Session 3: Testing Requirements and Performance Characteristics of Common Barrier Systems


FAST Act Guardrail Training
Highway Barrier Design Training
Session 3:
Testing Requirements and Performance Characteristics of Common Barrier Systems
U.S. Department of Transportation
Federal Highway Administration
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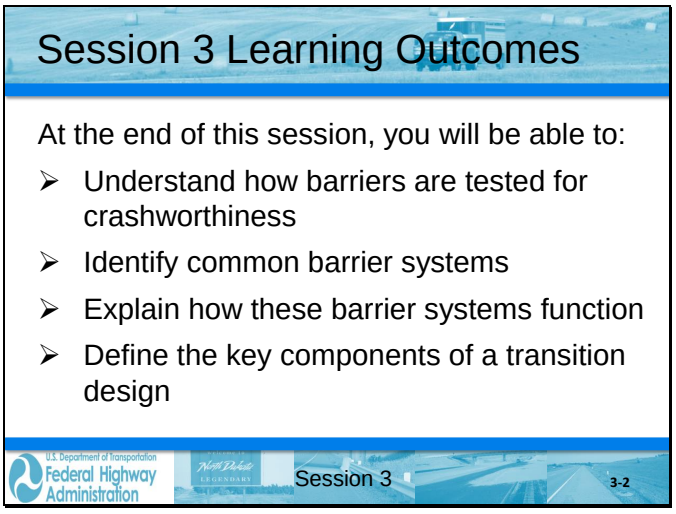
Session 3 Learning Outcomes
At the end of this session, you will be able to:
Understand how barriers are tested for crashworthiness
Identify common barrier systems
Explain how these barrier systems function
Define the key components of a transition design
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Crash Testing Guidelines

- In 1993, crash testing and evaluation criteria were published as NCHRP Report 350
- In 2009, the Manual for Assessing Safety Hardware (MASH) was published by AASHTO. It was used by FHWA as the testing standard for all new products
- In 2016, an update to MASH was adopted and a timetable for implementation of new installations complying with this edition was signed between FHWA and AASHTO

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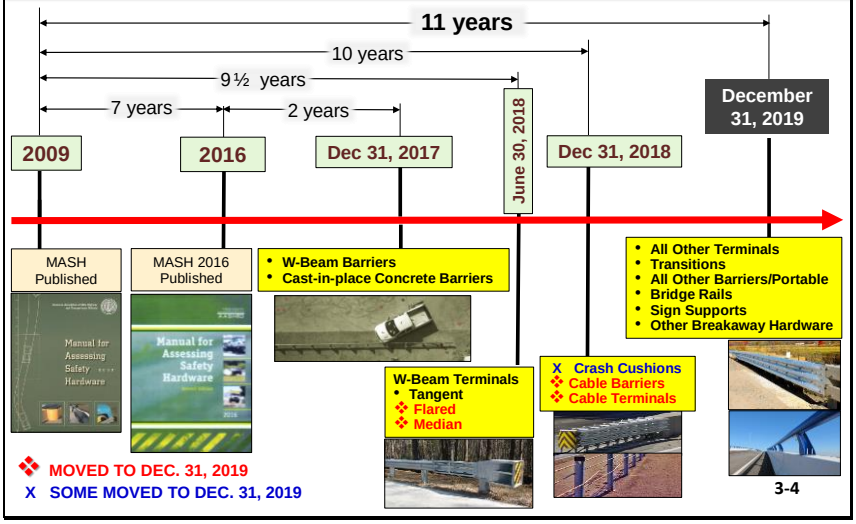
MASH Implementation Timeline

(AASHTO/FHWA Joint MASH Implementation Agreement Issued January 7, 2016)



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NDDOT MASH Implementation-2018

Implementation Timeline by NDDOT – 2018 Construction

- NDDOT Implemented MASH using the Design Guidelines (Section I-06)
- Implement MASH when items are available

NDDOT MASH Implementation-2018

NDDOT Implemented MASH using the Design Guidelines (Section I-06)

- Minor Rehab & Structural Improvement
  - Changed minimum from NCHRP Report 230 to NCHRP Report 350
  - Upgrade to MASH if not in conformity to NCHRP Report 350
- Major Rehab & New/Reconstruction
  - Changed minimum from NCHRP Report 350 to MASH
- If safety hardware is not available for MASH performance criteria, use NCHRP Report 350 minimum.

