

FHWA Roadway Departure Technology Transfer Roadside Safety Systems Installer Training

Session 8: Maintenance of Systems

Course Topics

- Session 7 – Inspection of Completed Work and Liability Issues
- **Session 8 - Maintenance of Systems**

Session 8 Objectives

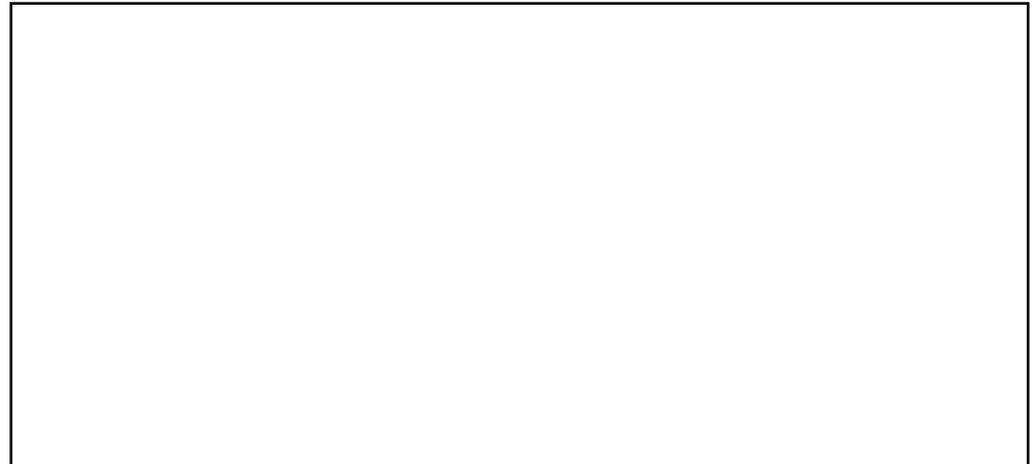
- Determine when damaged barrier needs to be reset, repaired, rebuilt, or removed.
- Understand when a damaged barrier terminal is no longer functional, and know whether to repair, replace in-kind, or upgrade to a newer design.
- Make repairs in a safe, cost-effective manner.

Session 8 Outline

- Introduction
- Determine Extent of Damage & Damaged Materials
- Inventory of Replacement Parts
- Replacement In-Kind vs. Upgrade
- Upgrade Existing Deficient Systems
- Removal Options & Material Handling/Storage
- Performing the Repair
- Protection of Unfinished Work
- Inspection, Reporting and Documentation Procedures

Introduction

- Guardrail systems usually require repair after crashes.
- Guidelines concerning guardrail repair / replacement are addressed in Technical Briefs.
- Delaware has procedures for pavement preservation but will explore options for repair guidelines.



Need To Repair



VIDEO

Need To Repair



VIDEO

W-BEAM GUARDRAIL REPAIR

*A Guide for Highway and Street
Maintenance Personnel*

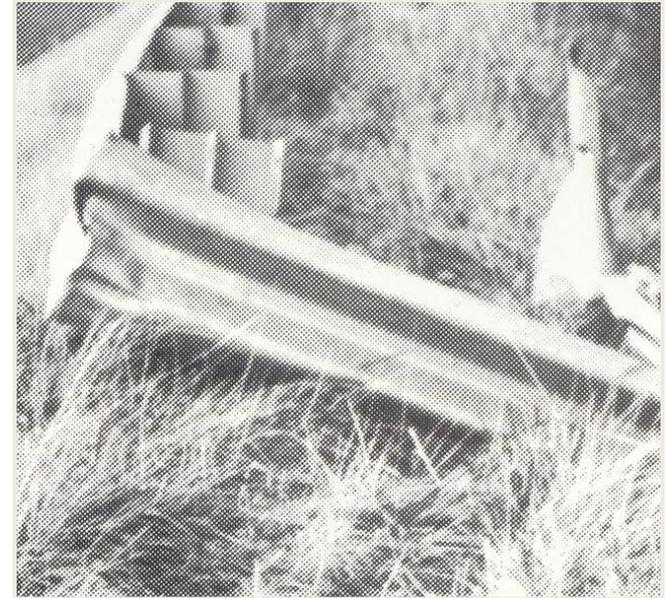
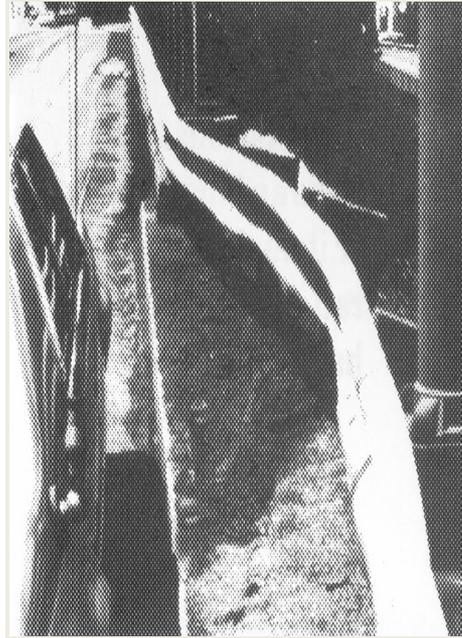


November 2008



U.S. Department of Transportation
Federal Highway Administration

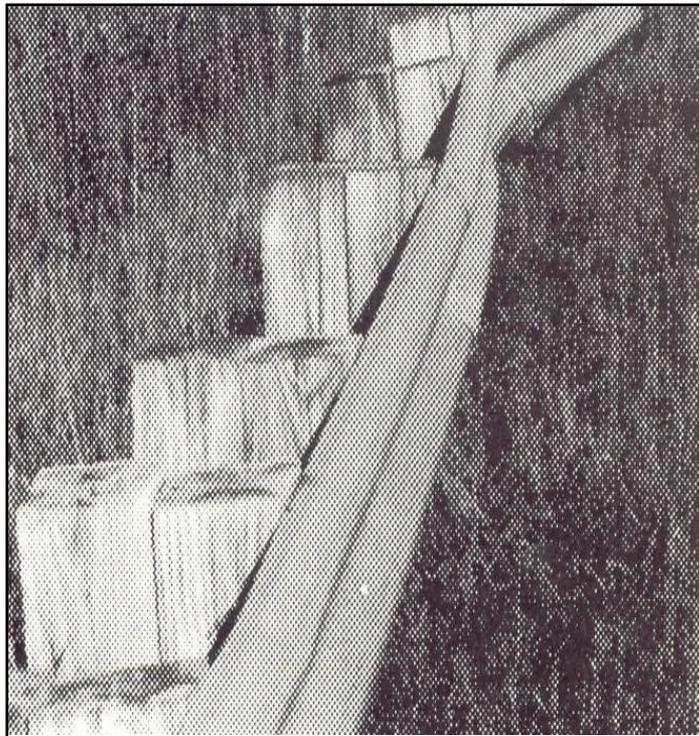
Determine Extent of Damage



FHWA Repair Guide & NCHRP Report 656 are intended to identify methods to better determine whether minor damage to W-Beam barriers poses a crash safety risk. It is intended to enable maintenance crews to prioritize repairs.

