., rapidly changing and emergency traffic control measures</p> <p>Protection in congested urban work sites</p>

*NCHRP Report 350 Test Level.

PCB – Portable Concrete Barrier

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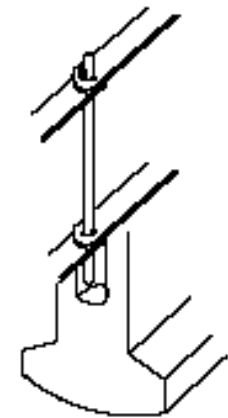
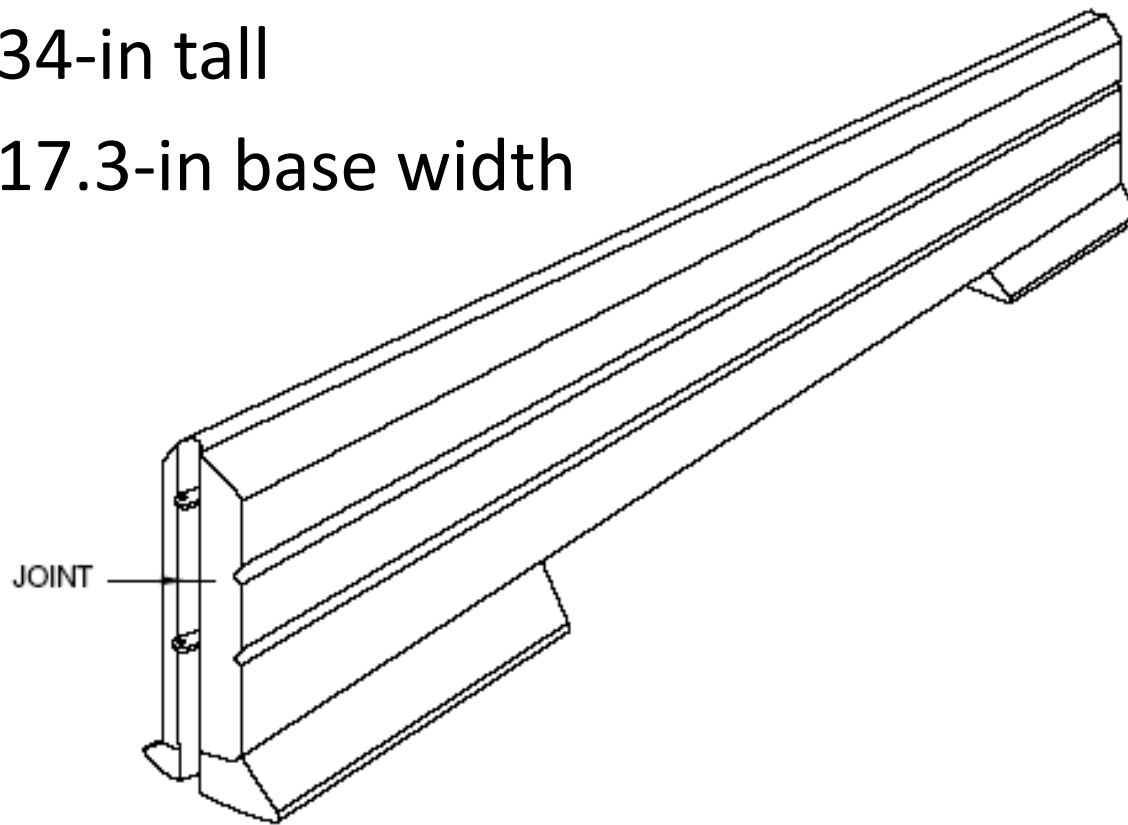
- Positive protection to road workers
- Avoid penetration in work area
- Modular design
 - ▣ Impact angle: 15°- 25°
 - ▣ Height: 32"
 - ▣ Base width: 24"
 - ▣ Top width: 6"
 - ▣ Length: 84" (7')
 - ▣ Maximum deflection: 0 – 5 feet

GPLINK Pre-cast PCB

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- 20-ft long sections
- 34-in tall
- 17.3-in base width



JOINT DETAIL

Not to Scale

Portable Concrete Barrier

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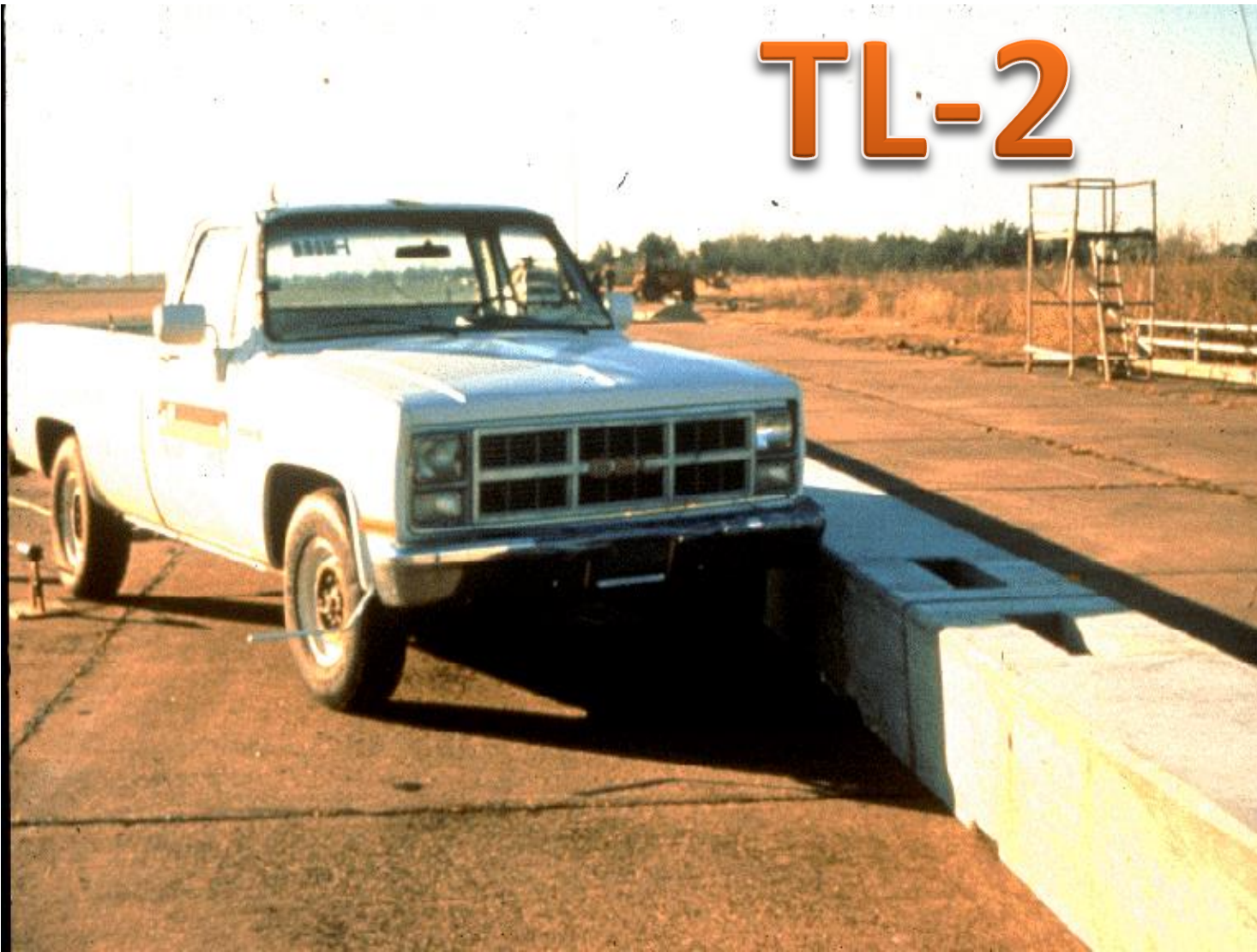
18 10 2005