MASH Test Conditions

Selection of a performance level is based on speed and traffic mix.

- **TL-1**, **TL-2**, and **TL-3**: crash tests with small car and pickup truck with a 25˚ impact angle at 31, 44, and 62 mph, respectively.

2,420 lbs.
1100C

5,000 lbs.
2270P

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NCHRP 350 comparison with MASH Crew Cab Truck

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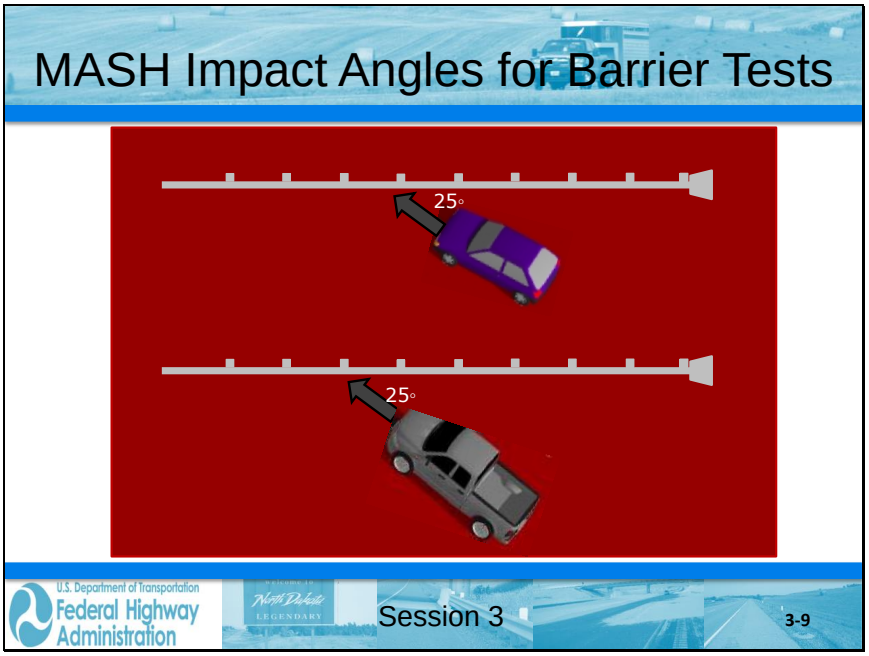
MASH Impact Angles for Barrier Tests
25°
25°
U.S. Department of Transportation
Federal Highway Administration
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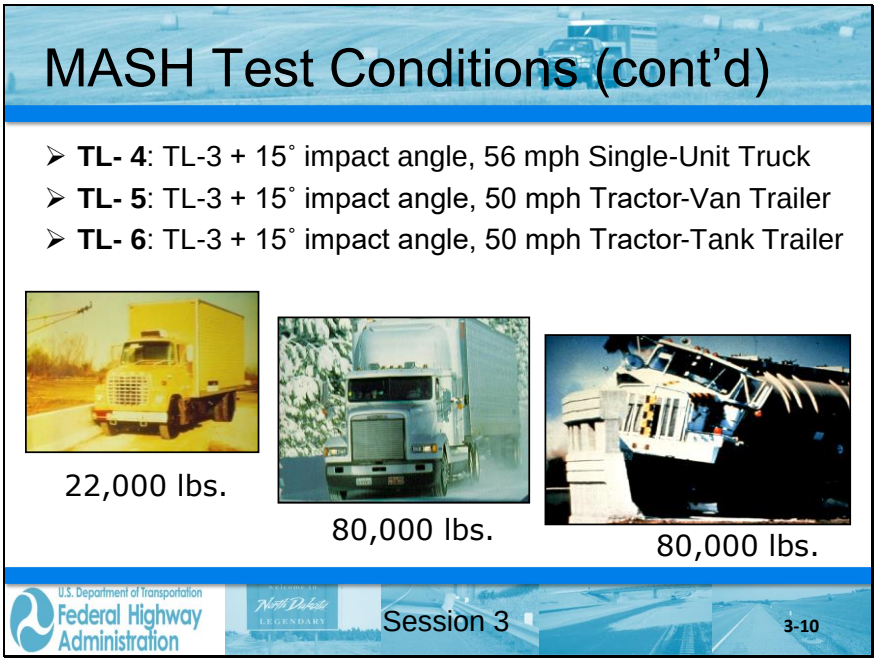
MASH Test Conditions (cont'd)
TL- 4: TL-3 + 15˚ impact angle, 56 mph Single-Unit Truck
TL- 5: TL-3 + 15˚ impact angle, 50 mph Tractor-Van Trailer
TL- 6: TL-3 + 15˚ impact angle, 50 mph Tractor-Tank Trailer
22,000 lbs.
80,000 lbs.
80,000 lbs.
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Functional Requirement of Barrier