Determine Severity

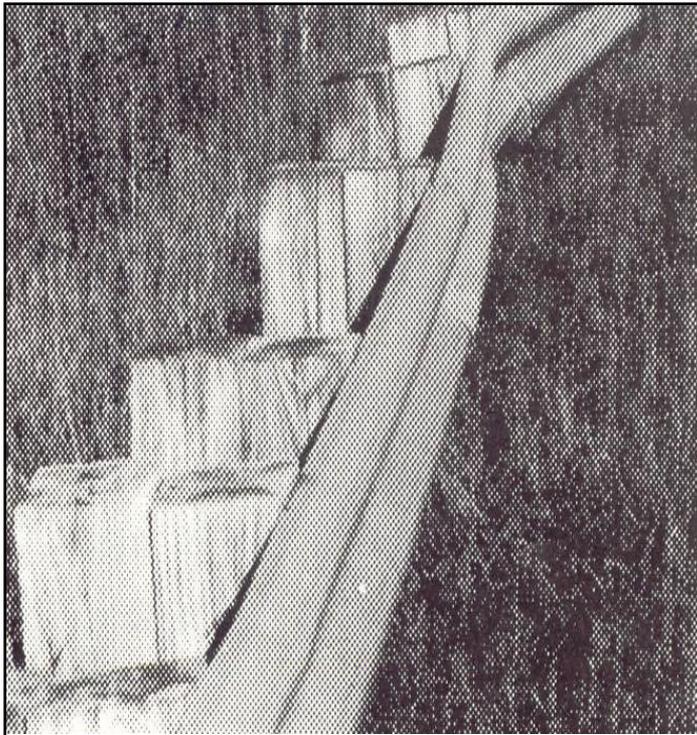
➤ LEVEL ONE



- Guardrail damage is minor and may continue to function when:
 - Rail beam is slightly crushed or flattened but not cut.
 - No posts are broken off or separated from the rail beam.
 - Rail beam is bent or pushed out of line less than 6”.

Determine Severity (cont'd)

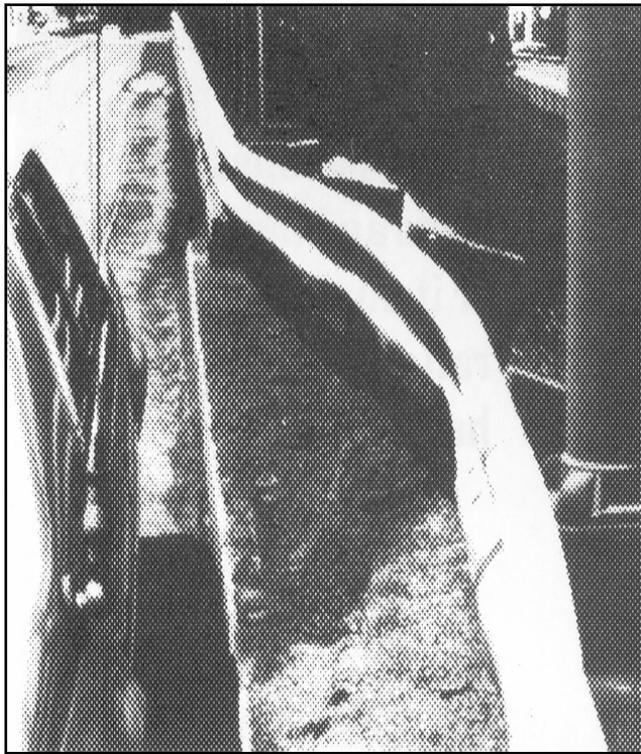
➤ LEVEL ONE



- Decide if the damage is bad enough to warrant repair.
- If so, decide how much is to be repaired.
- Report what is to be done for any repair thought to be needed, and schedule the repair when convenient to the work schedule.

Determine Severity (cont'd)

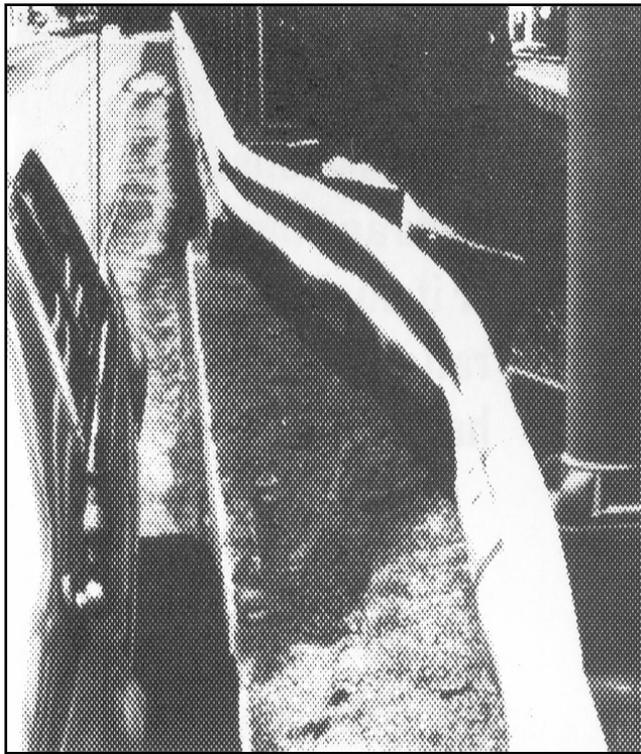
➤ LEVEL TWO



- Guardrail is obviously damaged but may work for some traffic conditions when:
 - Even though badly bent or crushed, rail beam is not separated anywhere.
 - Two or fewer posts are broken off or separated from the rail beam.
 - Rail beam is bent or pushed out of line less than 12”.

Determine Severity (cont'd)

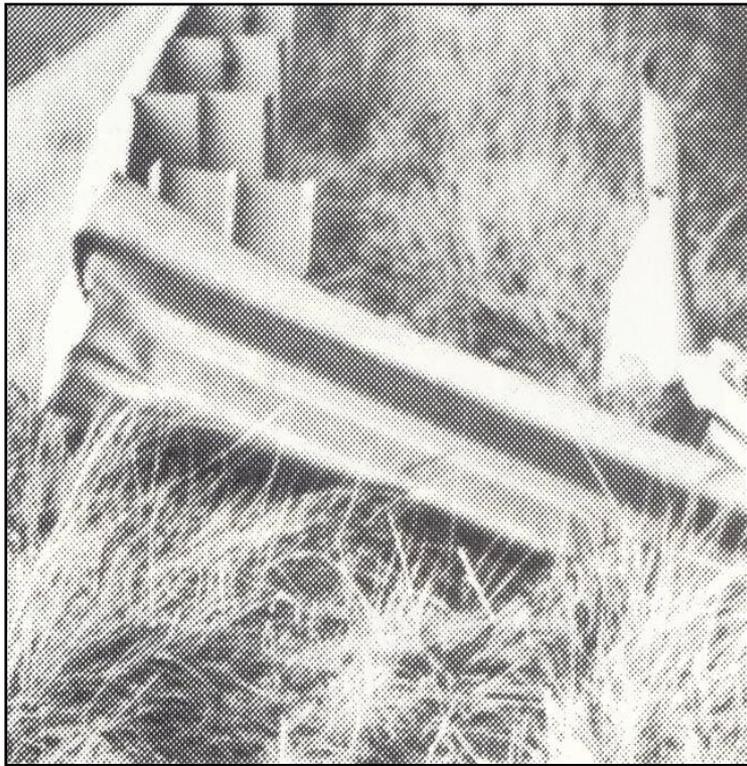
➤ LEVEL TWO



- Make a good inspection of the damage to be certain it is reasonably functional.
- Make a damage inspection report and repair request for parts and equipment.
- Schedule the repair along with other scheduled work.
- Check the damage barrier site frequently to see if it has been hit again or damaged worse than first thought. Such damage may make it important to repair the damage sooner than originally scheduled.

Determine Severity (cont'd)

➤ LEVEL THREE



- Guardrail damage is so bad that it no longer functions and may itself be a hazard to motorists when:
 - The rail section is pulled completely apart.
 - Three or more posts are broken off or are no longer attached to the rail.
 - Rail beam is bent or pushed more than 18" out of line.