PCB Low Profile

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TL-2



ArmorGuard Barrier

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ArmorGuard Barrier

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- ❑ Portable positive guidance freestanding barrier
- ❑ Interlocking steel sections comes in 28 ft (8.5 m)
- ❑ No foundation anchoring required
- ❑ Maximum deflection
 - ▣ TL-2: < 2 m
 - ▣ TL-3: <1 m

System Characteristics:

- Barrier Section Width - Approximately 28 inches (710mm)
- Barrier Section Height - Approximately 33 inches (830mm)
- Barrier Section Weight - Approximately 3,700 lbs. (1680kg)
- Barrier Section Length - Approximately 28 feet (8.5m)

ArmorGuard Gate

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- Steel barrier gate in 13, 26 and 52 ft length spans

TL-3



Vulcan Barrier

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Vulcan Barrier



- Portable steel redirecting longitudinal barrier
- Effective lengths = 4, 8, and 12 meters
- Vertical steel pivot allows system to follow curves
- Needs to add end treatments (cushions or barrels)
- Lightweight and stackable design
- Vulcan Anchor straps can be provided for applications or work zones requiring minimum deflection

Steel BarrierGuard 800

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TL-3,4



SBG

STEEL BARRIERGUARD™ 800
PERMANENT AND PORTABLE

Steel BarrierGuard 800

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- Steel galvanized longitudinal barrier
- Section length: 20 and 40 ft
- Positive barrier protection
- Barrier deflection: TL-3 (<4.9 ft) TL-4 (6.6')
- Special installation system for bridges
 - ▣ Needs anchorage every 20 ft
 - ▣ Very low deflection at base (< 1 in)

Characteristics:

- Barrier Section Base Width - Approximately 21 inches (540 mm)
- Barrier Section Top Width - Approximately 9.2 inches (235 mm)
- Barrier Section Height - Approximately 31.5 inches (800 mm)
- Barrier Section Weight - 40' (12m) - Approximately 2,400 lbs. (1080 kg)
- Minimum Radius - 120 feet (36m)



BarrierGuard 800 Gate

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- Access for work zones, emergency vehicles, or incident management
- Gates can be linked in 20 ft (6 m) sections



Triton Portable Barrier

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Temporary Barrier: Triton System

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- Portable water filled polyethylene barrier
- Interlocking barrier sections with internal steel framework
- Positive, crashworthy protection up to 100 kph (62 mph) does not allow penetration into work areas
- Absorbs collision energy and safely redirects errant vehicles
- Fast and easy deployment

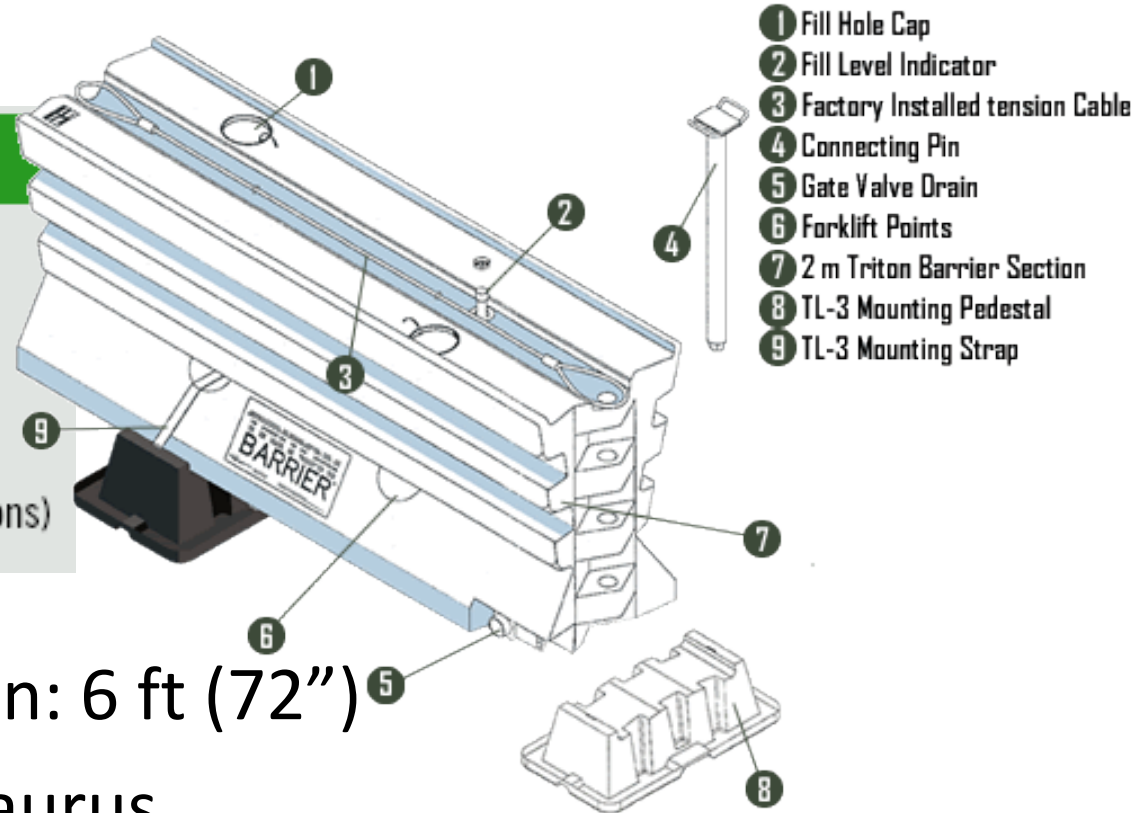
Triton Barrier

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



SPECIFICATIONS

Length	2 m	(78")
Height	800 mm	(32")
Width	500 mm	(21")
Weight Empty	65 kg	(140 lb)
Weight With Water	610 kg	(1,350 lb)
Water Ballast	550 liters	(145 gallons)



- ❑ Maximum deflection: 6 ft (72")
- ❑ Test vehicle: Ford Taurus
- ❑ Speed: 55 mph



