Roadside Safety Hardware

Katherine Smutzer, INDOT
INDOT Highway Design Conference 2021
Takeaways for this Meeting

- When placing roadside safety hardware, place to standard where possible.

- Where a standard roadside safety hardware system cannot be placed given site specific restrictions, contact INDOT Standards and Policy, Email: designmanualinquiries@indot.in.gov

- When modifying the roadway adjacent roadside safety hardware review the effects to the roadside safety hardware
  - What is the final height of the roadside safety hardware?
  - What is the final grading to the face of the roadside safety hardware?
Alternate Culvert Guardrail Options

Where the appropriate cover can not be provided to drive a standard guardrail post, the preferred methods of crossing guardrail over a culvert is to omit a guardrail post within a run of MGS guardrail or place a MGS Long Span Guardrail System. Of course, the problem is the maximum out-to-out width of a culvert, parallel to the roadway. To use an omitted post within a run of MGS w-beam guardrail, the culvert out-to-out width should not exceed 10’-6” (desirable) and 11’-0” (maximum).

An Omitted Post shall only be used with a run of MGS W-beam Guardrail.

12”

It is not desirable, however, the 12” clear distance to the post can be reduced to 9”.


ELEVATION VIEW
MGS W-BEAM OMITTED POST
Alternate Culvert Guardrail Options

To place a MGS Long Span Guardrail System, the culvert out-to-out width should not exceed 22’-6” (desirable) and 23’-0” (maximum), with a Type 2 installation.

It is not desirable, however, the 12” clear distance to the post can be reduced to 9”.
Alternate Culvert Guardrail Options

Where an Omitted Post within a run of MGS w-beam or MGS Long Span will not fit your culvert, the next standard option is the use is a Structure Top-Mounted Post. This is a good option in lower fill areas. It has been determined that this option may not be as maintenance friendly where the cover is greater than 2 feet due to the fact that a lane closure would be needed for several days to complete the guardrail repair.

Are there other options? Yes
Alternate Culvert Guardrail Options

Two other options, not in the INDOT Standard, that can be considered:

- MGS Headwall-Mounted Post, and
- MGS Socketed Post.
Alternate Culvert Guardrail Options

MGS Headwall-Mounted Post and MGS Socketed Post spacing must be 3’-1.5” to meet the MASH TL-3 test criteria. In addition, a transition is not required for these railing systems. They can be attached directly to Standard MGS Guardrail.

Only MASH crash tested for top rail height of 31”, can not be used for w-beam guardrail with 27 ¾" top rail height.
Alternate Culvert Guardrail Options

MGS Headwall-Mounted Post is mounted to the outside of the culvert headwall

The headwall is to be at ground level, this is not a curb. This system cannot be used with a curb.
Alternate Culvert Guardrail Options

MGS Headwall-Mounted Post is mounted to the outside of the culvert headwall

There are minimum dimensions the headwall must have. In addition, there is also a minimum amount of reinforcement and concrete strength required.

3. The minimum culvert headwall reinforcement shall be 4-#4 longitudinal steel evenly spaced and #4 transverse stirrups spaced on 12 in. centers. The minimum culvert slab reinforcement shall be #5 longitudinal steel on 12 in. centers and #4 transverse reinforcement on 18 in. centers for both the top and bottom reinforcement mats in the culvert slab. Design loads may call for more reinforcement.

4. The minimum compressive concrete strength shall be 5000 psi.

Again, this is not a curb 😊
Alternate Culvert Guardrail Options

MGS Socketed Post.

- **W-Beam Backup Plate** at all posts
- **MGS W-Beam Rail**
  - Embedment: 7” Min.
  - **Cover:** 12.5” Min. to 36” Max.

**Concrete Shaft**

- **Top of Shoulder Pavement**
- **HEADWALL**

**This is not a curb 😊**

Minimum Deck Reinforcement and Concrete Strength, ask me
Alternate Culvert Guardrail Options

MGS Socketed Post.

The entire #4 bar embedded length shall be installed using a minimum epoxy bond strength of 1,305 psi.
Alternate Culvert Guardrail Options

MGS Headwall-Mounted and MGS Socketed Post do have placement limitations.

MINIMUM DISTANCE BETWEEN HEADWALL-MOUNTED POST AND GURDRAIL END TREATMENT

Center of MGS Headwall-Mounted Post

≥ 12'-6" of MGS Standard Post Spacing

≥ 62'-6"

Guardrail End Treatment

MINIMUM DISTANCE BETWEEN HEADWALL-MOUNTED POST AND GUARDRAIL END TREATMENT
Alternate Culvert Guardrail Options

MGS Headwall-Mounted and MGS Socketed Post do have placement limitations.

