

## Session 5: Installation/Common Errors of Systems



Session 5: Installation/Common Errors of Systems

FAST Act Guardrail Training  
Highway Barrier Installer, Inspector and  
Maintenance Training

**Session 5:  
Installation/Common  
Errors of System**

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**Session 5 Learning Outcomes**

At the end of this session, you will be able to:

- Describe key components of barrier systems
- Identify common installation errors

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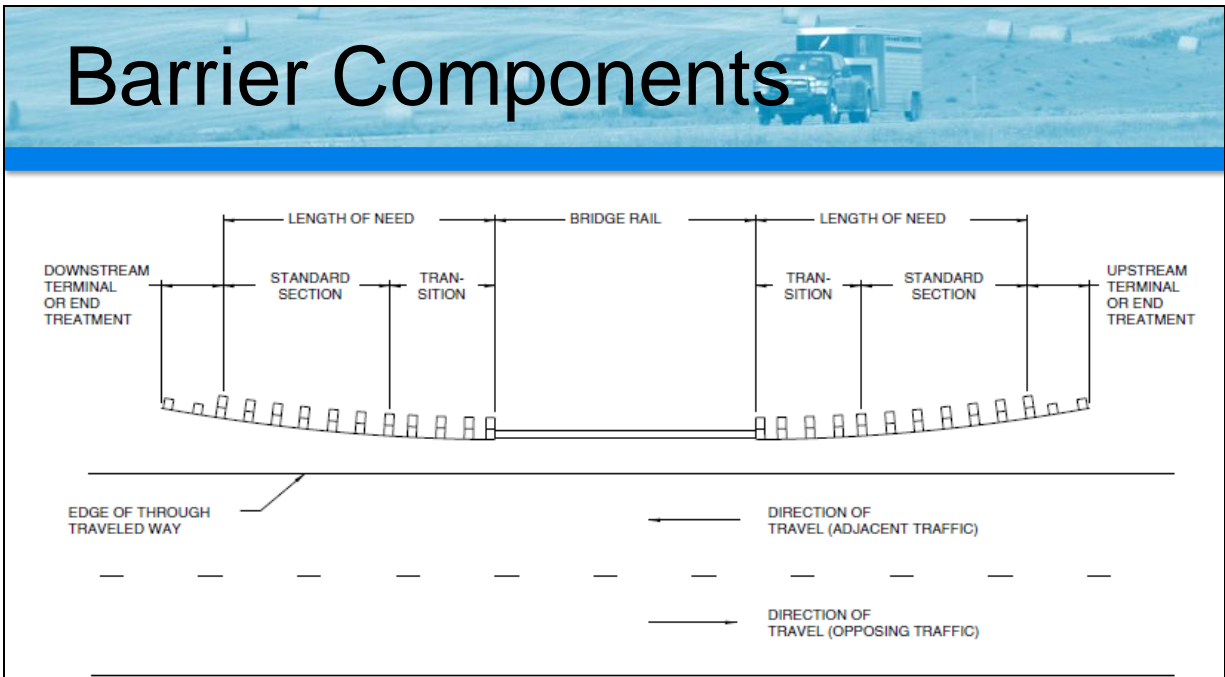
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**Figure 5-4. Definition of Roadside Barriers**

REF: AASHTO Roadside Design Guide, 4<sup>th</sup> Edition, Figure 5-4



### Key Components of Barrier Systems

1. Standard Run of Barrier
2. Transition to a Stiffer System
3. Terminal
4. Crash Cushion

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## 1. Standard Run of Barrier

- a. Barrier Design Principles
- b. Height Measurement
- c. Tension Continuity
- d. Other Considerations
- e. Barriers in Work Zones



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## a. Barrier Design Principles



**Deflection**



**Soil Backing**



**Slope in Front of Barrier**



**Barriers and Curbs**



**Flare Rate**



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## b. Height Measurement

### ➤ Concrete Barrier Standards

- Roadside & Median Barrier - ND typically 32" Jersey shape
- Work zone - ND typically 32" Jersey shape



## b. Height Measurement

### ➤ Low Tension 3 Cable Guardrail

- ND Std. Dwg. D-764-32





## b. Height Measurement

### ➤ High Tension Cable Barrier

- If the agency uses foundations, insure top is at proper height. This will effect the height of the cable.



## High Tension Cable Systems

- The installation requirements are specific to the manufacturer. Referral to the manufacturer's installation manual is essential.
- The next slide shows an example of a installation checklist from a manufacturer's manual.

### INSTALLATION CHECKLISTS

**Cable Checklist**

- ☐ Is there anything in front of the cable barrier that might cause a vehicle to vault the barrier or make the barrier ineffective? Items to look for include vegetation, rough ground, debris, or hard packed snow. These items should be removed if present.
- ☐ Has the roadside grading been completed correctly?
- ☐ Is there enough clearance between the barrier and the hazard for the expected barrier deflection? Minimum clearance is dependent upon post spacing.
- ☐ Is the cable barrier the correct height?