- Structural adequacy of the tested feature
  - *Contain vehicle with no penetration, under-ride or over-ride of the installation*
- Occupant risk
  - *Test vehicles (car and pickup) must remain upright* (75 deg max rotation)
  - *No penetration or significant deformation of the passenger compartment*
  - *Tolerable passenger impact velocities (40 ft/sec max) and deceleration (20G's max)*

Standard Barrier Section

- Rigid Systems
- Semi-Rigid Systems
- Flexible Systems
- Median Barrier Systems

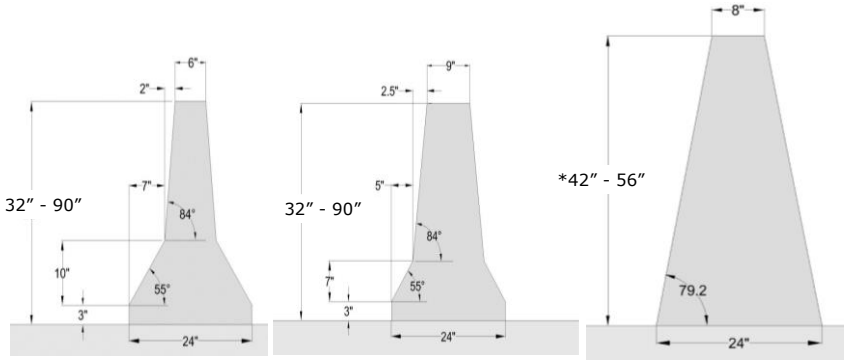
Barrier Systems: Rigid Barriers

Rigid Barrier Systems have little (between 0 to 1 ft.) deflection under the TL-3 pickup impact. They are generally anchored by some acceptable means.

Examples include:

- New Jersey Safety Shape Concrete Barrier
- F-shape Concrete Barrier
- Single or Constant Slope Concrete Barrier
- Vertical Wall

Rigid Barrier



New Jersey Shape F-Shape Single Shape


ND New Jersey Barrier – 32” MASH TL-3
(Needs to be 36” for TL-4)
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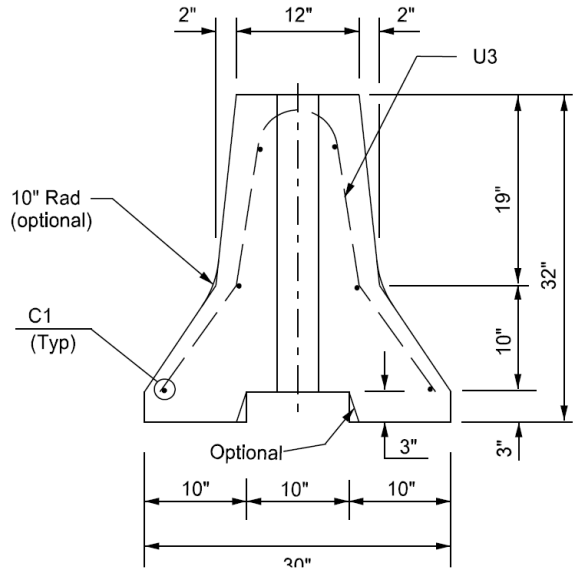
MASH Testing
of 32" New
Jersey Shaped
Concrete
Barrier
Video Clip

NDDOT NJ-Shape- Temporary



Ref: NDDOT Standard Drawing, D-704-51, 09/27/2017

Barrier Systems: Semi-Rigid

Semi-Rigid Barrier Systems have deflections of a few feet (between 2 to 5 ft.) under the TL-3 pickup impact.

Typically consist of beam and post elements.

Barrier Systems: Semi-Rigid

- W-Beam Guardrail – **PREVIOUS STANDARD (G4 28")**
  - 12" wide W-beam rail section (12-gauge thickness).
  - Posts are spaced at 6'-3" centers
  - Nominal rail height is 28".