Triton CET Concrete End Treatment

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TL-2

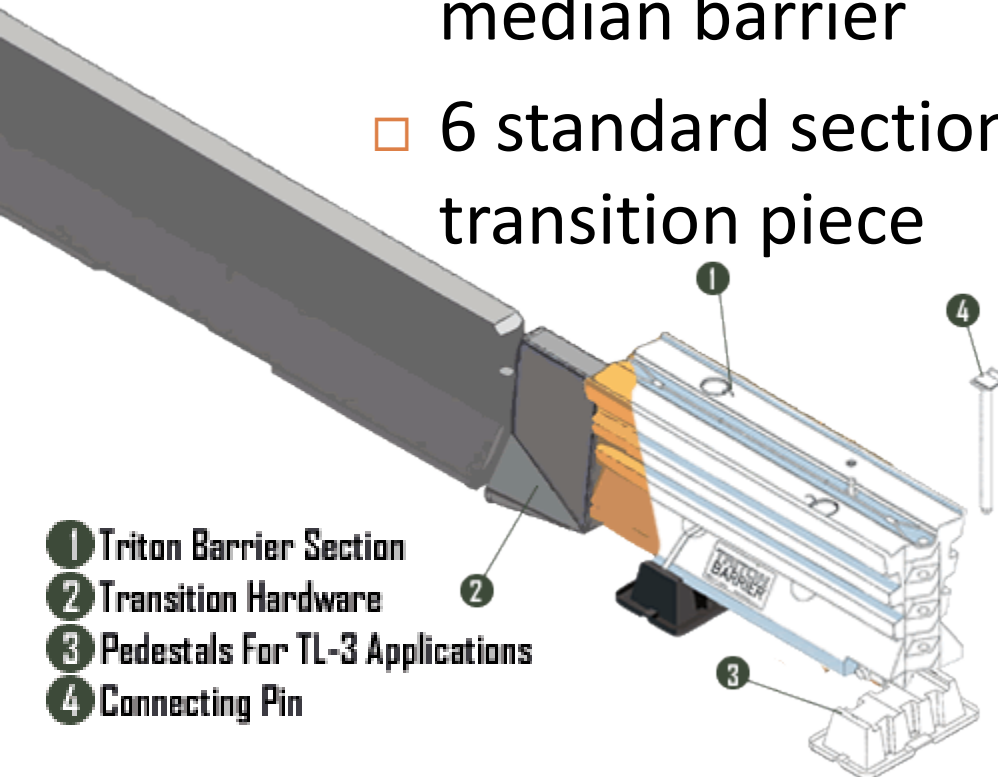
(TL-3 w/ pedestal)

Triton CET Concrete End Treatment

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- Gating, non-redirective, portable cushion
- Partially reusable can be used as transition between Triton and portable concrete median barrier
- 6 standard sections and a portable concrete transition piece



SPECIFICATIONS

Length (6 Triton Barrier sections & transition)	12.5 m	(40')
Width	500 mm	(21")
Height	800 mm	(32")
Weight Empty (per barrier section)	65 kg	(140 lb)
Weight With Water (per barrier section)	610 kg	(1,350 lb)

BARRACUDA Portable Barricade

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



- Portable and interconnecting barricade
- Can be used as longitudinal channelizing barricade, traffic delineator, and visual marker
- Each module weighs 80 lbs (empty), 1350 lbs (filled with water)
- Not designed to prevent intrusion
- Can be connected to the end of a Triton Barrier



Water Wall



- Durable polyethylene plastic portable longitudinal barricade
- 30-degree pivoting hinge design allows Water-Wall to handle curved roads

NCHRP 350 Approved As:

TL-1	Longitudinal Barrier – HSA-10/B-130
TL-2	Longitudinal Barricade – HSA-10/WZ-224
TL-3	Barricade – HSA-10/WZ-224

Specifications

Length	6'
Height	32"
Width	18"
Weight (empty)	90 lbs
Weight (filled w/water)	1,110 lbs
Material	Linear Low Density Polyethylene
Color	Orange/Red or White



Movable Barriers



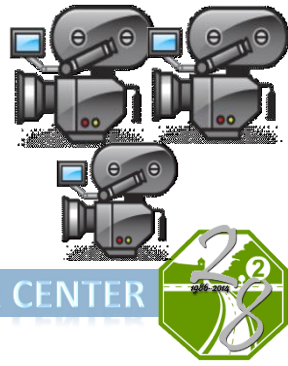
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- Provee más carriles para los períodos de horas pico
- Espacios expandidos para zonas de construcción durante horas pico
- Protección para trabajadores y motoristas
- Transfiere barrera hasta 24 pies



Quickchange Moveable Barrier



PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER

- Chain of modified F-shape barrier segments
- T-shape on top to allow pick up of segments
- Lateral movement from 4 to 18 ft
- Maximum deflection of 28 in at TL-3 design impact
- Transfer speed of 5 to 10 mph



TL-3

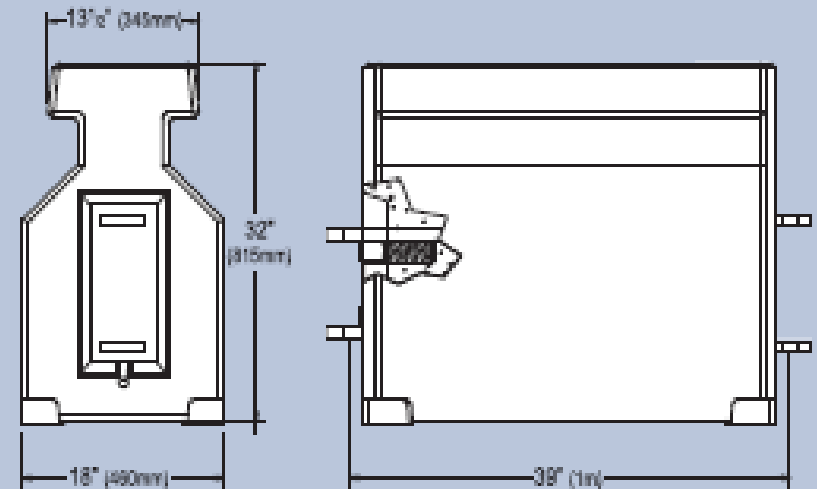
QMB Specifications

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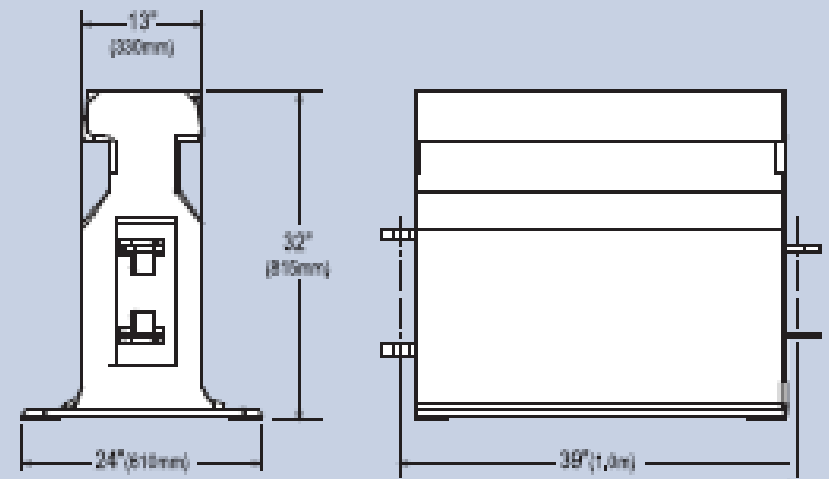
Concrete Reactive Tension System

- Heavily reinforced concrete barrier sections with Reactive Tension elements to reduce deflection while providing a narrow profile.
- Outstanding performance for locations where low deflection is required.