Cable heights measured to the middle of the cable are as follows:


	Top	Middle	Bottom
<b>Median &amp; Roadside</b>	29.5 in [750 mm]	25.5 in [650 mm]	21.5 in [545 mm]

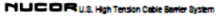
- ☐ Are the cables properly tensioned?
- ☐ Are there irregular curves or joints where an errant vehicle might snag?  
Is there evidence of corrosion or damage to the cable? The cable should be scheduled for repair if either of these circumstances exist.
- ☐ Check to see that nuts are installed on the special locking hook bolts.

**Post Checklist**


Is there sufficient soil behind the posts to prevent them from being pushed out when the barrier is hit? Eroded or disturbed soil should be replaced and recompact.

- ☐ Is the post spacing correct?
- ☐ Is there evidence of corrosion or damage to the posts? The posts should be replaced if either of these circumstances exist.





Revised Jan-08 V. 4.2 Page 22



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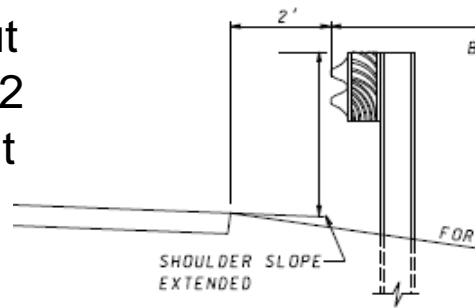


## G4 Guardrail - Height Measurement

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

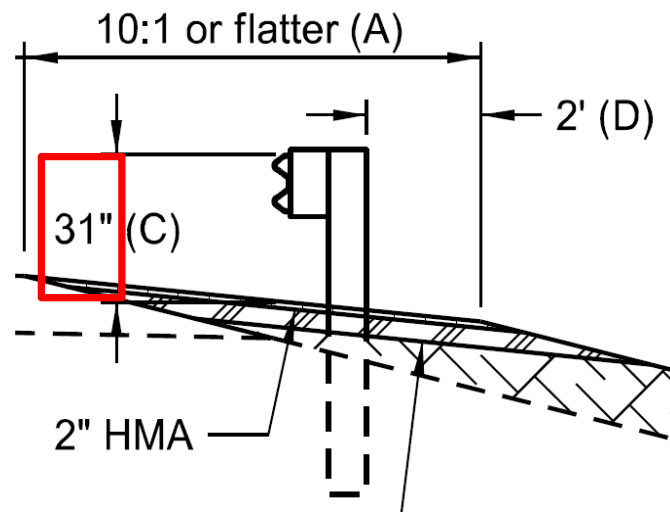
**Only for the G4 Guardrail**



**PLACEMENT ON SLOPE**

# MGS Height Measurement

## ➤ MGS W-Beam



Ref: ND Standard Drawing, D-764-49 July 14, 2017



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## b. Height Measurement



**Rail too high**



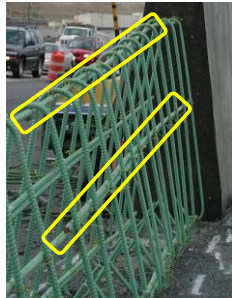
**Rail too low**

## c. Tension Continuity

- Concrete Barrier
  - Continuous reinforcement and anchored to/in the pavement
- High Tension Cable
  - Proprietary systems typically use a type of turn buckle between successive cables and end terminal anchors.
- W-Beam
  - Splices with 8 bolts tying panels together, and some type of end anchor or structural tie to a rigid object/bridge rail (transition)

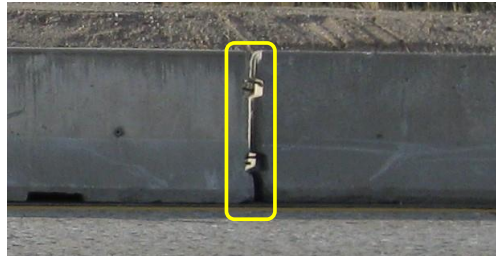
## c. Tension Continuity

### Cast In Place Concrete Barrier



Horizontal bars maintain continuity for cast in place barrier

### Precast Concrete Barrier



Missing connection pin  
NO TENSION



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## c. Tension Continuity

### ➤ W-Beam

- 8 bolts tying panels together and a structural connection to a rigid barrier with 5 thru bolts



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## c. Tension Continuity

- Thrie Beam Connection
  - 5 bolts required for a structural connection to a rigid barrier



## c. Tension Continuity



Missing  
bolts



No  
Structural  
connection



## d. Other Considerations

### ➤ Lapping

- For one-way traffic, all guardrail panels should be lapped in the direction of traffic with the upstream panel lapping the downstream panel including terminal elements and end sections. (Some exceptions, i.e. CAT)
- For two-way traffic always mount guardrail going with adjacent traffic, meaning rail laps will be opposite on each side of the road.



## d. Other Considerations

### ➤ Lapping


#### **ND Standard Specifications Section 764**

#### **C. W-Beam Guardrail.**

Join the rail sections so the splices are lapped to flow in the direction of the traffic nearest the guardrail. Construct the lap splices so the plate ends make contact throughout the entire area of the splice.