  (Installation tolerance - ¼" ; + 1")
  - Rail splice at the post.
  - Wood posts: 6" x 8" x 6'-0" long.
  - Block-outs: 6" x 8" wood.

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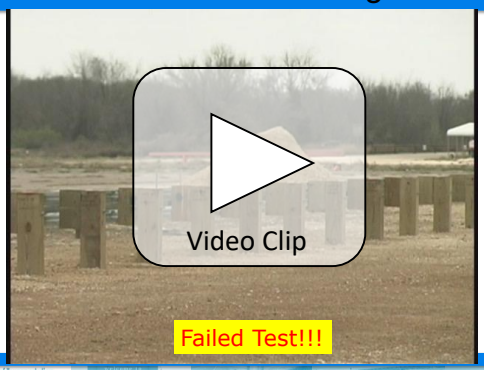
SPWB with Wood Post & Wood Block-Out 27 5/8" Height



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Guardrail Height for Existing 28"(G4)

W-Beam guardrail that is less than 26 ½ inches high <u>after an overlay</u> should be raised, reset, or reconstructed.

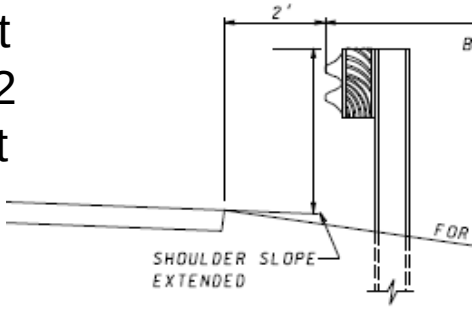
While new installations must be at least 27 ¾ inches high, this guidance recognizes that it is not cost effective to raise an existing barrier if it is slightly lower.

G4 Guardrail - Height Measurement

For slopes 10:1 or flatter, the height is measured from the ground directly beneath the rail

For slopes steeper than 10:1 but no steeper than 6:1, and within 2 feet of the breakpoint, the height is measured from the shoulder slope extended as shown

Only for the G4 Guardrail



PLACEMENT ON SLOPE

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Barrier Systems: Semi-Rigid

- Midwest Guardrail System (MGS)
  - 31” Height – Tolerance ±1”
  - Rail Splice mid-span.
  - Post spacing 6’-3”
  - Wood posts: 6” x 8” x 6’ long
  - Block-out: 8” deep wood

Ref: FHWA Eligibility Letter B-212 (steel post); B-230 (WP) & B-230A (SYP)

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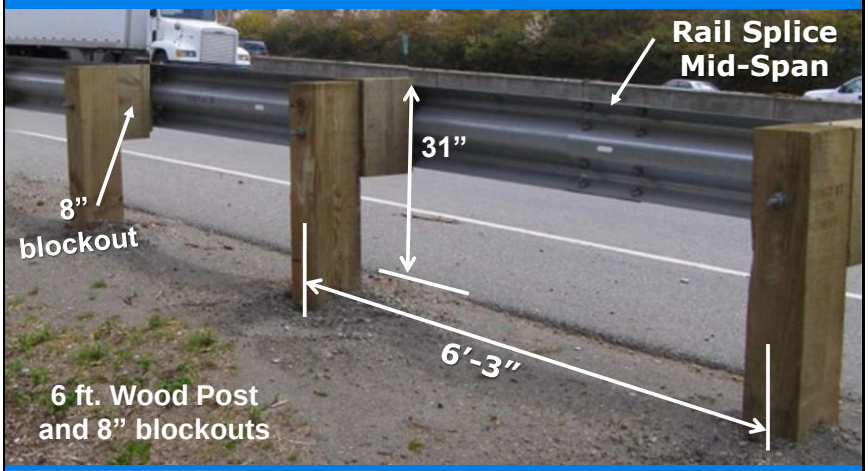
Midwest Guardrail System (MGS)