Determine Severity (cont'd)

➤ LEVEL THREE

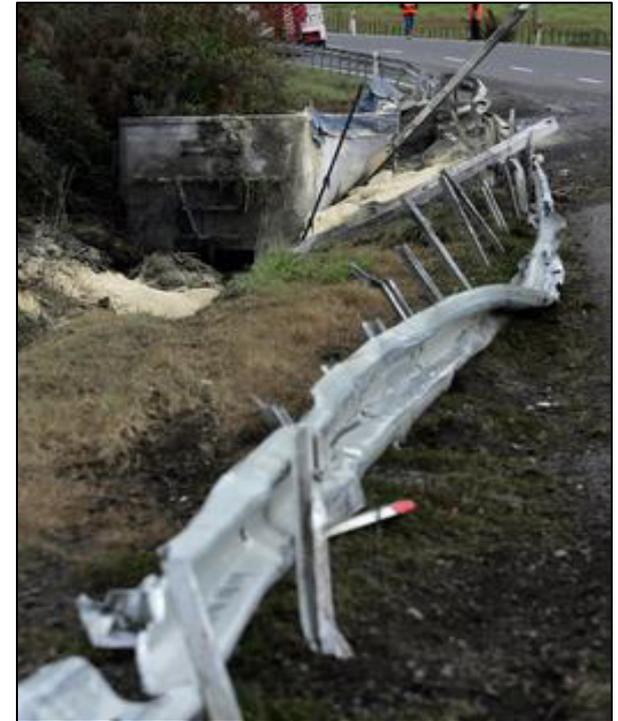


- Clear any debris from the traffic lanes and shoulder.
- Put out temporary warning devices such as vertical panels, small barricades, or barrels to warn motorists if it cannot be fixed immediately.
- Determine what materials and equipment are needed to fix it, and get the repair job started as soon as possible (high priority).

Determine Severity (cont'd)



Determine Severity (cont'd)



Should these damaged rails be shielded with a temporary barrier?

Determine Severity (cont'd)



Was this hit again? Maybe this damaged rail should have been shielded with a temporary barrier...

NCHRP

REPORT 656

NATIONAL
COOPERATIVE
HIGHWAY
RESEARCH
PROGRAM

Criteria for Restoration of Longitudinal Barriers

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

Modes of Barrier Damage

BARRIERS

(Based on experimental testing)

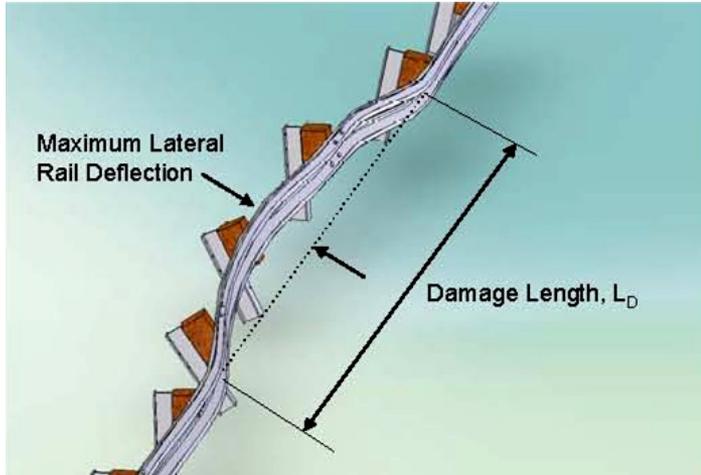
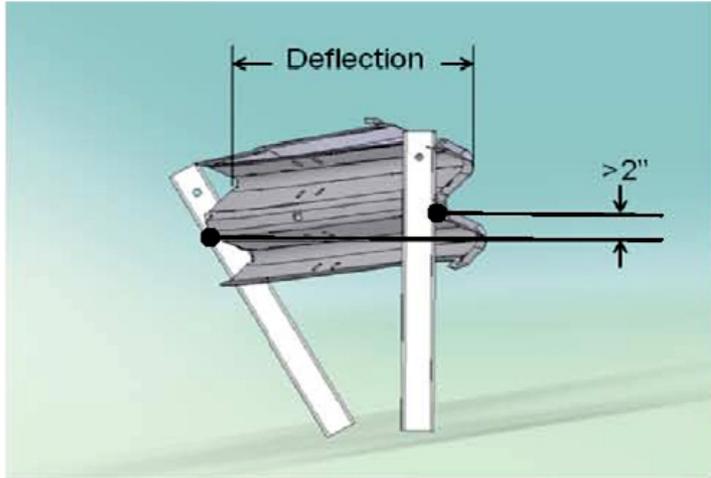
- Post and rail deflection
- Rail deflection only
- Rail flattening
- Posts separated from rail
- Missing/broken posts
- Missing blockouts
- Twisted blockouts
- Non-manufactured holes
- Damage at a rail splice
- Vertical tear
- Horizontal tear

End Treatments

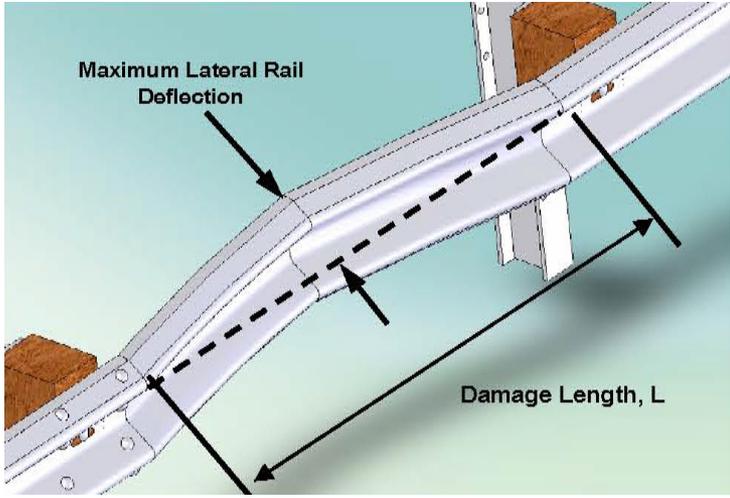
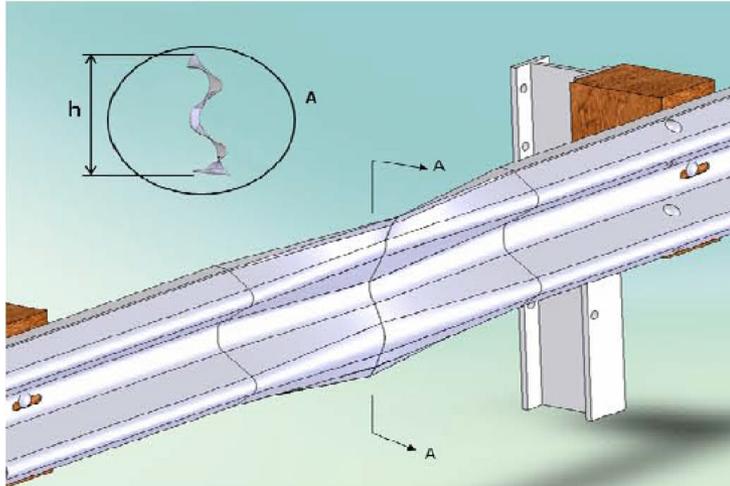
(Based on Engineering Judgment)

- Damaged end post
- Anchor cable missing
- Anchor cable loose
- Anchor cable bracket
- Stub height
- Lag screws
- Bearing plate

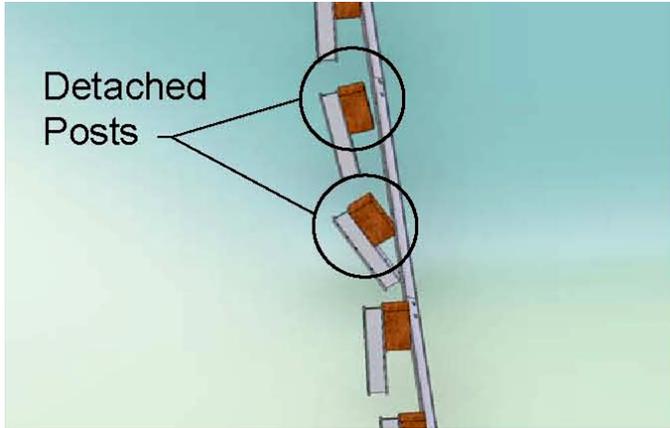
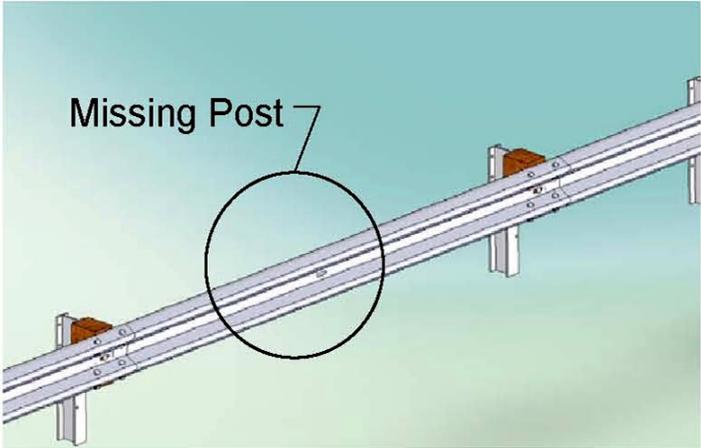
Barriers