### d. Other Considerations



Incorrectly Lapped

Correctly Lapped

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### d. Other Considerations

**Typically NO WASHERS**  
Unless called for in the plans



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## d. Other Considerations



Use of delineators under rail to post bolts is discouraged as it can inhibit bolt pull through



ND: 6 x 10 inch plate attached to block, 25 or 50 foot centers, see **Std. Dwg. D-764-40 note 1**

## d. Other Considerations

Drilling of holes into the rail FOR THE RAIL TO POST CONNECTION is not recommended.

Better to bolt block to post, no rail attachment, for one or two consecutive posts.



## d. Other Considerations

Drilling of holes into the rail FOR THE RAIL TO POST CONNECTION is not recommended.



## d. Other Considerations

**Cutting a slot, hole or a rail section with a torch is NOT PERMISSIBLE**



Using a torch on the rail element may compromise the strength of the rail.

Tests results have shown this becomes a weak point in the rail and can cause ripping and rupturing.



# ND Inspection Check List

## INSPECTION CHECKLIST - W-BEAM GUARDRAIL AND END TREATMENT

North Dakota Department of Transportation Maintenance

District* <input type="text"/>		Section* <input type="text"/>	
Highway Direction <input type="radio"/> North <input type="radio"/> South <input type="radio"/> East <input type="radio"/> West		Location of Roadside <input type="radio"/> Left <input type="radio"/> Right <input type="radio"/> Both	
Highway*	Beginning Mile Post*	Ending Mile Post*	In Median? <input type="radio"/> Yes <input type="radio"/> No

Type: ☐ Fleat ☐ SRT ☐ SKT ☐ Other

Items that may cause vaulting? <input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> N/A	Connecting pieces to bridge or barrier damaged? <input type="radio"/> Yes <input type="radio"/> No
Damage to the end treatment, tension cable or rod and bracket? <input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> N/A	Slotted rail been damaged? <input type="radio"/> Yes <input type="radio"/> No
Guardrail height correct 28" (to Top of rail) <input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> N/A	Slot guards in place? <input type="radio"/> Yes <input type="radio"/> No
Impact head attached to first post? <input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> N/A	Any posts or spacer blocks cracked or broken? <input type="radio"/> Yes <input type="radio"/> No
Impact head chevron sticker faded or damaged? <input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> N/A	Are all reflectors in place and in good condition? <input type="radio"/> Yes <input type="radio"/> No
Spacer blocks toe nailed to post? <input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> N/A	Anchor cable securely fastened? <input type="radio"/> Yes <input type="radio"/> No
W-Beam damaged? <input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> N/A	Anchor Cable tight? <input type="radio"/> Yes <input type="radio"/> No
Are w-beam fasteners tightened to posts? <input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> N/A	