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MGS MASH Test 3-11
Video Clip
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Federal Highway Administration
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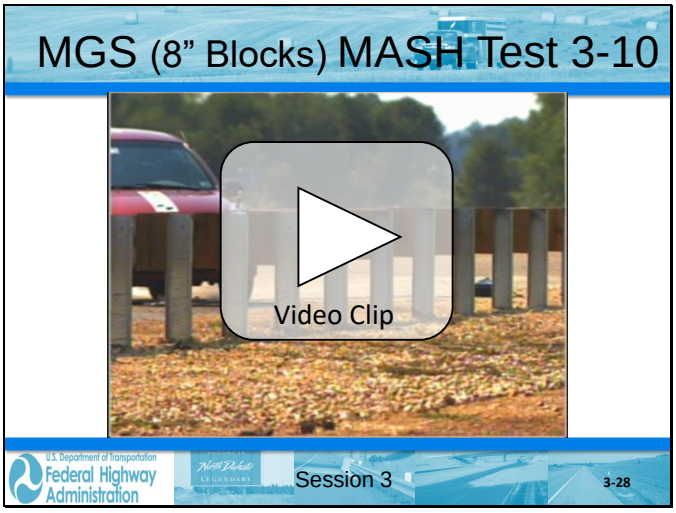
MGS (8” Blocks) MASH Test 3-10
Video Clip
U.S. Department of Transportation
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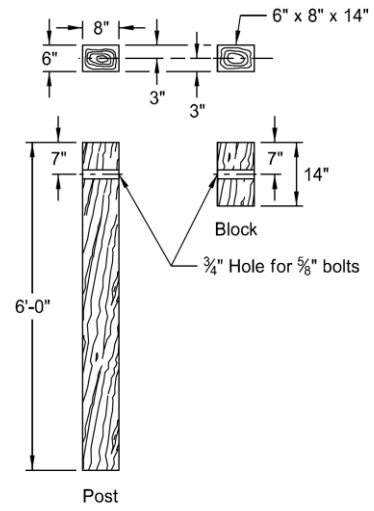
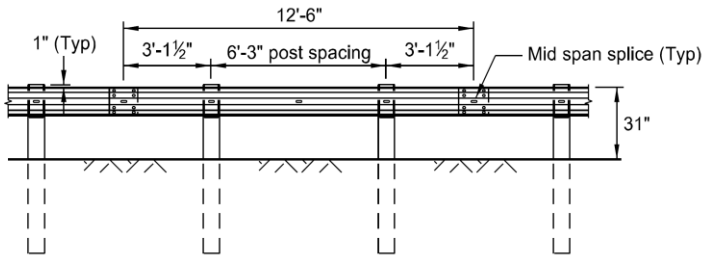
NDDOT MGS Detail



6" x 8" WOOD POST & BLOCK

NOTE: Where soil conditions require, alternate lengths may be specified, in 6" increments.