Steel Reactive Tension System

- High strength steel structure filled with concrete and Reactive Tension elements resulting in the narrowest profile and low deflection.
- Ideal for locations where low deflection is required and minimum lane width exists.







Work Zone Barrier End Treatments

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



- Flared
- Flared and Tapered
- Sand Barrels
- Other Crash Cushions

Flare end of barrier



Temporary barrier





Work Zone Crash Cushions

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



QuadGuard CZ Terminal

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



TL-3

QuadGuard CZ Terminal

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



- Energy absorbing, redirecting portable terminal
- Same QuadGuard system performance
- Modular plate bases reduce anchorage and speed installation
- 80% reusability after most design impacts
- Widths available in 24, 30, and 36 inches

REACT 350 WZ Terminal

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



TL-1,2,3*

* Based on the number of cylinders



REACT 350 WZ Terminal

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



- ❑ Non-gating, redirective crash cushion
- ❑ Same REACT 350 terminal performance
- ❑ High-density polyethylene plastic cylinders
- ❑ Regain up to 90% of their original shape and capacity after design impacts
- ❑ Can support widths as narrow as 36 inches.
- ❑ Installs as a single unit with minor assembly
- ❑ Available with a self-contained backup or a concrete-mounted backup system

ABSORB 350 Crash Cushion

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



- ❑ No-redirigible , tipo “gating” y “energy absorbing”
- ❑ Contenedores llenos de agua
- ❑ Protege extremos de vallas de hormigón
- ❑ No necesita anclaje
- ❑ Fácil de instalar y reparar
- ❑ Aplicaciones permanentes y temporeras



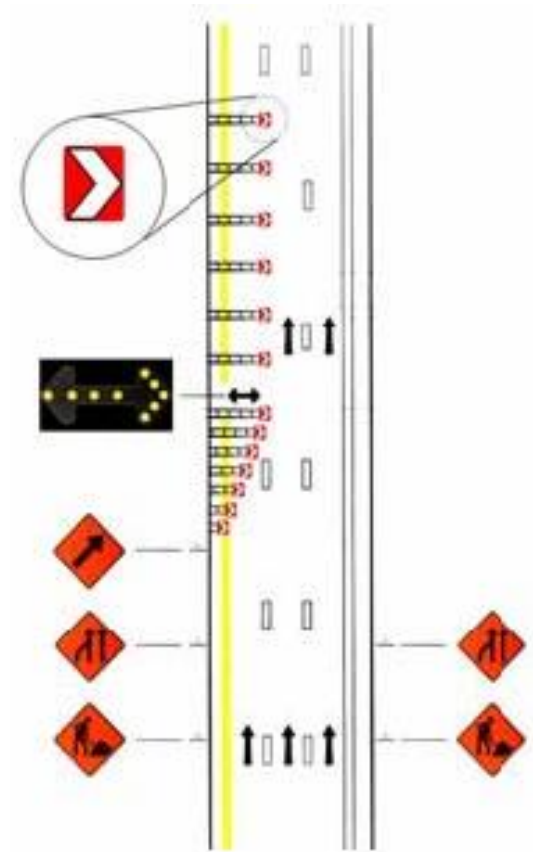
SwiftGate™ Lane Closure System



PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



- Automated lane closure gate
- System includes gate modules and signagemodules
- Pivoting gates made of high-density polyethylene
- Meets NCHRP Report 350



WZ Category 4 Devices

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



- Portable, usually trailer-mounted devices
- Lighting supports, flashing arrow panels, temporary traffic signals, & changeable message signs
- Should be delineated or shielded
- Use good placement practices

Truck Mounted Attenuators (TMA)

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



- Three classes of applications
 - Shadow vehicle – moving truck spaced a short distance from a moving operation
 - Barrier vehicle - truck parked upstream from a stationary operation
 - Advance warning truck – truck parked a considerable distance upstream of a moving or stationary operation displaying an arrow panel and signs (if in the traveled way)



TMA Applications

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



TMA Applications

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER

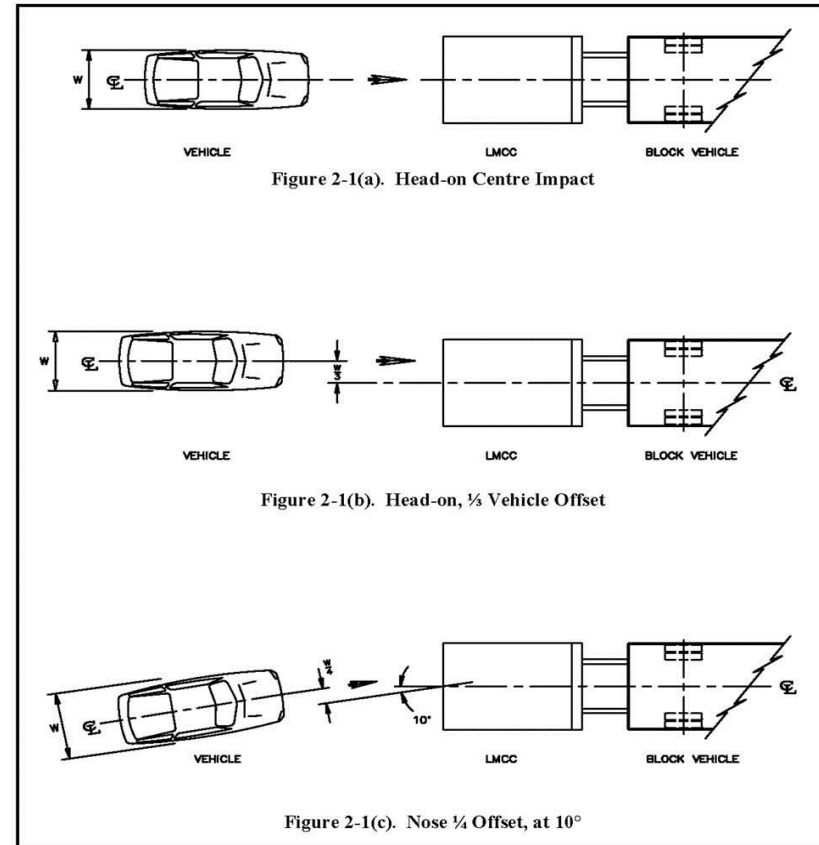


Truck Mounted Attenuators (TMA)

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



- NCHRP 350 tested and approved for all mandatory and optional offset and angled impacts
 - ▣ TL-2 is basic level
 - ▣ TL-3 can accommodate higher speeds but often result in more complex units
- Mass of shadow vehicle should be similar to test vehicle – 9,000 kg (19,800 lb) +/- 450 kg (990 lb)



Buffer Distance



- Space between the protective vehicle and the work activity

For Shadow Vehicles Weighing 10000 kg [22,000 lb] or More					
Operating Speed/Speed Limit ^a		Recommended Spacing ^b			
		Stationary Operation		Moving Operation ^c	
		m	[ft]	m	[ft]
Greater than 90	[Greater than 55]	45	[150]	52.5	[172]
70 – 90	[45 – 55]	30	[100]	45	[150]
Less than 70	[Less than 45]	22.5	[74]	30	[100]

^a Should use operating speed if higher than posted speed limit.