## e. Barriers in Work Zones

Barrier should be in GOOD condition



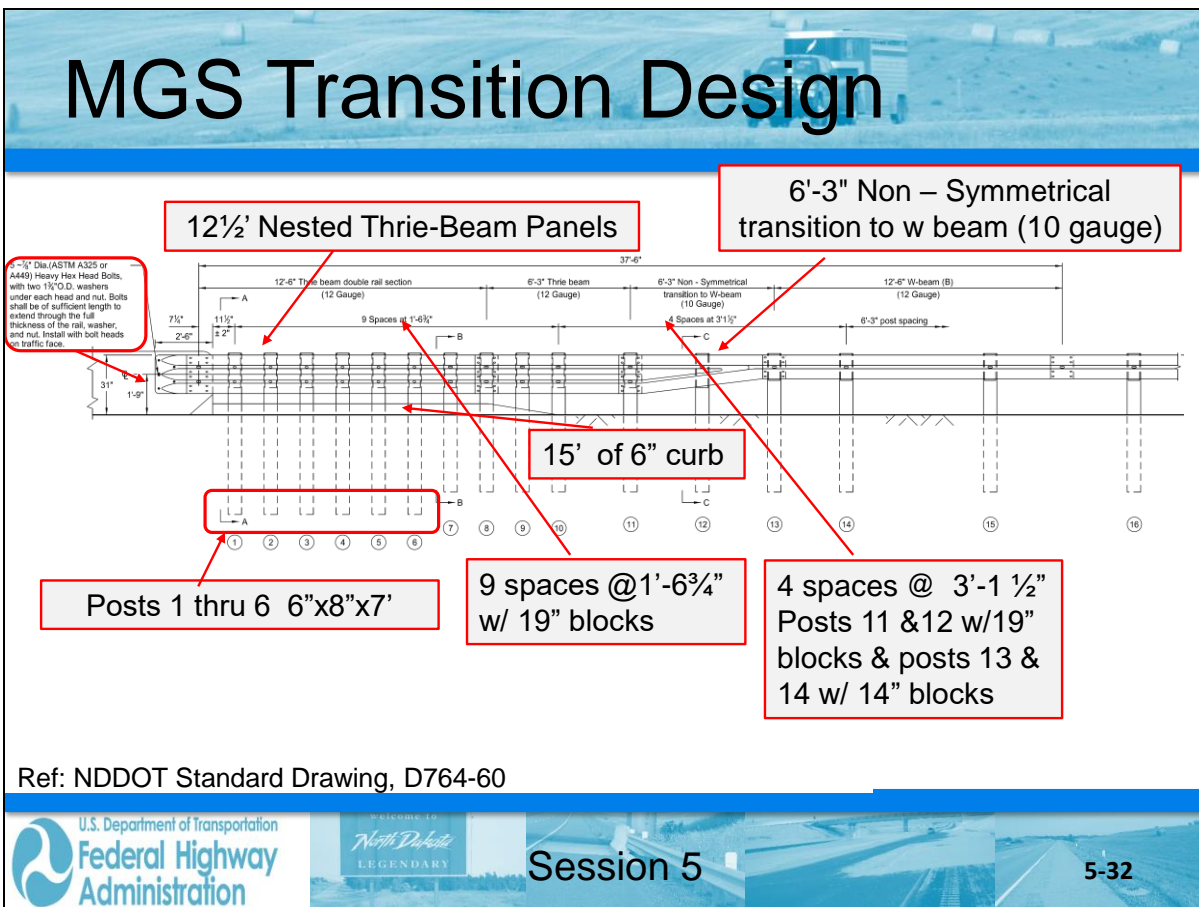
## e. Barriers in Work Zones

Flare rate appears to be too excessive here









### 3. Terminals

- a. Manufacturers Manuals
- b. Post types
- c. Panel requirements
- d. Grading
- e. Breakaway Cable **Anchorage**
- f. Other Common Errors
- g. Delineation



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### 3. Terminal

**RULE #1:  
Follow  
manufacturers  
instructions  
and standard  
plans.**




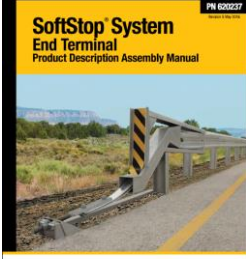
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### 3. Terminal


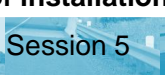


a. Manufacturers Manuals

**Must follow manufacturer's installation instructions & State standards**



**These are all readily available online**

**Example of installation manuals**



**TAKE ADVANTAGE OF  
MANUFACTURER TRAINING  
FOR DETAILED INSTRUCTION  
ON INSTALLING ANY OF THE  
PROPRIETARY END  
TREATMENTS**



## Session 5: Installation/Common Errors of Systems

**BEAT and BEAT-MT Installation Inspection Checklist**

State: \_\_\_\_\_ Date: \_\_\_\_\_  
 Project #: \_\_\_\_\_ Inspection performed by: \_\_\_\_\_  
 Location: \_\_\_\_\_

- ☐ The 6"x 6" end tube section is the special 1.8" thickness tube as supplied by the manufacturer with the corners cut at the approach and where the impact head is placed.
- ☐ Both the Roadside BEAT terminal and Median BEAT-MT terminal have at least one 18'-0" long 6"x 6" x 3/16" standard tube section joining with the special 12'-0" long end tube section.
- ☐ The end tube section is bolted to the standard tube section with the special rail tie splice.
- ☐ The height of the 6"x 6" box beam tubing is in accordance with the plans:  
 -Roadside BEAT rail height = 2'-4"  
 -Median BEAT-MT rail height = 2'-4"
- ☐ The 6"x 6" box beam tubing is attached to rail support brackets with proper hardware:  
 -Roadside BEAT post bolt = 5/16" x 7 1/2" hex bolt  
 -Median BEAT-MT post bolt = 5/16" x 7 1/2" hex bolt
- ☐ The rail support brackets are attached to posts with proper hardware:  
 -Roadside BEAT posts #1 & #2 support bracket bolts = 1/2" x 2" hex bolt  
 -Median BEAT-MT posts #2 through #5 support bracket bolts = 1/2" x 1 1/2" hex bolt  
 -Median BEAT-MT post #1 support bracket bolt = 1/2" x 2" hex bolt
- ☐ The upper and lower sections of post #1 are properly connected with a 5/8" x 8" hex bolt.
- ☐ The 3" weak posts have the soil plate positioned the same direction as the rail.  
 -Roadside BEAT has a 3" weak post at post location #2 plus at least three more 3" weak posts spaced at 6'-0" within the standard downstream 6"x 6" box beam barrier.  
 -Median BEAT-MT has a 3" weak post at post locations #2 through #5.
- ☐ The impact head is properly inserted into the end tube section with the large triangular gusset plates facing down. The bottom of the impact head is approx. 12" above ground.
- ☐ The post breaker is installed on the proper side of post #1 and stabilized with two bolts.
- ☐ The 8" x 8" bearing plate at post 1 is correctly positioned with the 5" dimension up & the 3" dimension down. The anchor cable is taut and correctly installed.
- ☐ The Median BEAT-MT has a tether cable properly attached to restrain the impact head.
- ☐ If the posts were augered, be sure the backfill material around the posts is compacted.