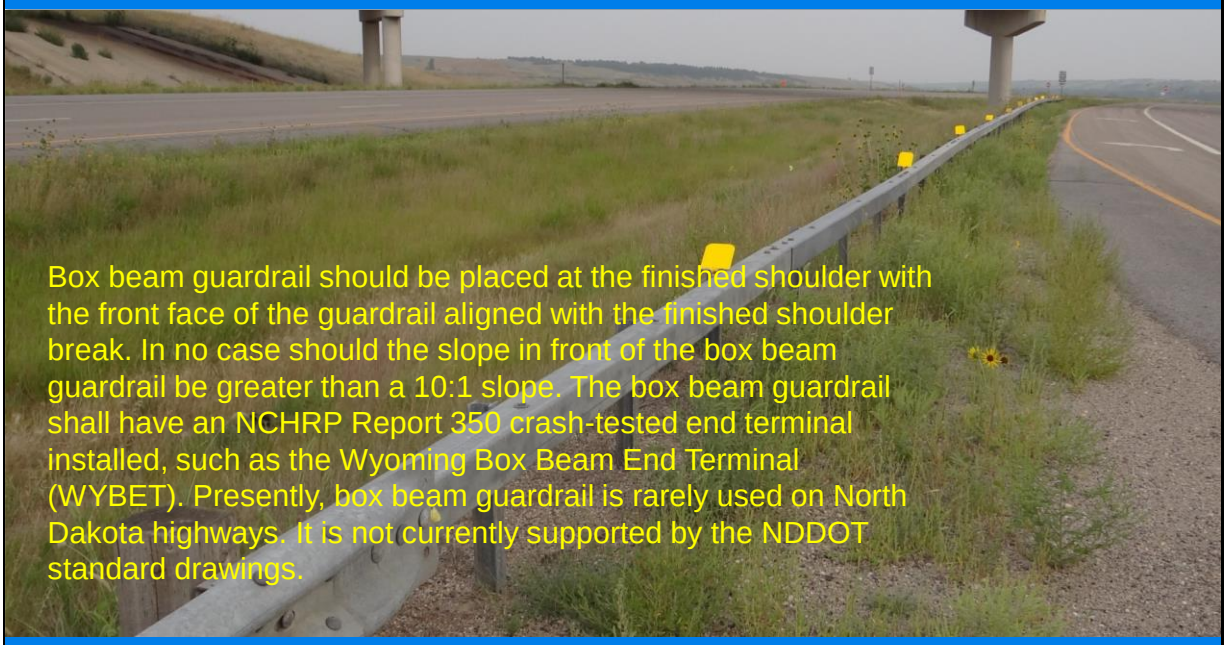
STANDARD MGS GUARDRAIL SYSTEM

Ref: NDDOT Standard Drawing, D-764-40, July 2017

Guardrail Height for MGS

- The installation tolerance for the 31 inch MGS is +1 inch/ - 1 inch.
- After an overlay the minimum height should be 28 inches.

Existing ND Box Beam



Box beam guardrail should be placed at the finished shoulder with the front face of the guardrail aligned with the finished shoulder break. In no case should the slope in front of the box beam guardrail be greater than a 10:1 slope. The box beam guardrail shall have an NCHRP Report 350 crash-tested end terminal installed, such as the Wyoming Box Beam End Terminal (WYBET). Presently, box beam guardrail is rarely used on North Dakota highways. It is not currently supported by the NDDOT standard drawings.

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Barrier Systems: Flexible Barriers

Flexible Barrier Systems typically have relatively large deflections

Examples of Flexible Barriers include:

- Weak post W-beam
- Low tension cable
- High tension cable

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Barrier Systems: Flexible Barriers

Advantages of cable systems include:

- Low initial cost
- Lower deceleration forces
- Effective vehicle containment and redirection
- Installation conditions

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ND Three Cable Low Tension System

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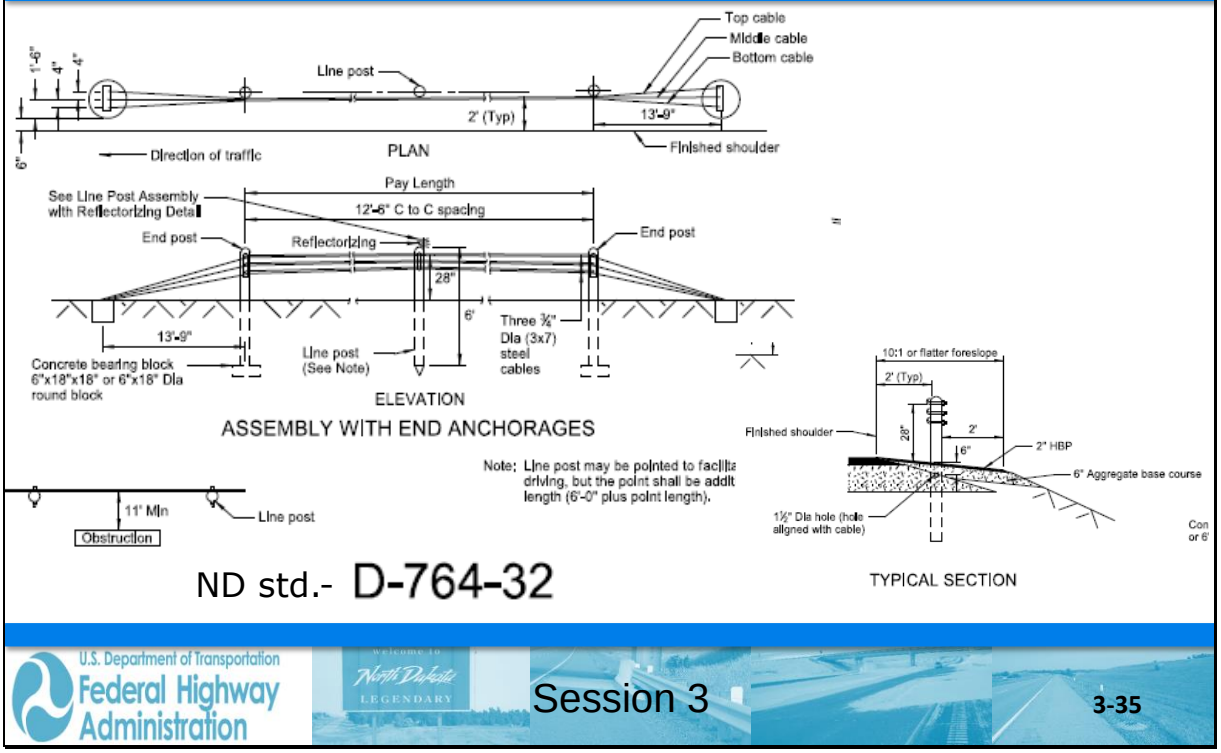
ND Three Cable Low Tension System