^b Recommended spacing is distance between front of shadow vehicle and beginning of work area, that is the first worker/operation/vehicle to be protected.

^c Distances are appropriate for shadow vehicle speeds up to 25 km/h [15.5 mph].

^d Shadow vehicles shall weigh 8000 kg to 9000 kg [17,600 lb to 19,800 lb] on all Department construction projects.

Buffer Distance



- Space between the protective vehicle and the work activity

For Shadow Vehicles Weighing Less than 10000 kg [22,000 lb] but Greater than 4500 kg [9,900 lb] ^d

Operating Speed/Speed Limit ^a		Recommended Spacing ^b			
		Stationary Operation		Moving Operation ^c	
		m	[ft]	m	[ft]
Greater than 90	[Greater than 55]	52.5	[172]	67.5	[222]
70 – 90	[45 – 55]	37.5	[123]	52.5	[172]
Less than 70	[Less than 45]	30	[100]	30	[100]

^a Should use operating speed if higher than posted speed limit.

^b Recommended spacing is distance between front of shadow vehicle and beginning of work area, that is the first worker/operation/vehicle to be protected.

^c Distances are appropriate for shadow vehicle speeds up to 25 km/h [15.5 mph].

^d Shadow vehicles shall weigh 8000 kg to 9000 kg [17,600 lb to 19,800 lb] on all Department construction projects.

Suggested Priorities for Use of TMA



Closure/Exposure Condition	Examples of Typical Construction Maintenance Activities	Ranking*			
		Freeway	Non-Freeway		
			80 km/h [50 mph]	70 km/h [45 mph]	60 km/h [40 mph]

Mobile Activities:

No Formal Lane Closure

Shadow vehicle for operation involving exposed personnel	Crack pouring, patching, utility work, striping, coning	A-1	A-2	A-3	A-4
Shadow vehicle for operation not involving exposed personnel	Sweeping, chemical spraying	E-1	E-2	E-3	E-4

No Formal Shoulder Closure

Shadow vehicle for operation involving exposed personnel	Pavement repair, pavement marking, delineator repair	B-2	B-3	C-3	C-3
Barrier vehicle for operation not involving exposed personnel	Open excavation, temporarily exposed bridge pier	E-2	E-3	E-4	E-5

Suggested Priorities for Use of TMA



Closure/Exposure Condition	Examples of Typical Construction Maintenance Activities	Ranking*			
		Freeway	Non-Freeway		
			80 km/h [50 mph]	70 km/h [45 mph]	60 km/h [40 mph]

Stationary Activities:

Formal Lane Closure

Barrier vehicle for operation involving exposed personnel	Pavement repair, pavement marking	B-2	B-3	C-4	D-5
Barrier vehicle for condition involving significant obstruction	Open excavation	E-2	E-3	E-4	E-5

Formal Shoulder Closure

Barrier vehicle for operation involving exposed personnel	Pavement repair, pavement marking, guardrail repair	C-3	C-4	D-5	D-5
Barrier vehicle for condition involving significant obstruction	Open excavation	E-3	E-4	E-5	E-5

Suggested Priorities for Use of TMA



* The alphabetic ranking indicates the priority assigned to the use of a protective vehicle. The use of protective vehicles:

A — is very highly recommended

B — is highly recommended

C — is recommended

D — is desirable

E — may be justified on the basis of special conditions encountered on an individual project when an evaluation of the circumstances indicates that an impact with a protective vehicle is likely to result in less serious damage and injury than would impact with a working vehicle or the obstruction

* The numerical rank indicates the level of priority assigned to the use of a TMA on an assigned protective vehicle. The use of a TMA under the defined conditions:

1 — is very highly recommended

2 — is highly recommended

3 — is recommended

4 — is desirable

5 — may be justified on the basis of special conditions encountered on an individual project

LS-Pro TMA

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



LS-Pro TMA

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



- Lightweight (900 lb) and compact (4 ft in length) aluminum cartridge
- Durashell Nose returns to original shape after low-speed nuisance hits
- Tapered nose minimizes corner damage and streamlines appearance
- Economically designed to shield work zone vehicles during low speed impacts (30 mph)

SPECIFICATIONS

Length (from Back of Truck)	1.44 m (4'8")
Width	2.36 m (7'8")
System Weight	243 kg (535 lb.)
Road Clearance	31 cm (12.5" ± .25")

Alpha 70K Truck Mounted Attenuator

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Alpha 70K Truck Mounted Attenuator

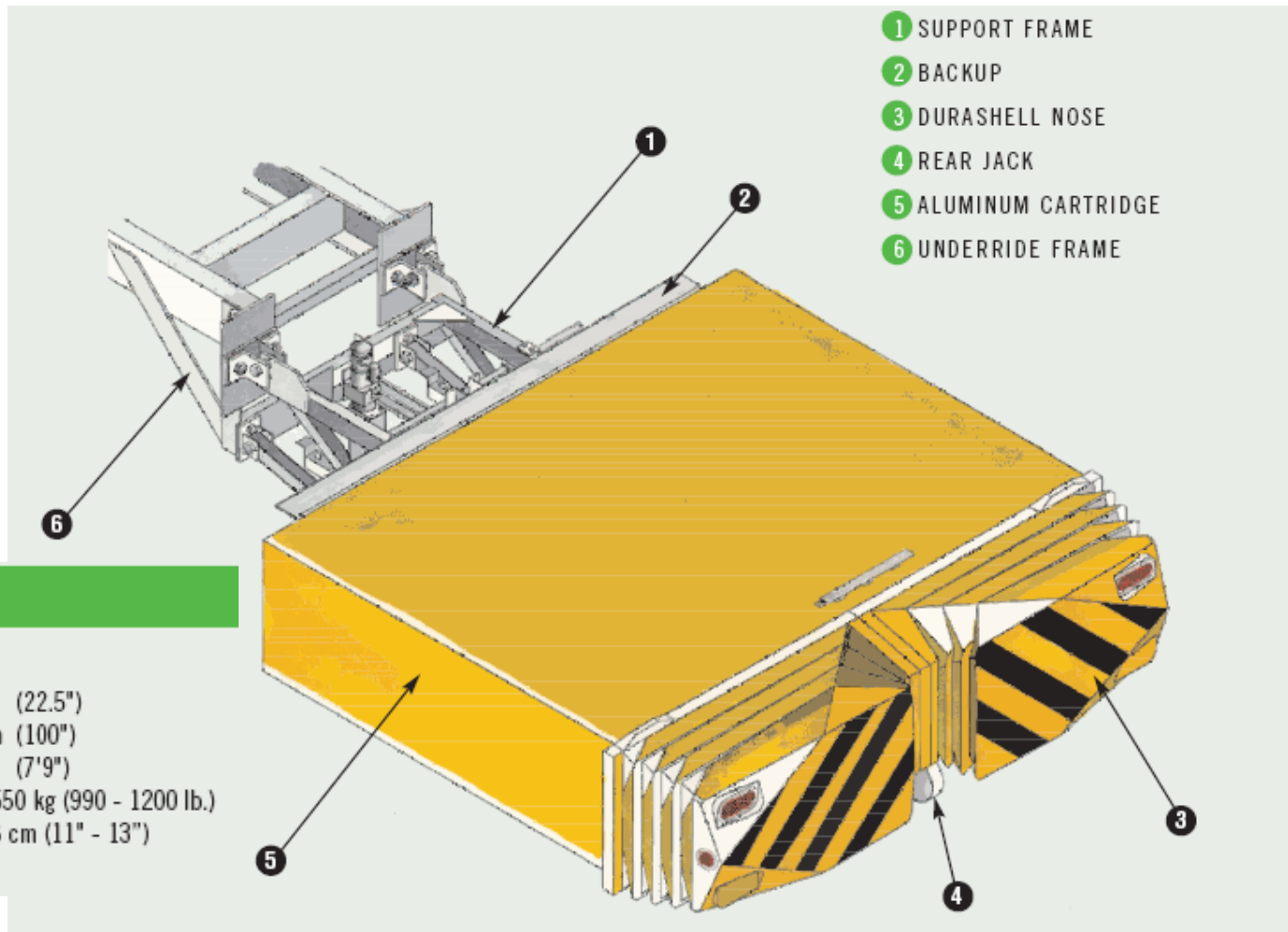
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- ❑ Lightweight aluminum cartridge
- ❑ Resilient Durashell® Nose resists nuisance hit damage
- ❑ Tapered nose shape minimizes corner damage
- ❑ Hydraulic system permits tilting of the unit to a safe height when driving through depressed medians or driveways and to 90° position for convenient storage