Damage Mode	Repair Threshold	Relative Priority	Measurement
Post and Rail Deflection	One or more of the following thresholds: <ul style="list-style-type: none"> • More than 9 inches of lateral deflection anywhere over a 25 ft length of rail. • Top of rail height 2 or more inches lower than original top of rail height. 	High	 <p>Maximum Lateral Rail Deflection</p> <p>Damage Length, L_D</p>
	6-9 inches lateral deflection anywhere over a 25 ft length of rail.	Medium	 <p>Deflection</p> <p>>2"</p>
	Less than 6 inches of lateral deflection over 25 ft length of rail.	Low	<p>(Weak Post W-Beam Shown Only for Clarity. Each measurement taken at rail middle fold)</p>

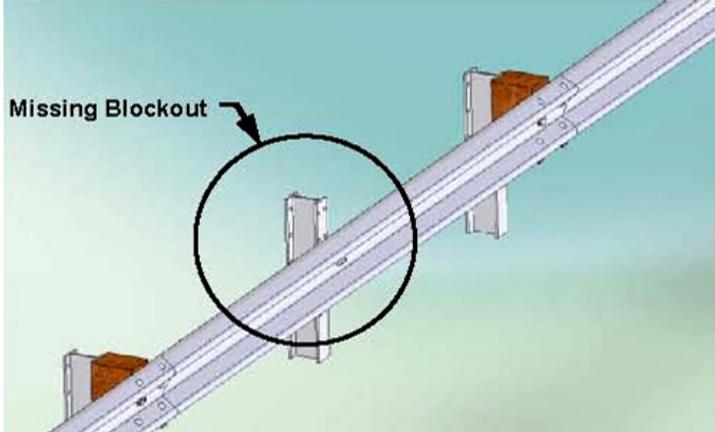
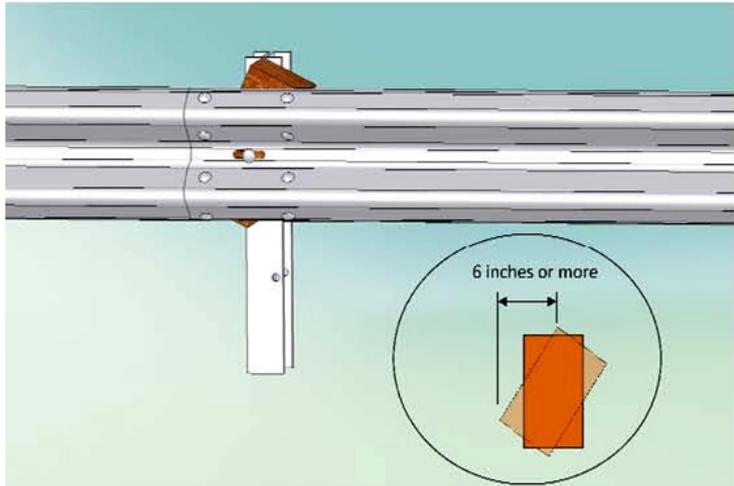
Barriers

Damage Mode	Repair Threshold	Relative Priority	Measurement
Rail Deflection Only	6-9 inches of lateral deflection between any two adjacent posts. Note: For deflection over 9 inches, use post/rail deflection guidelines.	Medium	 <p>The diagram shows a perspective view of a rail barrier with a post. A dashed line represents the original straight position of the rail. An arrow points to the maximum lateral deflection of the rail from this line. Another arrow indicates the 'Damage Length, L' as the distance between two adjacent posts.</p>
	Less than 6 inches of lateral deflection between any two adjacent posts.	Low	
Rail Flattening	One of more of the following thresholds: <ul style="list-style-type: none"> Rail cross-section height, h, more than 17" (such as may occur if rail is flattened). Rail cross-section height, h, less than 9" (such as a dent to top edge). 	Medium	 <p>The diagram shows a perspective view of a rail barrier with a post. A circular inset labeled 'A' shows a cross-section of the rail with a vertical dimension line labeled 'h' indicating the height of the rail. The rail in the main view shows a flattened or dented top edge.</p>
	Rail cross-section height, h , between 9 and 17 inches.	Low	

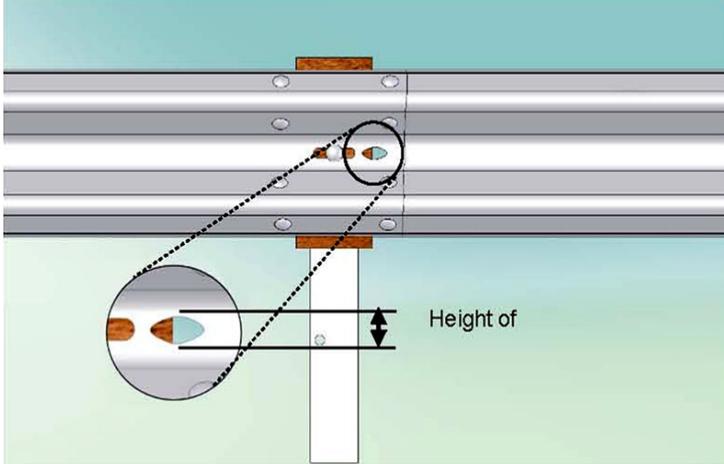
Barriers

Damage Mode	Repair Threshold	Relative Priority	Measurement
Posts Separated from Rail	<ul style="list-style-type: none"> • 2 or more posts with blockout attached with post-rail separation less than 3 inches. • 1 or more post with post-rail separation which exceeds 3 inches. 	Medium	 <p>Note:</p> <ol style="list-style-type: none"> 1. If the blockout is not firmly attached to the post, use the missing blockout guidelines. 2. Damage should also be evaluated against post/rail deflection guidelines.
	<ul style="list-style-type: none"> • 1 post with blockout attached with post-rail separation less than 3 inches. 	Low	
Missing/Broken Posts	1 or more posts <ul style="list-style-type: none"> • Missing • Cracked across the grain • Broken • Rotten • With metal tears 	High	

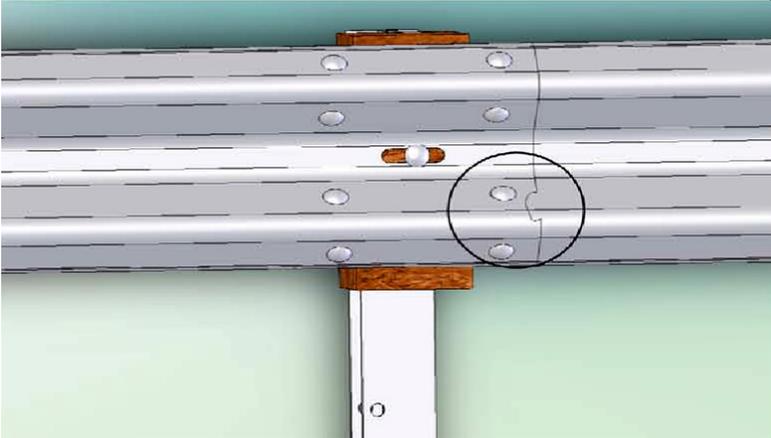
Barriers

Damage Mode	Repair Threshold	Relative Priority	Measurement
Missing Blockout	<p>Any blockouts</p> <ul style="list-style-type: none">• Missing• Cracked across the grain• Cracked from top or bottom blockout through post bolt hole• Rotted	Medium	 <p>The diagram shows a perspective view of a metal barrier post with several blockouts. One blockout is missing, and this area is circled in black. An arrow points to the circle with the text 'Missing Blockout'.</p>
Twisted Blockouts	<p>Any misaligned blockouts, top edge of block 6 inches or more from bottom edge.</p> <p>Note: Repairs of twisted blockout are relatively quick and inexpensive</p>	Low	 <p>The diagram shows a perspective view of a metal barrier post with a blockout. The blockout is twisted, and its top edge is significantly higher than its bottom edge. A circular inset shows a close-up of the blockout, with a double-headed arrow indicating a vertical distance of '6 inches or more' between the top and bottom edges.</p>