ND std.- D-764-32

Barrier Systems: Flexible Barriers

For new installations, North Dakota generally uses High Tension Cable Guardrail.

High Tensioned Cable Guardrail

- Five different proprietary designs available
- Each requires a unique proprietary terminal
- Advantages over low tension:
  - Somewhat reduced deflections
  - Generally easier maintenance
  - Can retain effectiveness after most impacts

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High Tension Cable Systems

Brifen

Trinity CASS

Safence

MASH 09

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High Tension Cable Systems

Gibraltar

Nucor

NCHRP 350

Reminder: *NDDOT is committed to MASH.*

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Four Cable High-Tension System

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Post Foundation and Typical Terminal



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Median Barriers

- Used to separate opposing traffic on a divided highway or to separate through traffic from local traffic.
- Many barriers approved for roadside applications can be modified for use in the median. They can be rigid, semi-rigid and flexible barriers.
- Width of the median is an important consideration.
- Also must consider the dynamic deflection of the barrier to avoid intrusion into opposing traffic.
- There are terminals designed specifically to shield the ends of median barriers.

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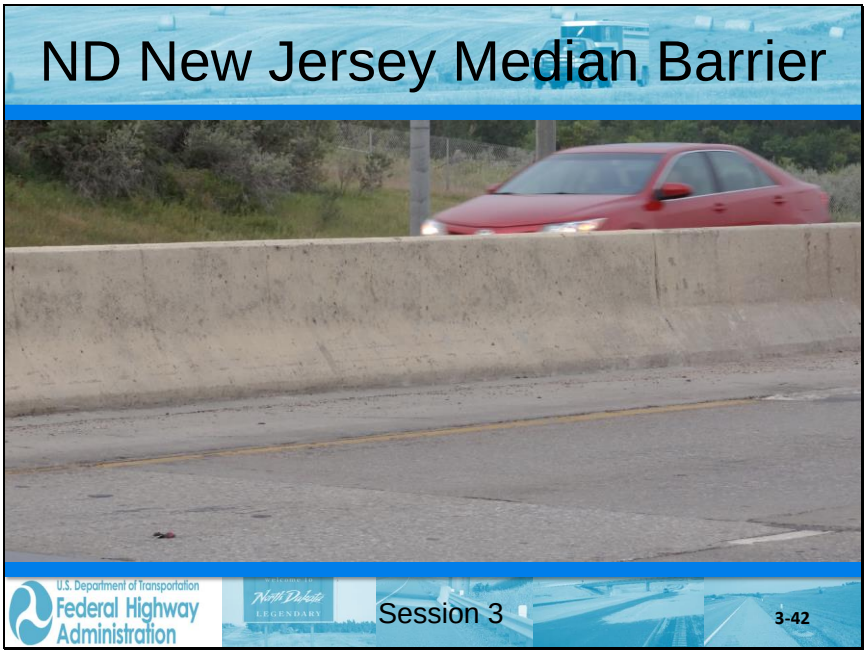
ND New Jersey Median Barrier
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Flexible Median Barriers
Median cable guardrail prevents a potential head-on crash.
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Federal Highway Administration
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Flexible Median Barriers
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Flexible Median Barriers
U.S. Department of Transportation
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Transition Sections

- When a softer (more flexible) barrier precedes a stiffer barrier, a gradual stiffening must occur between the two systems.
- An effective transitions must provide the following:
  - Adequate connection (TENSION continuity)
  - Adequate length to gradually increase stiffness.