Alpha 70K Truck Mounted Attenuator

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



SPECIFICATIONS

DEPLOYMENT MODE

Height*	57 cm (22.5")
Length*	254 cm (100")
Width*	2.36 m (7'9")
Weight - Complete System	450 - 550 kg (990 - 1200 lb.)
Road Clearance	28 - 33 cm (11" - 13")

*Cartridge Only-

SAFE-STOP TMA

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



TL-3



SAFE-STOP TMA

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



- Two lightweight aluminum cartridges contained in a reusable steel support frame
- When design impacted, the steel support frame collapses and the aluminum cartridges crush to absorb the energy of impact

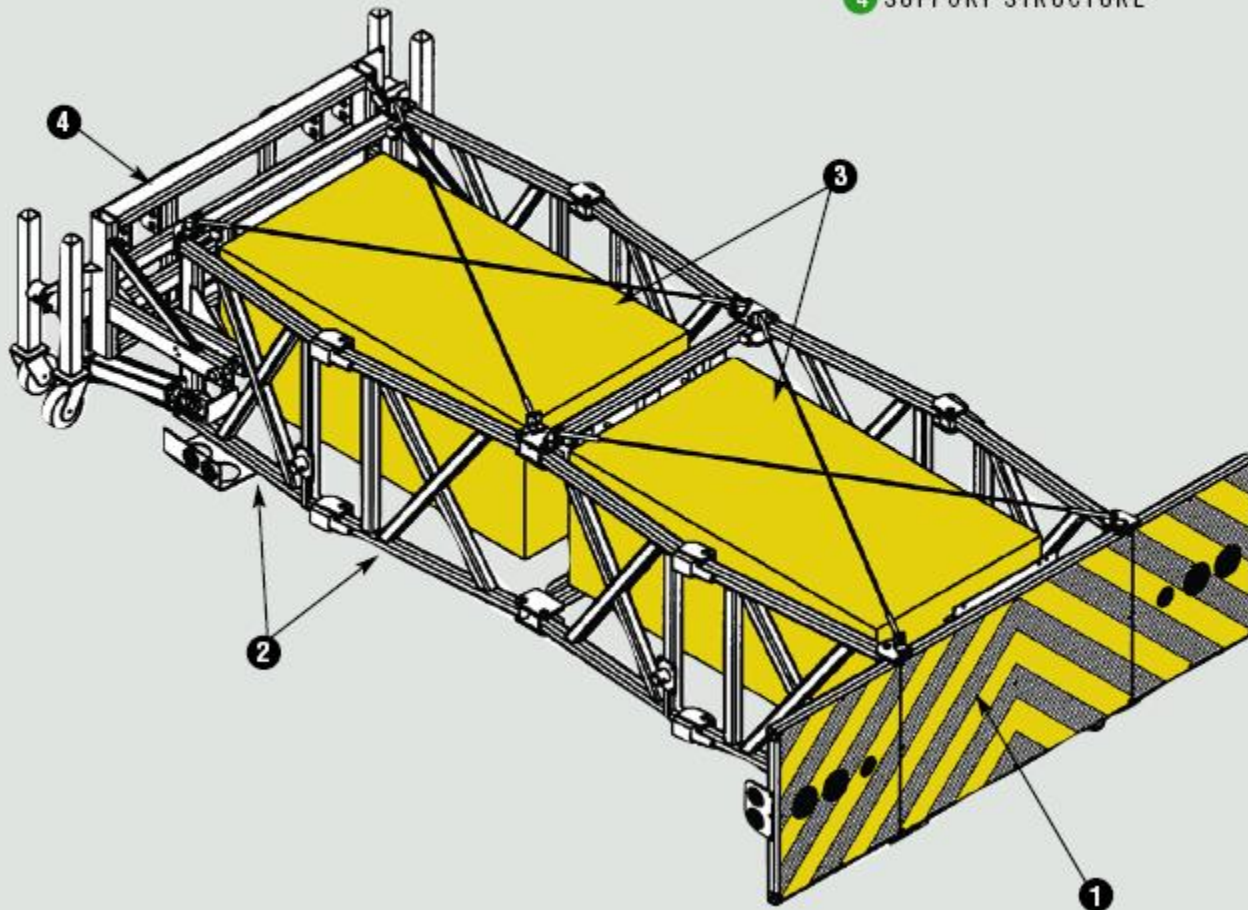
SAFE-STOP TMA

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



- ▶ Withstands nuisance impacts up to 10 km/h (6 mph) with little or no damage.
- ▶ Successfully tested in vibration, corrosion and water resistance tests.
- ▶ Field tested over 4000 km (2500 miles).