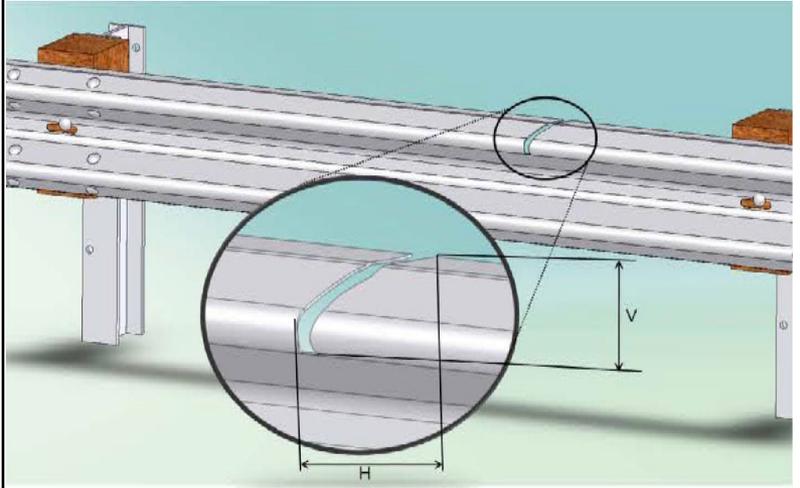
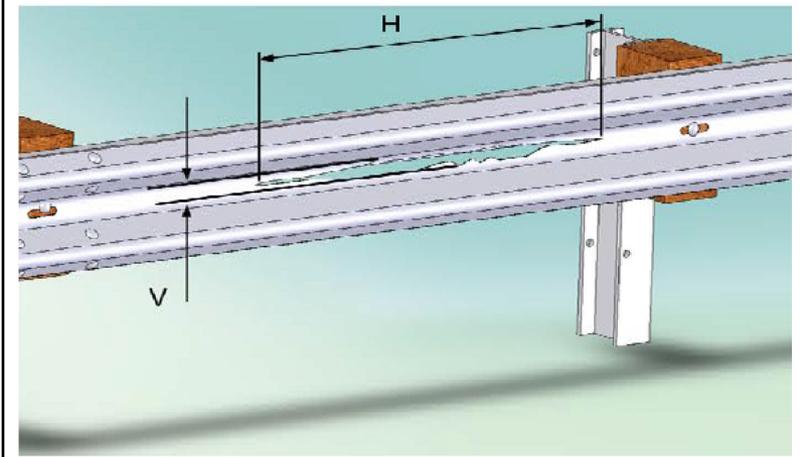
Barriers

Damage Mode	Repair Threshold	Relative Priority	Measurement
<p>Non-Manufactured holes</p> <p>(such as crash induced holes, lug-nut damage, or holes rusted-through the rail)</p>	<ul style="list-style-type: none"> • More than 2 holes less than 1" in height in a 12.5' length of rail. • Any holes greater than 1" height. • Any hole which intersects either the top or bottom edge of the rail. 	High	
	<p>1-2 holes less than 1" in height in a 12.5' length of rail.</p>	Medium	

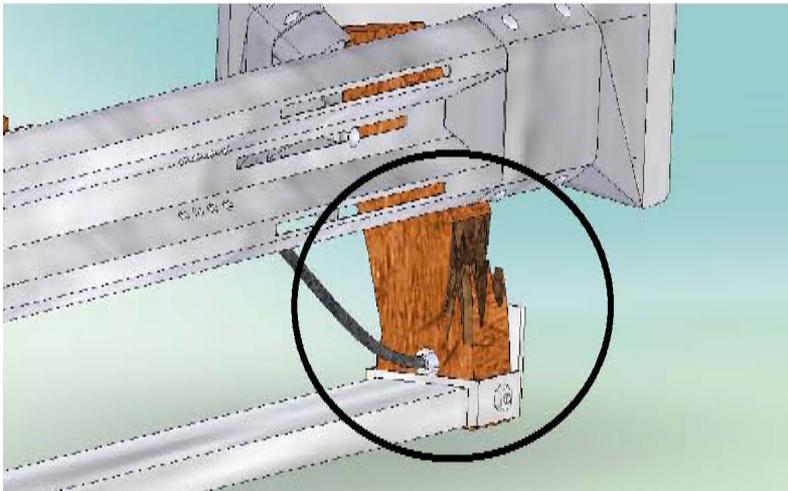
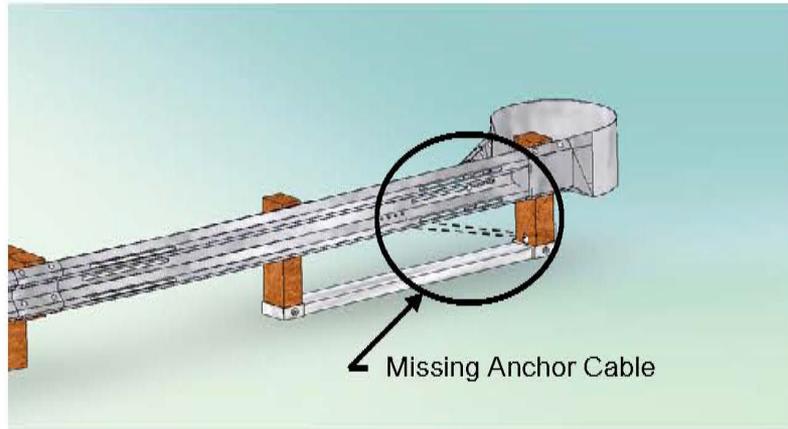
Barriers

Damage Mode	Repair Threshold	Relative Priority	Measurement
Damage at a rail splice	More than 1 splice bolt: <ul style="list-style-type: none">• Missing• Damaged• Visibly missing any underlying rail• Torn through rail	High	 A cross-sectional diagram of a rail splice. It shows two parallel metal rails joined by a central splice bolt. The bolt is missing, and the rails are slightly misaligned. A vertical wooden post is visible below the rails. A black circle highlights the gap between the rails at the splice point.
	1 splice bolt: <ul style="list-style-type: none">• Missing• Damaged• Visibly missing any underlying rail• Torn through rail	Medium	

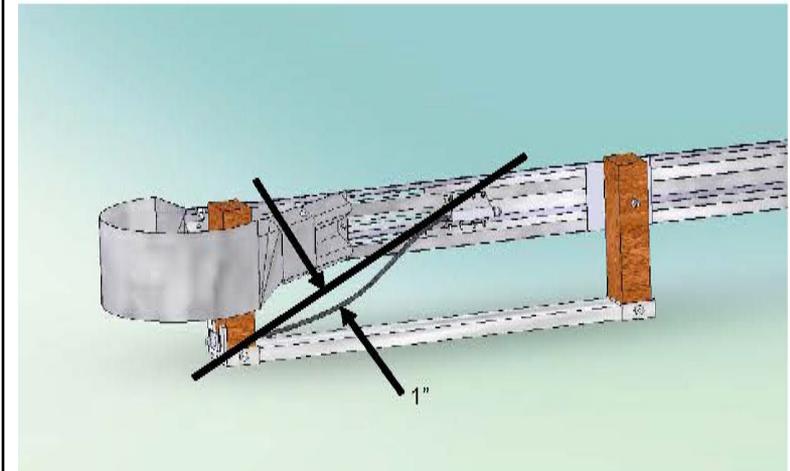
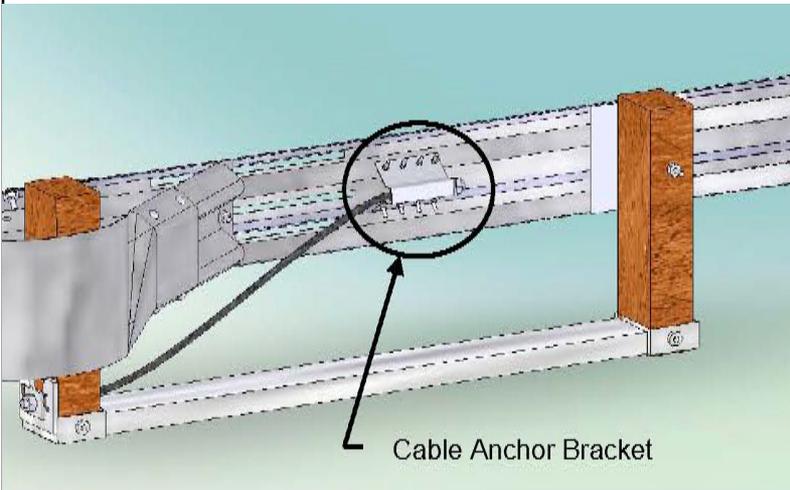
Barriers