Additional notes: \_\_\_\_\_

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**INSTALLING THE RAIL PANEL TO THE POST WITHOUT OFFSET BLOCK AT POST 2**

Complete the following steps to attach the rail panel to the post without offset block at Post 2:

Step	Actions
1. Select the Option A, Option B, or Option C to install the rail panel without offset block at Post 2:	
Option A For Wood Post	1. Insert a 5/8" (16 mm) diameter x 10" (255 mm) HGR Post Bolt (PN-3500G) through the rail and the wood post at location 2. 2. Place a 5/8" (16 mm) Round Washer (PN-3300G) under a 5/8" (16 mm) HGR Nut (PN-3340G) on the inserted bolt. Tighten the bolts. (There is no torque requirement for these bolts.)
Option B For SYTP™	1. Insert a 5/8" (16 mm) diameter x 1 1/4" (31 mm) HGR Bolt (PN-3360G) through the rail panel and the hole in the SYTP™. <b>Note:</b> For SYTP stubs, use the hole in the SYTP™ that will place the rail at the correct height. (If there are two (2) sets of holes in the SYTP™ stub for attaching the rail.) 2. Place a 5/8" (16 mm) Round Washer (PN-3300G) under a 5/8" (16 mm) HGR Nut (PN-3340G) on the inserted bolt.
Option C For HBA™ Post	Do NOT bolt the rail panel to the HBA™ post at location 2.

**WARNING:** Do NOT bolt the rail to the HBA™ post at location 2. Failure to follow this warning could result in serious injury or death in the event of a collision.

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## 3. Terminal

### b. Post Types

Each manufacturer may have several different types of post, even for the same system - both currently approved and previously used.

Must consult with the installation manual of the specific model being worked with for proper post type.

Only one generic special post for terminals – the CRT post with large holes to weaken it.



**Controlled  
Release Terminal  
(CRT) Post**



### 3. Terminal

#### c. Panel Types

Each system may have one or more different rail panels.

Must consult with the installation manual of the specific system for proper panel type



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### 3. Terminal

#### d. Grading

Check grading compliance with Standard Drawing (or plan details).

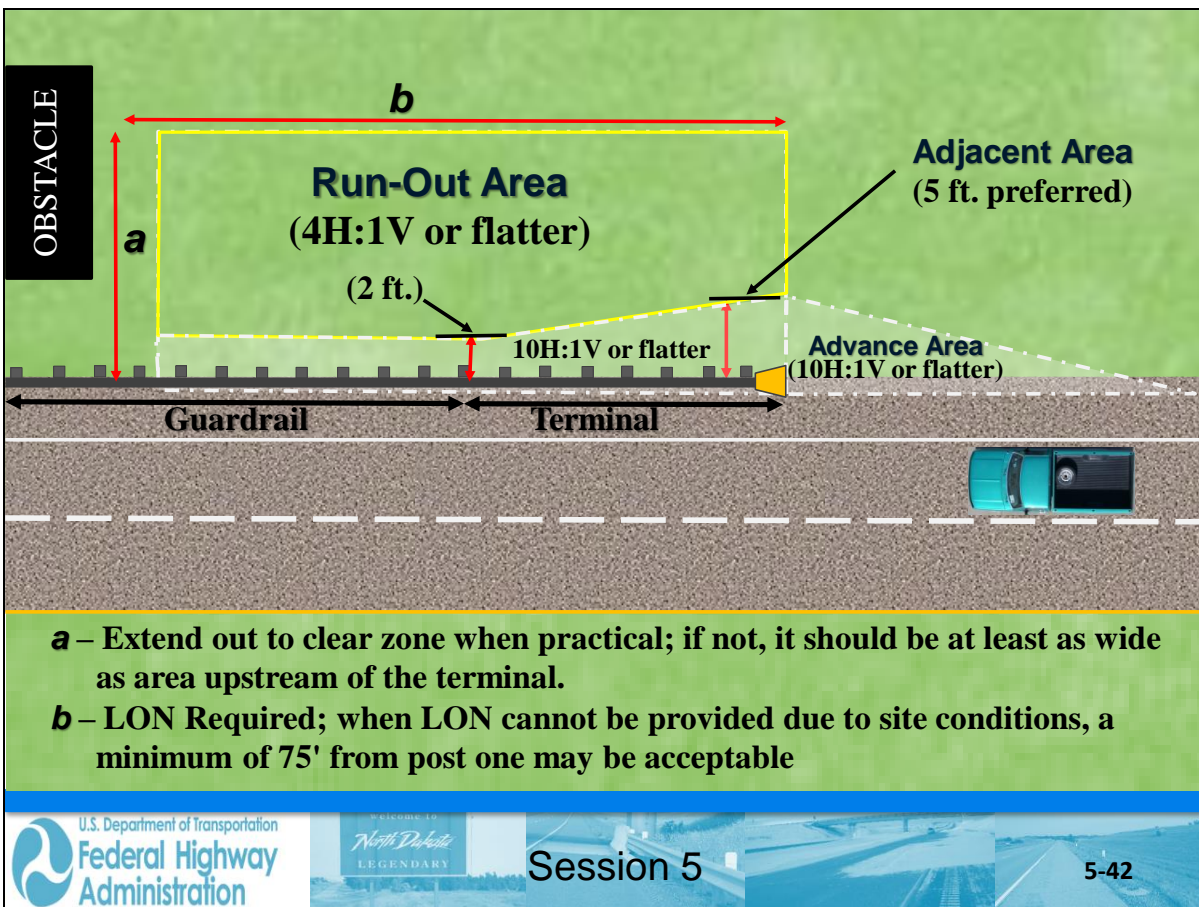
Check grading material for proper density. (Material must be compacted so it won't erode.)