MINIMUM DISTANCE BETWEEN HEADWALL-MOUNTED POST AND MGS CABLE TERMINAL ANCHOR SYSTEM

MINIMUM DISTANCE BETWEEN HEADWALL-MOUNTED POST AND FLARED MGS W-BEAM
When to Upgrade Guardrail

Items to review when considering guardrail upgrade include:

• **Functional classification of the roadway.** Interstates should have a higher priority for upgrading, regardless of project scope.

• **Scope of the project.** 4R, 3R, or Preventative Maintenance (PM)?

• **What system is currently in place?** Is the system NCHRP-350 TL-3 Tested, does it match Standard Drawing Series E601-WBGA? If the blockouts are steel, it is not NCHRP-350 TL-3.

• **How much guardrail removal is required,** if any.
## End Treatments, When to Consider Upgrade

<table>
<thead>
<tr>
<th>EXISTING GUARDRAIL END TREATMENT (TREATMENTS)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Work Type</strong></td>
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<tr>
<td><strong>Type I End Treatment</strong></td>
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<tr>
<td>Interstate (All Work Type, except PM)</td>
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<td></td>
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<tr>
<td>Interstate (PM)</td>
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<tr>
<td>Non-Interstate (4R)</td>
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<td></td>
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<tr>
<td>Non-Interstate (3R)</td>
</tr>
<tr>
<td>Non-Interstate (Functional or Structural)</td>
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<tr>
<td>Non-Interstate (PM)</td>
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</tbody>
</table>

D: Desirable M: Minimum
End Treatments, When to Consider Upgrade

1. Where existing guardrail is fully replaced or partial replacement encroaches into the existing end treatment, replacement is required.

2. Where existing guardrail is to remain in-place or partial replacement does not encroach into the existing end treatment, the existing end treatment may remain in-place. The existing end treatment to remain in-place must be inspected by a certified District inspector and determined to be in good condition and good working order.

3. Where the existing end treatment(s) is to remain in-place it must be inspected by a certified District inspector. Where the Length of Need changes the location of the existing end treatment, the existing end treatment should be reset or replaced.

4. Where end treatment replacement is recommended in this table, the end treatment removal will be included in the calculation for the existing guardrail run to be removed.
## Guardrail, When to Consider Upgrade

### EXISTING ROADWAY GUARDRAIL ANALYSIS for TREATMENT

<table>
<thead>
<tr>
<th>Work Type (Preventive Maintenance (PM), 3R, or 4R)</th>
<th>Existing Guardrail Compliance</th>
<th>Existing Guardrail Run to be Removed</th>
<th>Percent Removed</th>
<th>No Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>≥50% of the run</td>
<td>&lt;50% of the run but &gt; 200 ft</td>
<td>&lt;50% of the run and ≤ 200 ft</td>
</tr>
<tr>
<td>Interstate (3R and 4R)</td>
<td>Non NCHRP-350 Full Replacement</td>
<td>Full Replacement</td>
<td>Full Replacement</td>
<td>Full Replacement</td>
</tr>
<tr>
<td></td>
<td>NCHRP-350 D: Full Replacement M: Partial Replacement</td>
<td>D: Partial Replacement M: Replace In-Kind</td>
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<td>D: Full Replacement M: Leave In-Place</td>
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<td>Interstate (PM)</td>
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</tr>
<tr>
<td>Non-Interstate (4R)</td>
<td>Non NCHRP-350 Full Replacement</td>
<td>Full Replacement</td>
<td>Full Replacement</td>
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</tr>
<tr>
<td>Non-Interstate (3R) Spot Improvement (6)</td>
<td>Non NCHRP-350 Full Replacement</td>
<td>D: Full Replacement M: Partial Replacement</td>
<td>D: Full Replacement M: Leave In-Place</td>
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<tr>
<td>Non-Interstate (3R) Corridor Project Resurfacing (Minor or Major Structural) and PM with Grade Raise</td>
<td>Non NCHRP-350 Full Replacement</td>
<td>D: Full Replacement M: Partial Replacement</td>
<td>D: Full Replacement M: Leave In-Place</td>
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</tr>
<tr>
<td>Non-Interstate (PM) Corridor Project Resurfacing without Grade Raise</td>
<td>Non NCHRP-350 Full Replacement</td>
<td>Non-Interstate (3R) Spot Improvement</td>
<td>Leave In-Place</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NCHRP-350</td>
<td>Non-Interstate (3R) Spot Improvement</td>
<td>Leave In-Place</td>
<td></td>
</tr>
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</table>

D: Desirable M: Minimum
Guardrail, When to Consider Upgrade

(1) Removal of existing guardrail includes but is not limited to, construction access, maintenance of traffic, widening, structure removal, end treatment removal, or removal for placement of a MGS w-beam guardrail, MGS height transition, or MGS transition.