- 1 IMPACT FACE
- 2 SAFE-STOP COLLAPSIBLE FRAME
- 3 SAFE-STOP CARTRIDGES
- 4 SUPPORT STRUCTURE



SAFE-STOP 180 TMA

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



TL-3



TL-2

SAFE-STOP 180 TMA

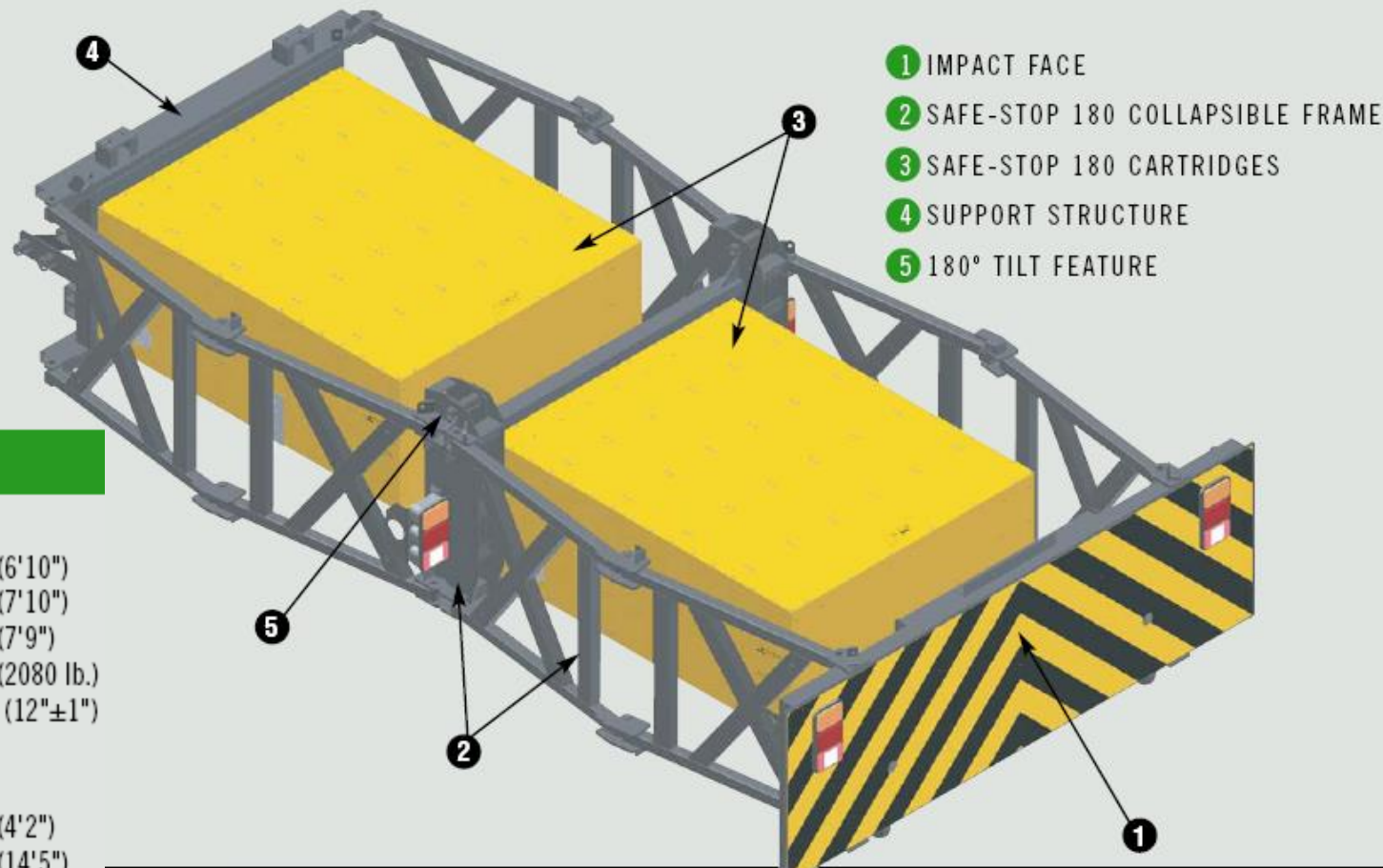
PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



- Folds at the center, reducing the total system's height to 6'10" in the storage mode
- Tested to NCHRP 350 TL-2 criteria in storage mode
- Over 50% reusability after a typical design impact

SAFE-STOP 180 TMA

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



SPECIFICATIONS

STORAGE MODE

Height	2.08 m (6'10")
Length From Back of Truck	2.39 m (7'10")
Width	2.36 m (7'9")
Weight	943 kg (2080 lb.)
Road Clearance	30.5 mm (12"±1")

DEPLOYMENT MODE

Height	1.27 m (4'2")
Length From Back of Truck	4.39 m (14'5")
Width	2.36 m (7'9")
Weight	943 kg (2080 lb.)
Road Clearance	30.5 mm (12"±1")

SAFE-STOP TRAILER SST TMA

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



TL-3



SAFE-STOP TRAILER SST TMA

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



- Modified version of the Safe-Stop 180 TMA
- Uses a hydraulic cylinder dampener system to minimize rotation during an offset impact



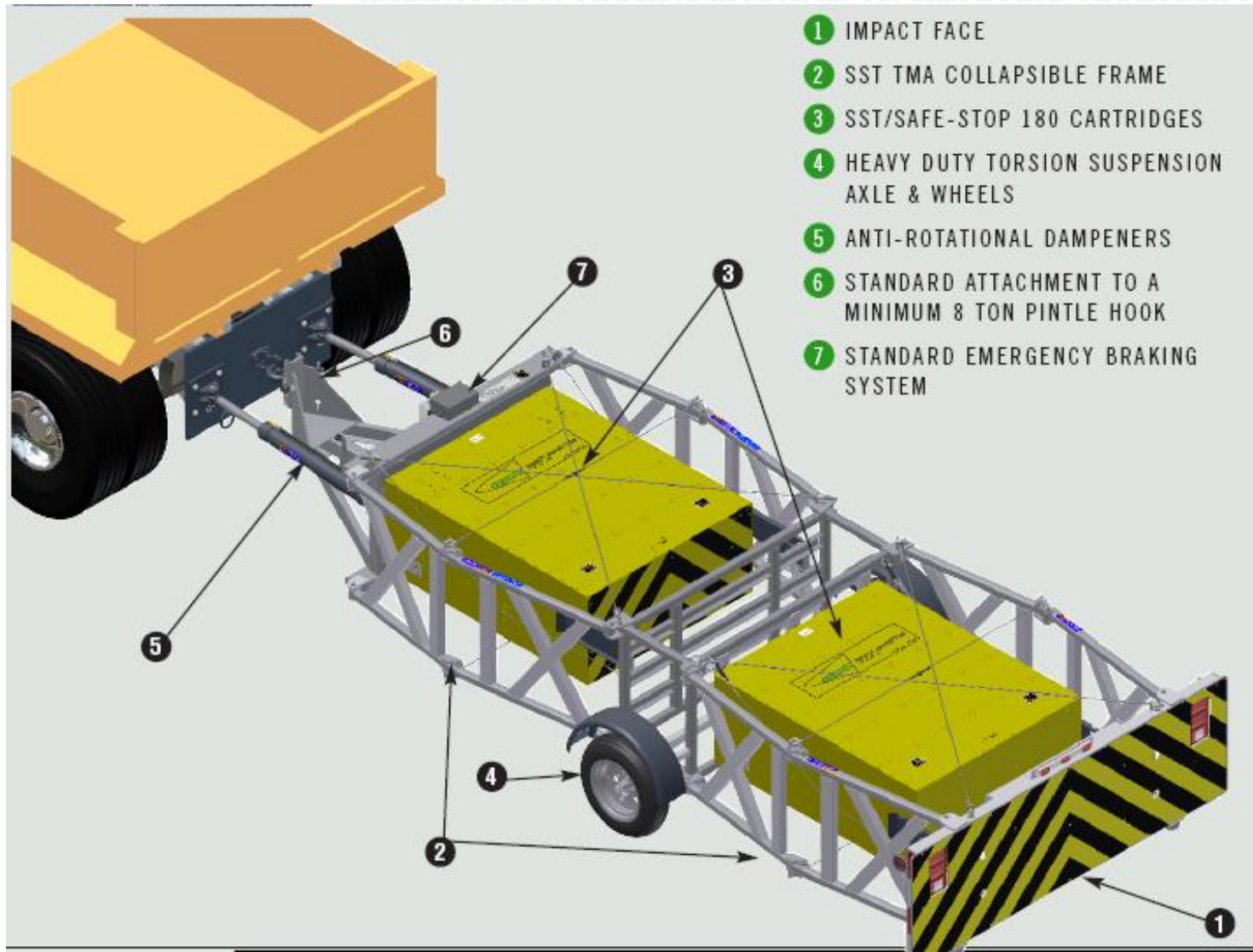
SPECIFICATIONS

Length
Weight
Width
Height

19' 3" (5.87 m)
2650 lb. (1202 kg)
7' 9" (2.36 m)
45" (1.14 m)

