

# Midwest States Pooled Fund Program Consulting Quarterly Summary

## Midwest Roadside Safety Facility

01-01-2010 to 04-01-2010

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### Pipe Runners (Safety End Treatment) For Skewed Culverts

#### Question

Date: 11-20-2009

I am looking for guidance on the use of pipe runners at skewed culverts. The current IL Tollway standards show pipe runners perpendicular to the roadway when the pipe is perpendicular to the roadway. Based on a departure angle of 25 degrees, a vehicle leaving the road would hit the pipe runners 25 degrees from perpendicular. For our skewed pipes and headwalls, the pipe runners are shown parallel to the pipe. Therefore for a culvert that is on a 30 degree skew (right hand forward) with pipe runners parallel to the pipe, that same vehicle departing at 25 degrees would now hit the pipe runners 55 degrees from perpendicular. This seems like too much of an angle. I was under the impression that the pipe runners should ideally be perpendicular to the path of the departing vehicle. Is there guidance for usage of pipe runners on skewed pipes?

Attachment: <https://mwrsf-qa.unl.edu/attachments/f32140286d96602cef8061b70d212f0f.pdf>

Attachment: <https://mwrsf-qa.unl.edu/attachments/8181b63c3a368b10ed861678616fe527.PDF>

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#### Response

Date: 01-04-2010

I have discussed your prior emails on the noted subject with my colleagues. Following this discussion, I must report that we are unaware of any design guidance for placing the culvert grates or pipe runners at angles other than at 90 degrees with respect to the traveled way when used with transverse drainage structures.

In recent years, MwRSF successfully performed full-scale crash testing on a culvert safety grate system that was used to protect a large culvert opening on a 3:1 fill slope according to the Test Level 3 (TL-3) safety performance criteria found in NCHRP Report No. 350. This testing involved both small car sedan and full-size pickup truck vehicles leaving the roadway and slope break point at 20 and 25 degrees, respectively, and at a target departure speed of 100 kph. For this test installation, the center-to-center pipe spacing was 30 in. From this testing, MwRSF researchers observed that the test vehicles could safely traverse the culvert grate system at high speeds and when the approach path was not orthogonal to the pipe runners.

Under oblique angles with respect to the pipes, the clear opening distance between pipes is increased from that found when the vehicle path is perpendicular to the pipes. As the approach angle is further increased, there exists a point when the vehicle could no longer traverse the pipes but instead would snag within the pipe system or contact the concrete culvert edge. For vehicles launched off of a fill slope and subsequently landing on the grate system, there would be increased safety risks as the effective clear opening width were increased, such as for higher approach angles or under situations where the pipes were skewed away from traffic.

In your email, you noted that there are situations where the culvert system is skewed with respect to the roadway, thus causing the pipe runners to be installed in the same skewed orientation on the fill slope. As noted above, skewed pipes could increase the potential for vehicles to drop between the pipe runners, thus resulting in front end or wheel snag on the pipes or at the culvert edges. As mentioned previously, we are not aware of any research nor guidance pertaining to the placement of skewed pipe runners. In the absence of testing and/or computer simulation modeling, we offer the following opinions and recommendations based on our best engineering judgment and available information.

1. In general, the culvert grate system was designed with the pipe runners to be installed perpendicular to the roadway. As such, the grate system or pipes should be installed orthogonal to the roadway when placed in combination with skewed culvert systems.
  2. When reverse direction impacts cannot occur, pipes may be skewed when the bottom end of the pipes are located upstream from the top end of the pipes.
  3. If it is absolutely necessary to skew the bottom end of the pipe runners downstream from the top end of the pipes, then it is our opinion that skew angles ranging between 0 and 10 degrees can be safely accommodated. In addition, there exists the potential that skew angles between 10 and 20 degrees may possibly be accommodated, although the safety risks are believed to be greatly increased.
  4. If skewed pipe runners are deemed necessary, it may be possible to utilize a narrower pipe spacing in order to decrease the clear opening width, thus reducing the potential for vehicle snag and instabilities. However, a reduced pipe spacing may also lead to an increased potential for debris to clog the drainage system.
  5. Further research and testing is necessary to accurately determine the safety performance of culvert safety grates when installed with skewed pipe runners.
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# Longer Posts for Guardrail Adjacent to Steep Slopes

## Question

State: IL

Date: 12-29-2009

We have information about how to build line posts for MGS when the steep slope begins at the back of post. However, a designer in one of our Districts is dealing with a location where the slope continues in a similar manner all the way to a bridge. Are there any recommendations about adding to the length of posts for the transition from MGS to a bridge parapet?

Our particular transition to the parapet, given adequate support behind the posts is given in our Standard 630001.

<http://www.dot.il.gov/desenv/hwystds/rev211/Web%20PDFs/>

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## Response

Date: 01-04-2010

At this time, we do not have any available design information for modifying the length of the transition posts when located on a steep slope near the bridge end. However, MwRSF does have a research project with the Wisconsin DOT to provide recommendations for addressing various transition issues. One of the noted issues will be to provide design guidance for situations when steep slopes are found behind the posts. It is expected that this effort will be initiated within 2 months.