Damage Mode	Repair Threshold	Relative Priority	Measurement
Vertical Tear	Any length vertical (transverse) tear	High	
Horizontal Tear	Horizontal (longitudinal) tears greater than 12 inches long or greater than 0.5 inches wide. Note: for horizontal tears less than 12 inches in length or less than 0.5 inches in height, use the non-manufactured holes guidelines.	Medium	

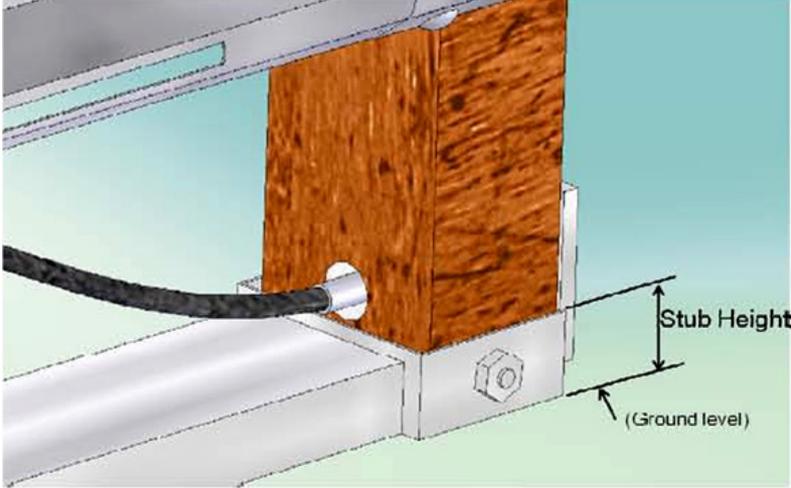
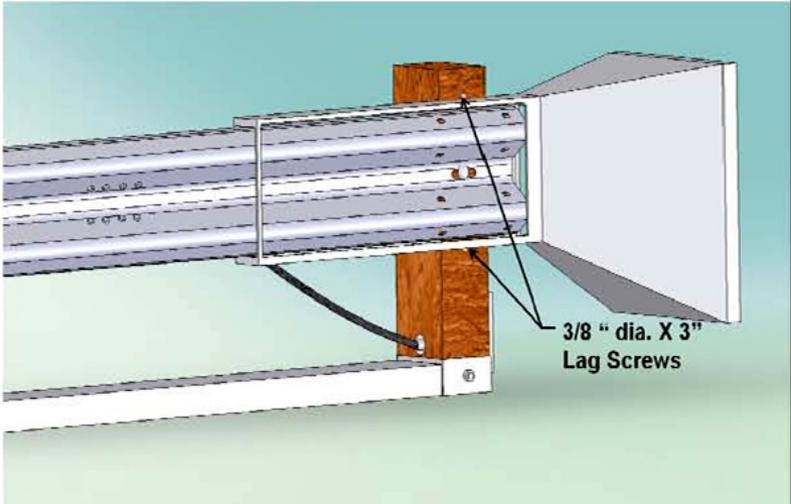
End Treatments

Damage Mode	Repair Threshold	Relative Priority	Measurement
Damage End Post	Not functional (sheared, rotted, cracked across the grain)	High	 A 3D CAD model of a structural assembly. A black circle highlights a vertical wooden post that is severely damaged, appearing rotted and sheared. The post is connected to a horizontal metal beam. The background is a light blue gradient.
Anchor Cable	Missing	High	 A 3D CAD model of a structural assembly. A black circle highlights a section of a horizontal metal beam where an anchor cable is missing. An arrow points from the text 'Missing Anchor Cable' to the circle. The background is a light blue gradient.

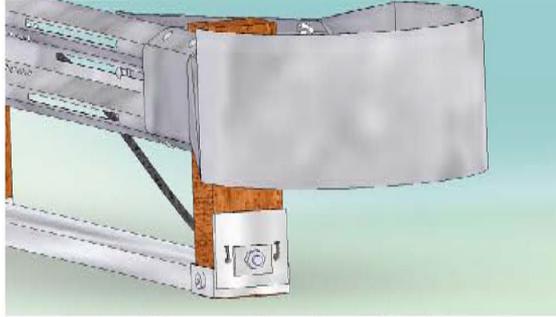
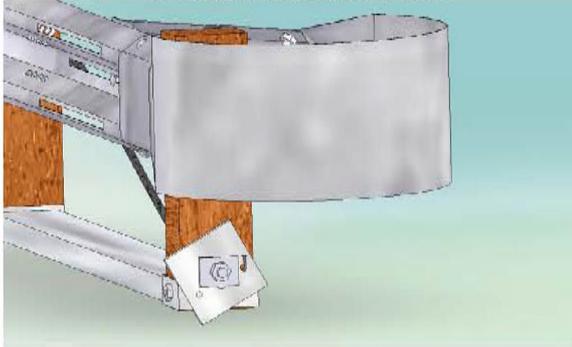
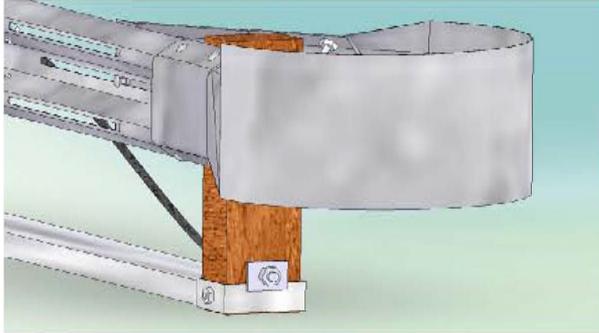
End Treatments

Damage Mode	Repair Threshold	Relative Priority	Measurement
Anchor Cable	More than 1" of movement when pushed down by hand	Medium	 A 3D perspective diagram of a cable anchor assembly. It shows a metal rail with a cable attached to a bracket. A vertical wooden post is on the right. Two black arrows point to the cable's movement: one points to the cable's position when it is pushed down, and the other points to its original position. A '1"' label is placed between the two arrowheads to indicate the measurement.
Cable Anchor Bracket	Loose or not firmly seated in rail	Medium	 A 3D perspective diagram of the same cable anchor assembly. A black circle highlights the cable anchor bracket where it meets the rail. An arrow points from the text 'Cable Anchor Bracket' to this circled area.