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Inadequate Transition

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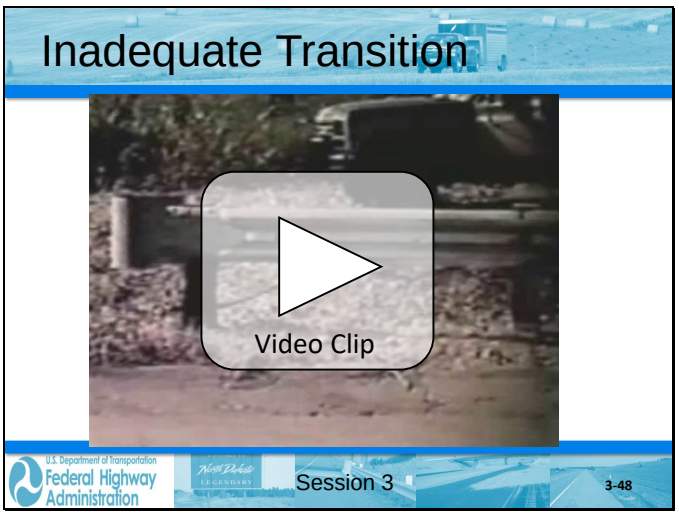


Transition Sections

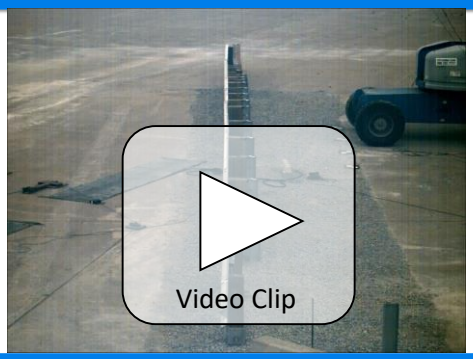
Successfully crash-tested transitions include the following essential elements (in addition to a structural connection):

- Additional and/or Larger Posts
- Nested rail (w-beam or Thrie-beam)
- Prevention of Snagging (such as Curbs {only as crash-tested transition unit}, Rub Rails, Flared Parapet Wall)

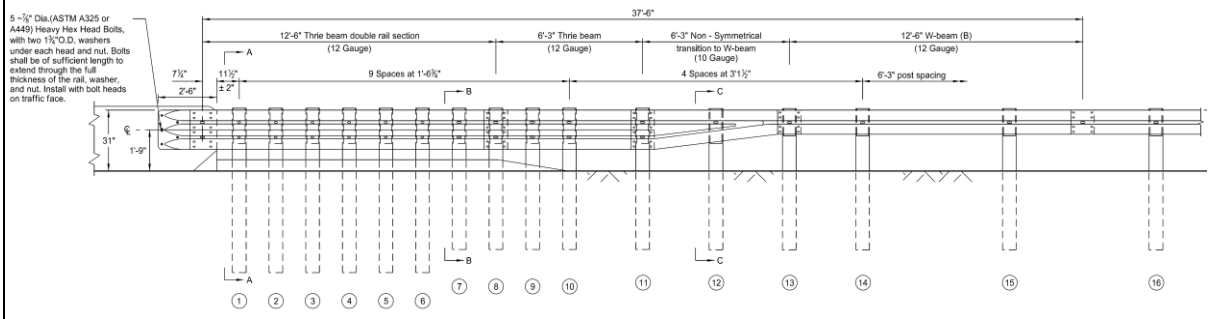
MGS Transition Design

- Compatible with most existing Thrie-beam to bridge railing transition designs
- Uses a non-symmetrical w-beam to thrie-beam transition piece.
- Posts can either be steel or wood.

MGS Transition



MGS Transition Design



Ref: NDDOT Standard Drawing, D764-60

Positive Connection.

5- 7/8 “Dia.(ASTM A325 or A449) Heavy Hex Head Bolts with two 1 3/4“ O.D. washers under each head and nut. Bolts shall be of sufficient length to extend through the full thickness of the rail, washer and nut. Install with bolt heads on traffic face.
ND Std. Plan 764-60

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ND Transition

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Transition: HTC to Guardrail (Spatial)
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Transition: HTC to Guardrail (Spatial)
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High Tension Cable to W-Beam Transition

Manufacturers may not be providing this under MASH 16

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Review Learning Outcomes

- Understand how barriers are tested for crashworthiness
- Identify common barrier systems
- Explain how these barrier systems function
- Define the key requirements of a transition design

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