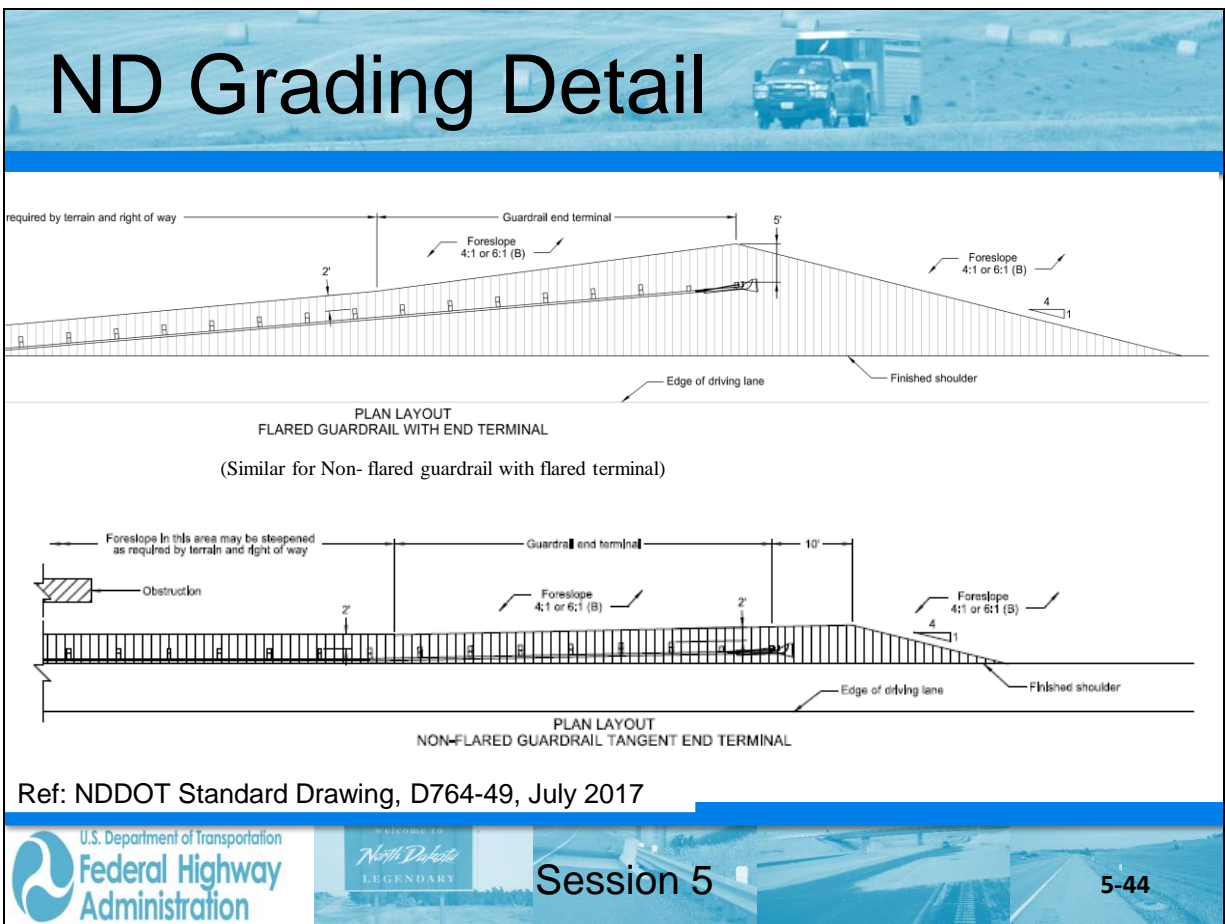
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### 3. Terminal

#### d. Grading

#### *Improper Grading*



A common error with all terminal types.

### 3. Terminal

#### d. Grading

#### Telltale of poor grading



- Connection of top & lower post too high
- Strut too high
- Grading suspect

(Also bearing plate misaligned)

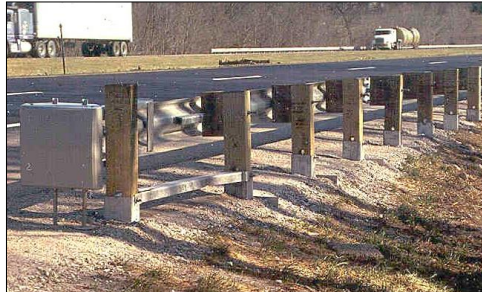
Common Error applies to both energy absorbing and non energy absorbing terminals



### 3. Terminal

#### d. Grading

#### Telltails of poor grading



- Soil tubes/foundation posts installed too high
- Soil plates exposed
- Strut too high

Common Error applies to both energy absorbing and non energy absorbing terminals



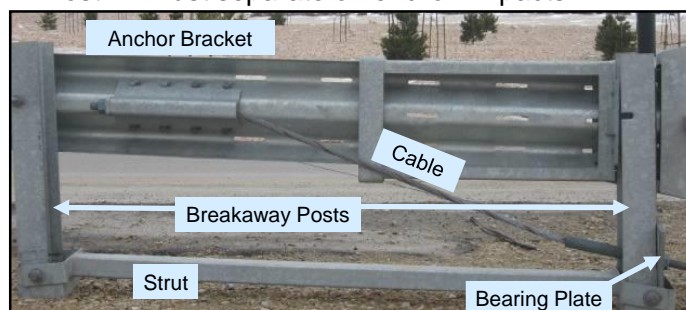
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### 3. Terminal

#### e. Breakaway Cable Anchorage Assembly

- Transfers tensile load for downstream side impact.
- Post #1 must separate on end-on impacts.