(2) Percent removed is calculated for each side of the road and includes the end treatment, longitudinal run of guardrail, guardrail transition, bridge railing transition, and bridge railing.

(3) Guardrail replacement or reset should be consistent throughout the project, regardless of percent removal on individual guardrail runs.

(4) Where final height of remaining guardrail is less than 27 in., full replacement or adjusting guardrail height is required. Adjusting guardrail height may only be considered where the existing posts have been pre-drilled and the pre-drilled hole does not raise the top rail height more than 4 inches.

(5) W-beam with steel blockout. Where final height of guardrail is less than 27 in., full replacement or adjusting guardrail height is required. Adjusting guardrail height may only be considered where the existing posts have been pre-drilled and the pre-drilled hole does not raise the top rail height more than 4 inches. Aluminum guardrail. Where the existing guardrail is aluminum full replacement is required.

(6) Spot Improvement projects are identified in the Engineering Assessment Manual section 3-2.0

(7) Bridge Replacement or Rehabilitation Projects (not kinned with a corridor project) Where the guardrail is needed to shield the bridge or bridge embankment, the full length of guardrail needed for the embankment should replaced. (put in a picture)

(8) Bridge Replacement or Rehabilitation Projects (not kinned with a corridor project) Where the guardrail is needed to shield the bridge or bridge embankment, refer to note 4. (put in pictures)
Guardrail, When to Consider Upgrade, Example

Minor Structural Overlay, no grade raise, existing guardrail is NCHRP-350 w-beam guardrail with top rail height of 27", and the existing guardrail is in place due to the location of a bridge. We also know that the bridge will be rehabbed or replaced in the next 5 years.
(4) Where final height of remaining guardrail is less than 27 in., full replacement or adjusting guardrail height is required. Adjusting guardrail height may only be considered where the existing posts have been pre-drilled and the pre-drilled hole does not raise the top rail height more than 4 inches.
When to Upgrade Guardrail

Other Items to review when considering guardrail upgrade include:

- **Crash history.** Frequent crash locations may benefit (in safety and maintenance) from upgrading.

- **Traffic Counts.** High traffic volumes are typically associated with higher risk.

- **Time frame of future work.** If your project is a short term bandage and the entire roadway is being reconstructed 5 years from now, the second project is likely the better opportunity for upgrading. If the guardrail only serves to protect the bridge ends, then the concrete overlay project (even though PM) may be the right opportunity to upgrade.
Guardrail guidelines for bridge rehabilitation:

- Where the guardrail is for the bridge, upgrading the guardrail is:
  - **Required** for Non-NCHRP-350 tested guardrail.
  - **Recommended** for NCHRP-350 tested guardrail but partial upgrade to MASH (Placement of a MGS Transition) may be considered if the existing guardrail top rail height is between 27 and 30 inches or the existing posts already have pre-drilled holes to allow the top rail to be raised to between the height of 27 and 29 inches. In addition, the top rail height raise may not exceed 4 inches.
Where the guardrail is for the bridge??? What does that mean?

Guardrail is for the bridge if the length of need was calculated for:
- an embankment that is required to complete the crossing of the obstruction, i.e. road, railroad, stream, or

**Bridge Crossing Requiring an Embankment**
Bridge Rehabilitation Projects and Guardrail

Guardrail is for the bridge if the length of need was calculated for:

• a hazard associated with the bridge or crossing

Guardrail LON appears to be calculated for a hazard associated with the bridge or crossing.
Guardrail is for the bridge if the length of need was calculated for:

- a hazard associated with the bridge or crossing, or

Guardrail LON is not calculated from a hazard associated with the bridge or crossing, it extends because of the stream paralleling the roadway. This may be a case where partial replacement would be considered.
Existing posts already have pre-drilled holes to allow the top rail to be raised to between the height of 27 and 29 inches. In addition, the top rail height raise may not exceed 4 inches. What does that mean?

The center-to-center dimension of the pre-drilled hole from the current bolt placement should not exceed 4”. In this case the railing could not be reset because the center-to-center dimension is approximately 5.5” >4”.

W-beam Guardrail should never be reset to 31”
Cable Barrier Placement – Additional Guidance

Recently INDOT has recognized that some additional guidance may be needed for Cable Barrier placement.

• Where to place cable barriers in horizontal curves?
• Where is it acceptable to place cable barrier with a shoulder wider than 4 ft?
• What are the desirable slopes of a median with cable barrier?
• What is the desirable distance between the cable barrier posts and the median ditch?
• Where a roadway profile grade raise adjacent a cable barrier is required, how should the existing cable barrier and the median be addressed?
Where to place cable barriers in horizontal curves?

- Cable barrier should be placed on the inside of a horizontal curve, see picture below and IDM 49-5.01(04) item #4a.
- Layout suggestion, place the cable barrier in the horizontal curves first and then fill in the gaps along the rest of the corridor.
- Changes from one side of the median to the other should be in tangent sections see RDP E627-R-546d for more details given specific break points or cable barrier median locations.
Where is it acceptable to place cable barrier with a shoulder wider than 4 ft?