SAFE-STOP TRAILER SST TMA

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



Vorteq TL-3 Trailer TMA

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



TL-3



Vorteq TL-3 Trailer TMA

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



- Lightweight multi-stage, tube-in-tube energy absorbing technology that inwardly shapes the steel tubing
- Attaches to all types of host vehicles with a standard pintle hook and 7 pin electrical connector
- Wheels and axle are designed to stay connected and functional after design impacts
- Significantly reduces debris scatter

Vorteq TL-3 Trailer TMA

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



- 1 IMPACT HEAD
- 2 WHEEL/AXLE ASSEMBLY
- 3 TUBE-IN-TUBE FRAME RAILS
- 4 X-BRACE
- 5 TONGUE ASSEMBLY



SPECIFICATIONS

Length	22.9 ft.
Width	92 in.
Height	30.5 in.
Tongue Weight	300 lb.
Total Weight	<1300 lb.

MPS-350 Mobile Protection System TMA

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



TL-3

MPS-350 Mobile Protection System TMA

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



- ❑ Open design and all-steel functional components
- ❑ Stationary or moving shadow or support vehicles
- ❑ No bulky crushable cartridges

SPECIFICATIONS

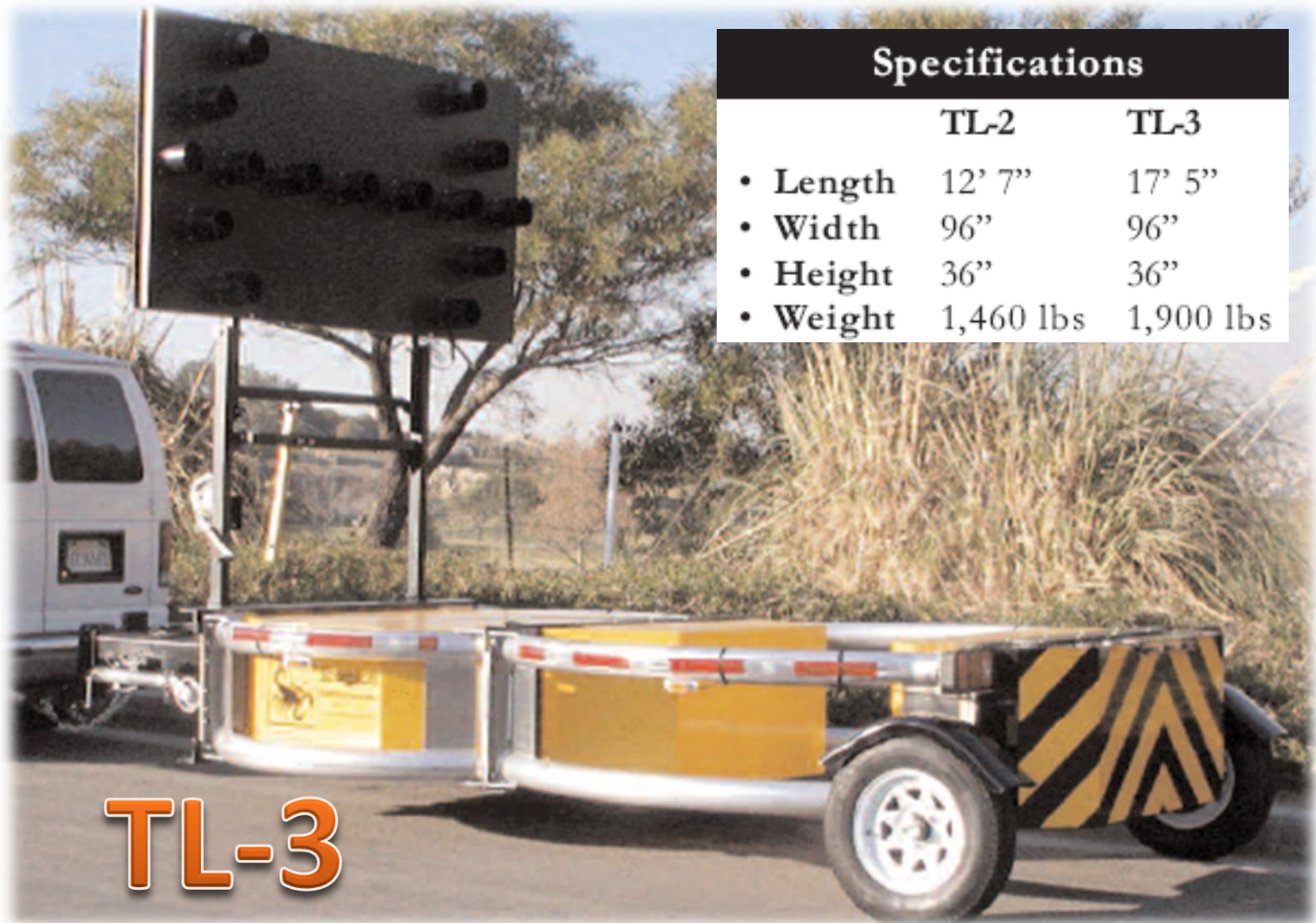
MPS-350™

- 14' L (4.30 m) in down position
- 12'6" H (3.81 m) when raised
- 69" (1.75 m) without plastic side panels
- 72" (1.83 m) with plastic side panels
- 1800 lbs. weight (816 kg)



Scorpion TMA

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



Specifications

	TL-2	TL-3
• Length	12' 7"	17' 5"
• Width	96"	96"
• Height	36"	36"
• Weight	1,460 lbs	1,900 lbs

TL-3

Scorpion TMA

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



- Modular design crushes in progressive stages allowing quick and economical replacement of damaged parts
- Telescoping Anti-Rotational System (TARS™) minimizes Scorpion Trailer rotation during angled impacts and prevents trailer separation from host vehicle
- Unique curved design gives full width protection to the back of the host vehicle and protects the “coffin corners” of the truck

Scorpion TMA

PUERTO RICO TRANSPORTATION TECHNOLOGY TRANSFER CENTER



TL-2

Module 7 Review

1. All Category 1 and 2 work zone devices must be certified as crashworthy.

True or False?

Module 7 Review

2. Which of the following factors is the most critical in selecting a work zone traffic barrier?

- a. test level
- b. design deflection distance
- c. barrier profile (NJ, F-shape, Single-slope)

Module 7 Review

3. Any precast portable concrete barrier that is equivalent in size, shape and connection detail to a formally accepted barrier may be considered acceptable for use on the NHS after October 2002.

True or False?

Module 7 Review

4. Barrier terminals and crash cushions used in work zones are substantially different from those acceptable for use in permanent installations.

True or False?

Module 7 Review

5. TMA's can be mounted on any size support vehicle.

True or False?