**Must follow manufacturer's installation instructions.**



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### 3. Terminal

#### e. Breakaway Cable Anchorage Assembly

##### Breakaway Post #1

- Proprietary steel posts.
- Must separate on end-on impacts



### 3. Terminal





### 3. Terminal

#### e. Breakaway Cable Anchorage Assembly

Bearing Plate & Strut

- Should be in up position and secured to post.
- Strut secured at posts required locations.



Strut secured at breakaway posts 1 & 2



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### 3. Terminal

#### e. Breakaway Cable Anchorage Assembly

Buried and upside down bearing plate – won't release



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### 3. Terminal

#### e. Breakaway Cable Anchorage Assembly

Most systems require an anchor bracket and anchor cable.

- Anchor block must release from rail if system has impact head
- Non-energy absorbing system does not have to release from rail.



Energy absorbing



Non-energy absorbing

### 3. Terminal

#### e. Breakaway Cable Anchorage Assembly

- Check the type and combination of breakaway posts against the State standards and the manufacturer's instructions.
- Not all posts in all terminals use a block-out.
- Check to see that the correct cable anchor bracket is used and it is properly attached to the rail.



Wrong anchor bracket



Anchor bracket not attached

### 3. Terminal

#### e. Breakaway Cable Anchorage Assembly

##### Anchor Cable

- Should be taut, lift up 1" or less
- Tightened by holding cable at bottom, not allowing cable twist.



### 3. Terminal

#### f. Other Common Errors

Terminals with an impact head: the end of the first W-beam rail section should be pushed against the throat area of the impact head so the end of the rail cannot be seen.





### 3. Terminal

#### Post Installed Backwards



### 3. Terminal

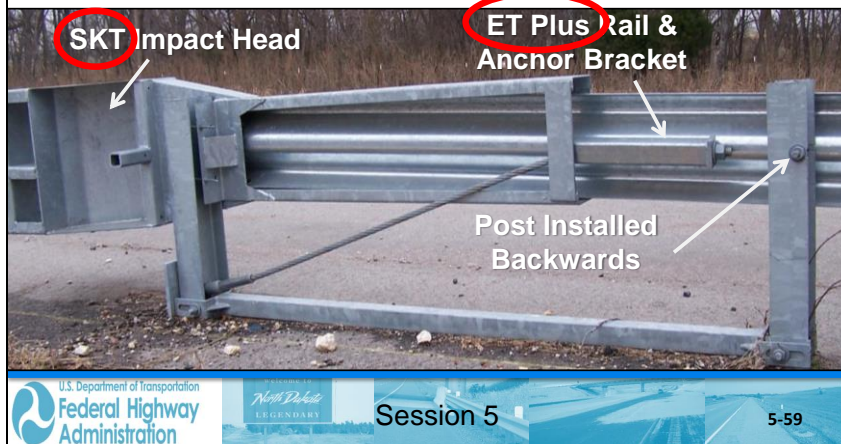
#### f. Other Common Errors

Energy Absorbing  
(compression based)  
Terminals MUST be installed  
on a straight line



### 3. Terminal

#### f. Other Common Errors



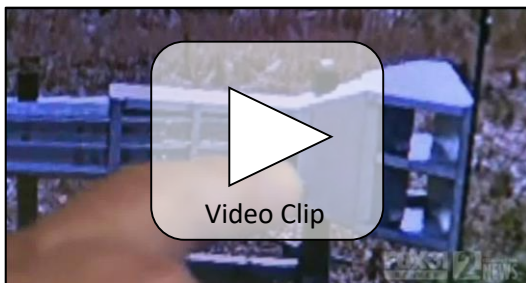
## 3. Terminal

### f. Other Common Errors



## 3. Terminal

### f. Other Common Errors (video)





## **ACTION:** Guardrail Terminal Installations and Repairs

**Date:** November 30, 2016, FHWA Memo

### ***Substitutions of components are allowable if any one of these conditions is met:***

1. The substitute components are generic items (e.g. guardrail line posts, w-beam rail elements, some fastener hardware, etc.) that meet the same specification as the crash tested parts.
2. The manufacturer of a patented device has determined that the part will not adversely affect the device's performance and has agreed that the part may be substituted.
3. The substitute component has been successfully crash tested as part of the same system.
4. A critical or "smart" part that was formerly covered by a patent is manufactured to the same specification as the original part.