Where a paved shoulder is greater than 4 ft, the 12 ft minimum distance between the edge of paved shoulder and the cable barrier can be reduced, so long as the cable barrier offset from the edge of travel way is not less than 16 ft. A minimum of 8 ft from the bottom of ditch should be attained. See RDP E627-R-546d sheet 1 (see below).
What are the desirable slopes of a median with cable barrier?

Where possible the slopes below would be preferred, whoever not every location will allow for a desirable condition.
What is the desirable distance between the cable barrier posts and the median ditch?

The cable barrier should desirably not be placed any closer than 8 ft of the bottom of the ditch. Where possible, avoid placing the cable barrier within 1 ft of the center line of the v-ditch or edge of a flat bottom ditch to avoid frost heave. See RDP E627-R-546d sheet 1 (see below).
Cable Barrier Placement – Additional Guidance

Where a roadway profile grade adjacent a cable barrier is required, how should the existing cable barrier and the median be addressed?

The slopes and cable barrier heights should be adjusted at a minimum per RSP E627-R-546d and manufactures recommendations.

Basically, some adjustment (median grading or cable barrier reset) may need to be completed on the cable barrier to allow it to continue to preform as tested.
Impact Attenuator Considering Reset

Contact District Maintenance to see if the impact attenuator is still supported by the manufacture, is in good condition, and is at least NCHRP-350 tested.

- If the existing impact attenuator is still supported by the manufacture, is in good condition, and is at least NCHRP-350 tested, the impact attenuator may be reset.
- If the existing impact attenuator is not supported by the manufacture or is not NCHRP-350 tested the impact attenuator should be upgraded to MASH.
Impact Attenuator Placement Permanent and Temp.

Make sure the wall you are attaching the impact attenuator to, bridge railing, concrete barrier, temporary barrier, be sure at least the last 3 ft of the wall (10 ft in the case of a temporary barrier wall segment) is parallel to the impact attenuator.
Double-Face MGS Transition in Medians

MGS Transitions may be doubled faced for median applications.

- The 12 inch blockout should be used on both sides of the post
- The same railing will be placed on both sides.
- The median barrier or pier should be tapered to a 30 inch width and 33 inch height.
- An anchor bolt may be used instead of a through bolt.
  - 7/8 inch diameter high strength threaded rod with washer and not galvanized.
  - 6 inch embedment
  - Maximum bolt length allowed past the nut shall be ¼ inch.
  - Minimum epoxy strength 1400 psi.
- A restrictive USP will be needed and a supplemental description "Double-Face" added to the MGS Transition Pay Item.
Double-Face MGS Transition in Medians

The median barrier or pier should be tapered to a 30 inch width and 33 inch height.
An anchor bolt may be used instead of a through bolt.

NOTES:
1. See Standard Drawings E 766-TTRC-02 through 03 for concrete bridge railing transition type TTC. See Standard Drawings E 200-TTRC-02 through 03 for concrete bridge railing transition type TTF. See Standard Drawings E 601-TTRC-01 through 05 for guardrail transition type TGS.
2. Preferred holes, for connection of the guardrail transition type TGS to the end of the concrete bridge railing transition type TTC or TTF.
3. The anchor bolt shall be 3/8 in. dia., high strength threaded rod, with nut, galvanized. The length of the anchor bolt shall allow for a minimum embedment of 6 in. and a maximum extension of 4 in., beyond the nut. The minimum epoxy bond strength shall be 1400 psi.
Double-Face MGS Transition in Medians

Double-Face MGS Transition at bridge pier consider extending the crash wall out from under the bridge deck so the connection of the MGS transition is not in conflict with the bridge deck. The post driver normally cannot be placed under a bridge deck and post holes have to be hand dug to place a post under the bridge deck.

Post holes would have to be hand dug, the post driver would hit the pier or the bottom of the deck.
Single or Double-Face MGS Transition at bridge pier, consider extending a crash wall out from under the bridge deck so the connection of the MGS transition is not in conflict with the bridge deck.
Takeaways for this Meeting

• When placing roadside safety hardware, place to standard where possible.

• Where a standard roadside safety hardware system cannot be placed given site specific restrictions, contact INDOT Standards and Policy, Email: designmanualinquiries@indot.in.gov

• When modifying the roadway adjacent roadside safety hardware review the effects to the roadside safety hardware
  • What is the final height of the roadside safety hardware?
  • What is the final grading to the face of the roadside safety hardware?
Questions

Katherine Smutzer, ksmutzer@indot.in.gov for this presentation

designmanualinquiries@indot.in.gov for all other guardrail questions