End Treatments

Damage Mode	Repair Threshold	Relative Priority	Measurement
Stub Height	Height which exceeds 4"	Medium	 <p>The diagram illustrates a cross-section of a wooden post (stub) mounted on a metal base. A vertical dimension line on the right side indicates the height of the wood above the base, labeled 'Stub Height'. Below the base, a horizontal line is labeled '(Ground level)'. A black cable is shown entering the wood from the left.</p>
Lag Screws (Energy Absorbing Terminals Only)	Missing or failed lag Screws	High	 <p>The diagram shows a metal terminal assembly mounted on a wooden post. A label '3/8 " dia. X 3" Lag Screws' with a leader line points to the screws that secure the terminal to the wood. A black cable is shown entering the terminal from the left.</p>

End Treatments

Damage Mode	Repair Threshold	Relative Priority	Measurement
Bearing Plate	Loose or Misaligned	Medium	 <p>(Correct Bearing Plate)</p>  <p>(Misaligned Bearing Plate)</p>
	Missing Bearing Plate	High	 <p>(Missing Bearing Plate)</p>

Damaged Materials



Damaged Materials



Damaged Materials

- Owner determines the extent of repair, replacement or upgrade.
- Non-salvageable materials are disposed of by the Contractor.
- Check for any specific agency requirements.
- Check for nuisance hits on terminals to be sure post #1 is not damaged.



Damaged Materials: Salvageable Components

- Salvageable sections of guardrail may be reused in the repair work:
 - Realigned (without removal or disassembly).
 - Reset (require removal).
- Salvageable materials that cannot be used in the work are delivered to the DOT.

Damaged Materials: Terminals

- Check for nuisance hits on terminals to be sure post #1 is not damaged.
- Even with claims of “reusability” – use best judgment and closely examine all salvageable parts.
- Some items may be re-used.
- Can Impact Heads can be returned to manufacturer for repair / recertification?
 - Strut/Foundation
 - Nuts/Bolts



Who Hit the Terminal?



Large Hit



Large Hit



Medium Nuisance Hit



Small Nuisance Hit



Small Nuisance Hit



Other Problems?









Other Problems?



Other Problems?



Other Problems?



Other Problems?



**Improper
Transition**

Other Problems?



Inventory of Replacement Parts

- Good inventory of replacement parts is essential to maintaining guardrail in a timely manner.
- W-Beam and other commonly used guardrail systems should be in inventory for installation contractors.
- Guardrail end terminals are very specialized. Some manufacturer's component parts for guardrail end terminals will interchange and some DO NOT (see manufacturer's installation manuals).

Replacement In-Kind vs. Upgrade

- Agency guidelines differ on this subject. **Example: Virginia**
 - Design speed: Repair in-kind on roadways with design speeds of 45 mph or less; on roadways with design speeds greater than 45 mph, the extent of damage governs repair / replacement.
 - Length of guardrail:
 - If the total run of guardrail is *200' or less*, replace the entire run of guardrail with an NCHRP 350 TL3 approved guardrail.
 - If the total run is more than *200' and more than 60%* of the entire run has been damaged, the entire run should be replaced with NCHRP 350 TL3 approved guardrail.
 - If the total run is more than *200' and less than 60%* of the run has been damaged, it is replaced in kind.

EXAMPLE:

Upgrade Existing Deficient Systems

- Tennessee: “Entire guardrail sections may also be removed and replaced to current standards, if the major portion of the section is damaged beyond repair and if directed by the Engineer.”
- Virginia: “Existing substandard guardrail systems and components shall be *upgraded* to the latest standard for the following situations:
 - When located within the project limits of a construction project.
 - When guardrail needs to be repaired/replaced under a maintenance project (e.g., guardrail, pavement, etc.).
 - When located within the project limits of transportation improvements associated with permitted land development projects.

EXAMPLE: Upgrade Existing Deficient Systems - Virginia

- Replace obsolete terminals (with NCHRP 350 approved terminals):
 - Breakaway Cable Terminals (BCT's).
 - Modified Eccentric Loading Terminal (MELT).
 - Turned-down strong-post terminals.



EXAMPLE: Upgrade Existing Deficient Systems - Virginia

- Replace / upgrade substandard fixed object attachments (e.g., transition to bridge rail).
- Reset guardrail that is more than 3” higher or lower than the standard for the system.

Removal Options

- Removal options:
 - “Remove and Dispose”
 - “Remove and Reset”
 - “Remove and Store”

Remove and Dispose

- The Contractor or Installer controls the removal process.
- If they try to salvage as much as they can, the process is similar to that for “remove and store.”
- If the panel has a considerable amount of damage or corrosion, they may elect to scrap all material.
- Generally the only items that are salvaged are the panels and posts. Cable, blocks and bolts are usually scrapped.



Remove and Reset

➤ “Upgrading The Guardrail”

- Reset the guardrail according to the project plans and local standards.
- Often times, you will reuse the post and rail, but replace the offset block.
- You will also replace damaged bolt and connection hardware.



Remove and Reset

➤ “Upgrading The Guardrail”

- Sometimes you will remove and reset the post or replace the offset block (lane additions).

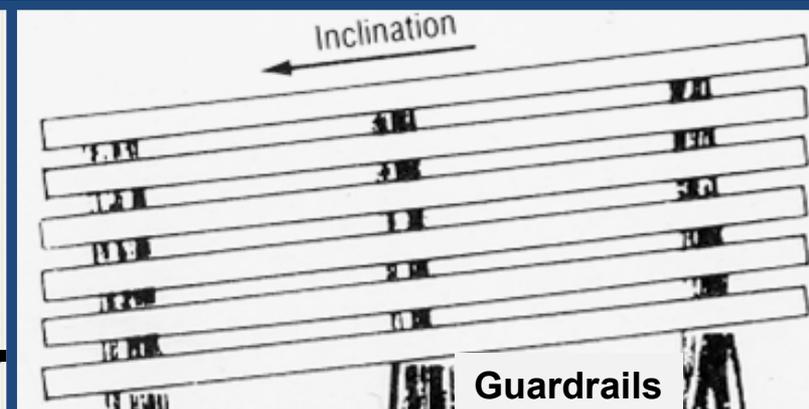
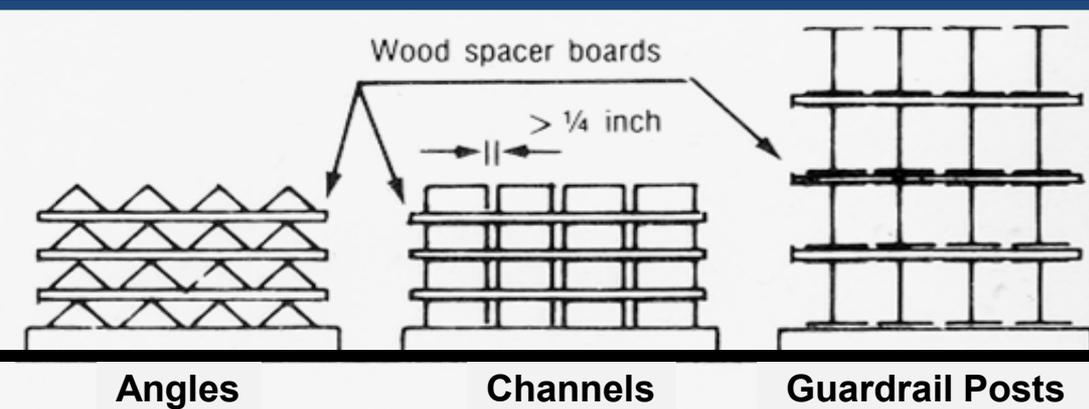
REPLACING STEEL BLOCKS WITH WOOD OR PLASTIC BLOCKS IS A TYPICAL UPGRADE PROCEDURE



Remove and Store

➤ “Yours To Keep?”

- The guardrail items are to be reused at a later date.
- Your handling practices will be influenced depending on whether the owner intends to keep materials or if you intend to resell or dispose of the material.
- However, if you plan on reusing any materials, make sure to store properly so that items do not deteriorate in wet conditions.



Performing the Repair

Pre-Site:

- Before performing repairs or maintenance you will need:
 - Temporary warnings/markers to mark the area you are working for your safety and the safety of drivers.
 - An adequate crew size.
 - Equipment and tools necessary to perform the repairs.

Performing the Repair

Upon Arrival:

- Set up traffic control.
- Disassemble the damaged guardrail.
 - Spray connecting bolts with penetrating oil (such as WD-40) for easier removal.
 - Unbolt the damaged rail beam sections.
 - If the elliptical shoulder is worn off the bolt, hold the smooth round head with vise grips to unscrew the nut. Use a torch to cut stubborn bolts. Avoid cutting rail sections that can be straightened and reused later.