*This guidance applies to the safety performance of barrier terminals, crash cushions, and the barriers themselves when considering the use of substitute components.*

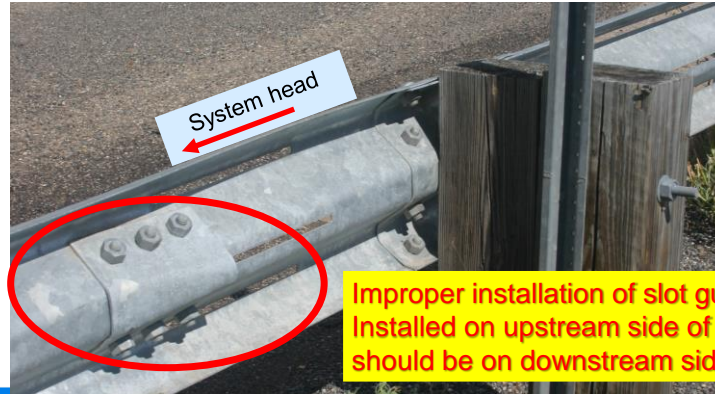


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### 3. Terminal

#### f. Other Common Errors



Improper installation of slot guard,  
Installed on upstream side of slot -  
should be on downstream side.

### 3. Terminal

#### f. Other Common Errors



It's easy to tell if it's wrong  
– the slot guards must be  
on the same end of the  
slots for the first (can't get  
it wrong) and second rail  
panels

### 3. Terminal

#### f. Other Common Errors

Bolt only impact head to post #1, NOT rail panel.

- Wood Post – Lag Screws (screwed in only)
- Steel Post – Hex Bolts



Refer to manufacturer's installation instructions.



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### 3. Terminal

#### f. Other Common Errors

**NO** rail to post connection at post 1 of systems with impact heads.

Note the **WRONG** rail for this terminal.



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### 3. Terminal

#### f. Other Common Errors

DO NOT place any washers or delineators on the face of a guardrail terminal unless specifically called for or allowed in manufacturer's installation instructions



### 3. Terminal

#### f. Other Common Errors

This is what can happen when washers are used.





### 3. Terminal

f. Other Common Errors



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### 3. Terminal

f. Other Common Errors



Nuts on the bracket should be on the roadside

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### 3. Terminal

#### f. Other Common Errors

Excessive flare on a terminal.



### 3. Terminal


#### f. Other Common Errors



**Improper Application - no deflection and within terminal**

### 3. Terminal

f. Other Common Errors



**Improper Application** – no runout for a non-energy absorbing terminal...LON (as well as grading)

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### 3. Terminal

f. Other Common Errors



**Improper Application** – Terminals should have 7' separation (and the sign should be beyond the terminal system)

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### 3. Terminal

#### g. Delineation



### 4. Crash Cushions

- a. Manufacturers Manuals
- b. Grading



## 4. Crash Cushions

### a. Manufacturers Manuals

**Must follow manufacturer's installation instructions and State standards.**



**These are all readily available online**



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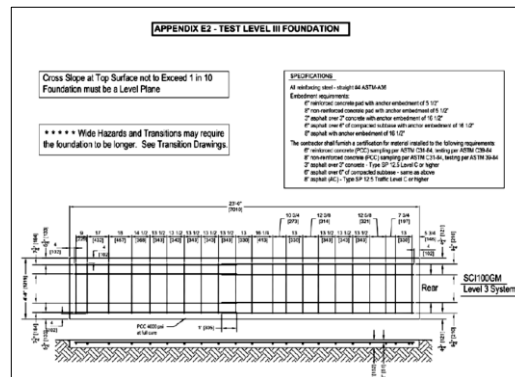
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## 4. Crash Cushions

### a. Manufacturers Manuals

Construct concrete pad if called for per manufacturer's requirements or state standards.

Clean out drilled holes WELL!!



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## 4. Crash Cushions

### a. Manufacturers Manuals

- Anchor bolts are required to secure the system to concrete pad. Number of bolts and length of bolts vary with systems.
- Bolts are typically required to be epoxied into concrete pad.
- Bolts may have a torque value.

Full bolt depth required



Cutting bolt prohibited



**Must follow manufacturer's installation instructions.**



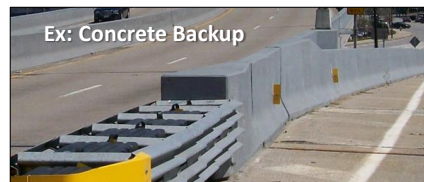
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## 4. Crash Cushions

### a. Manufacturers Manuals

- Backup varies among systems.
- May be connected to a barrier or may be a stand alone



**Must follow manufacturer's installation instructions.**



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## 4. Crash Cushions

### a. Manufacturers Manuals

- When system is placed in a bidirectional application a transition is required to prevent back side snagging



**Must follow manufacturer's installation instructions.**

## 4. Crash Cushions

### a. Manufacturers Manuals

- Place appropriate delineation on front of system



**Must follow manufacturer's installation instructions and state guidance**

## 4. Crash Cushions

### b. Grading

Grading should be so an errant vehicle impacts the system in a stabled condition – same as terminals

**Suspect  
Grading**



**Must follow manufacturer's installation instructions.**

## 4. Crash Cushions


Ex: results of improper torque values applied to fender panels.



**Must follow manufacturer's installation instructions.**

## Review Learning Outcomes

- Describe key components of barrier systems
- Identify common installation errors



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