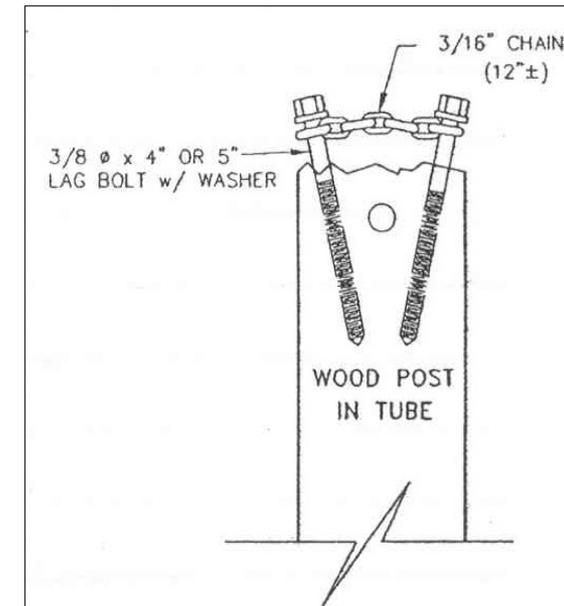
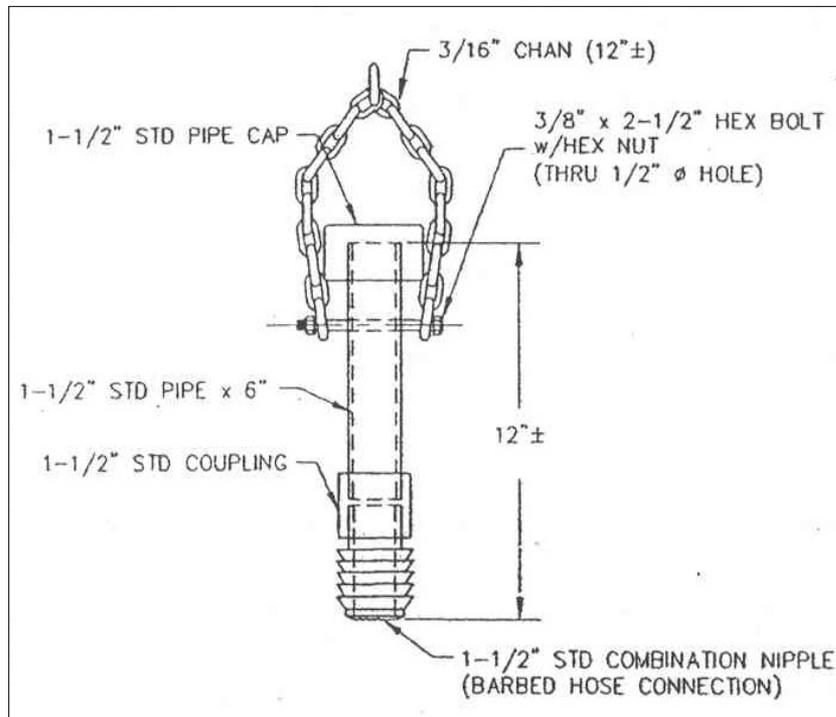
Performing the Repair

Post Excavation:

- Pull out the damaged posts.
 - Steel posts can often be worked out by hand or with a crowbar. Wood posts may have to be dug out or pulled with a chain and hoist.
 - Slightly twisted steel posts that are still firmly in the ground can often be straightened in place by pulling with a chain attached to a truck.
 - Posts that have only been pushed back off-line can be pulled back into line with a crowbar.
- If necessary, reshape the shoulder area with a grader and re-compact the soil for posts.

The Removal Process

➤ Example: Removal Instructions for damaged Wood Post Inside a Steel Foundation Tube



Post Pulling

- While pulling post you must remove all dirt in post flange for easy loading and stacking.
- When stacking, the stack of post pulling equipment must be level.
- Pull posts with attention to post condition. Rocky soil can also affect post pulling.



Post Pulling

- Even a steel post can pull up significant amounts of dirt... especially when damaged during pounding.
- Post holes should be backfilled immediately to prevent workers from twisting ankles in holes hidden by grass.
- Do not throw wood posts or blocks into brush behind guardrail. Dispose of them properly.



The Removal Process

Rail/Barrier Systems:

- Loosen and remove all hardware.
- Loosen and remove all splice post bolts to ensure guardrail will fall apart.
- Loosen and remove all mounting bolts (Make sure everyone is clear when guardrail falls to ground. Wood blocks will fall also).
- Loosen and remove block bolts if applicable.

Project Site Material Handling

- Manually load guardrail, posts, blocks and hardware in orderly position on company truck and/or trailer.
- Load end elements in orderly position on company truck and/or trailer.
- Load bridge connections and end terminals. Follow established loading procedures for specific project and/or type.
- Always remember to separate damaged and undamaged material!
- Take care not to damage any guardrail, posts, blocks or terminals.

Material Storage and Handling

- Material may need to be stored in a *secured area* close to the project (project yard).
- Project yard should be laid out with materials *placed in the order* in which they are to be removed (i.e. posts, blocks, rail, terminals).
- If *material belongs to* a DOT, either you deliver to the DOT yard or the DOT will load out of your project yard. Confirm details!
- Clean up project yard after all material is loaded.



Performing the Repair

Post Replacement:

- Set up a string line to position posts at the proper height, alignment, and spacing.
 - Mark the string line for proper post height and alignment.
 - Mark the proper post spacing with a measuring tape/ruler.
 - In the middle of an existing run of guardrail, check the height of the rail you are matching to be certain it is within 2" of the required standard height.

Performing the Repair

Post Replacement (continued):

- Drill or dig holes for the posts if necessary.
- Set or drive posts to proper height.
- Backfill & tamp the soil around posts.
- Check post alignment and height. Correct any major deviations.



Performing the Repair

Offset Blocks and Rail:

- Make a loose assembly of blocks.
 - Attach new offset blocks to posts.
 - Starting downstream and working backwards, hang new rail sections. Overlap the rail the same as the existing rail.
 - Use a drift pin to line up the holes for bolting.



Performing the Repair

Rail Connections:

- Make sure all 8 bolts are in place in each splice connection.
- Leave all connections finger tight to allow for lengthwise adjustment after all sections are in.
- When all rail is hung, go back and tighten all bolts snugly, but do not over tighten.
- Cleanup by smoothing out the shoulder and slope approaching the guardrail so the next vehicle to run off road has a smooth path.

Protection of Unfinished Work

- Unless the road you are working on is closed, **NEVER** leave any guardrail unfinished.
- Always complete the bridge attachments first, approach end terminals second, and trailing end terminals last.
- If for some reason the end of the guardrail run must be left unfinished, the end may need protected with a temporary attenuator and delineated.



Protection of Unfinished Work



Protection of Unfinished Work



Protection of Unfinished Work

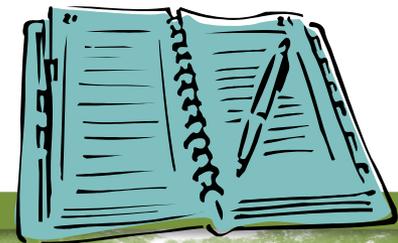


Protection of Unfinished Work



Inspection, Reporting, and Documentation Procedures

- Always inspect your work first to correct any mistakes.
- After initial inspection, re-inspect with agency (inspector or project engineer).
- Measure guardrail with agency to agree on all item quantities and have agency record in project diary.
- Record quantities on company's work sheet.
- On project plans, draw a sketch of each individual run of guardrail on the back of the opposite page. Include all different items installed.
- Use video or camera to document each run and record location, quantities installed, time, and date.



Session 8 Outcomes

- Know when damaged barrier needs to be reset, repaired, removed, or rebuilt.
- Know when a damaged barrier terminal is no longer functional, and whether to repair, replace in-kind, or upgrade to a newer design.
- Know how to make repairs in a safe, cost-effective manner.