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# Minnesota DOT T-1 Railing

## Question

State: MN

Date: 01-05-2010

For your info I've attached a copy of our proposed railing standard that we discussed on the phone (with the slotted holes in the base plate). The areas in green indicate the proposed changes.

Attachment: <https://mwrsf-qa.unl.edu/attachments/8883a9fe9acba41b92e78ac51d75646c.pdf>

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## Response

Date: 01-08-2010

The crash tested, combination tube bridge rail with concrete parapet and brush curb utilized a ¾-in. thick post base plate for anchoring the tubular post and rail system. The base plate was anchored to the concrete parapet with four 7/8-in. diameter, A193 B7 threaded rods which were provided as an equivalent option to the ASTM A325 anchor bolts (or SAE Grade 5 threaded rods). One inch diameter holes were used in the anchor plates.

Recently, the MnDOT inquired about replacing the existing 1-in. diameter holes with 2" long by 1-3/16" slotted openings in the longitudinal rail direction. This modification was desired in order to allow for improved constructability and attachment of the upper steel railing system to the parapet after the anchor bolts have been installed.

Based on the safety performance observed for the bridge railing using the TL-4 guidelines found in NCHRP Report No. 350, it would seem reasonable to modify the holes in the anchor plate to use a 2" by 1-3/16" slotted holes. However, it would be recommended that ¼-in. or 5/16-in. thick plate washers made from a structural grade material be used with the 7-8-in. diameter, high-strength anchor rods in combination with the slotted holes. When increasing the hole size, it is also recommended that consideration be given to providing the appropriate end/edge distances

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# MGS Transition to WYDOT Steel Tube Bridge Rail

## Question

State: WY

Date: 01-06-2010

I am working up the bridge rail transition for the MGS Guardrail System. In previous discussions, I recall that you said we could use a transition that was already approved by FHWA, however we would need to incorporate the "transition to the transition".

As you may recall, John Rohde worked with us to obtain approval from FHWA for adapting the Alaska Thrie Beam Transition to connect with WYDOT's TL-3 and TL-4 twin steel tube bridge rails. I have attached a mirror image of the Alaska design along with details for option "K" of the simplified transition recently tested by MwRSF.

I have a few questions to help me understand how to proceed:

1. Do we substitute only the last 12'-6" of the Alaska Design into the last 12'-6" of the MwRSF tested option?
2. For the MwRSF tested transition, the next section upstream of the double nested 12'-6" segment is a 6'-3" single thrie beam section. The post spacing drops to a quarter post spacing ( $18 \frac{3}{4}$ "") as it approaches the double nested 12'-3" section, so do we need to add one additional post into the Alaska design between posts A6 and A7 so there is a consistency in the progressive stiffness of the system?
3. In the car crash test, I noted significant snagging of the vehicle as it impacted in the area of the asymmetric w-beam to thrie beam section, although the test was a pass. Would it be prudent to add one additional half post spacing between posts M11 and M12? This would essentially be option "L" I believe. Although the Pooled Fund voted to test option "K" since it would require one less post, I remember you guys were much more confident of option "L" passing.
4. What do we need to do to gain FHWA approval for this transition?
5. Please let me know your thoughts concerning any other issues you feel relevant to this discussion.

Attachment: <https://mwrsf-qa.unl.edu/attachments/328bf3a1955c0f8eacfd4e470d50fee4.pdf>

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## Response

Date: 01-06-2010

I have previously drawn up the attachment of the newer MGS approach transition to an Iowa bridge rail transition that is very near the transition you sent to MwRSF with questions. Please see the attached PDF for these drawings.

The top design is of the Iowa transition, very similar to the one you submitted

The bottom design is the tested MGS approach transition " Design K.

The middle design is the Iowa transition with the approach (upstream) transition considerations.

Hopefully the middle design answers your questions about how to attach the approach (upstream) transition to your existing transition. If you need anything else, please let me know.

FYI " this adaptation will be included with another 4 transition adaptations in the project report to show how to attach the upstream transition to existing systems. Report coming soon.

Attachment: <https://mwrsf-qa.unl.edu/attachments/fba1a635af50e84e84007d499e632efe.pdf>

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# MGS with 1/4-Post Spacing to Shield Hazard and Placement Guidelines

## Question

Date: 12-18-2009

I have another MGS question for you. We have a situation where a sign truss foundation is located 13" from the back of guardrail posts. MGS with standard post spacing was installed which would deflect into the concrete foundation. The minimum deflection distance we are using for the 1/4-post spacing installation is 14" measured from the back of post to the near edge of the hazard. The designer is proposing to add posts and to stiffen the rail by doubling up on the rail element thereby further reducing the deflection.

Do you have any comments/objections to this approach seeing that we only need to reduce the deflection by 1"? Do you have any data on the anticipated deflection distance for this proposed installation?

See attached drawing of the proposed modifications. Note that the rail is gradually stiffened by using 1/2-post spacing and then the 1/4-post spacing. On the departure end of the 1/4-post spacing is 1/2-post spacing needed before getting back to standard spacing?

Attachment: <https://mwrsf-qa.unl.edu/attachments/c219f254ce2b506a64550883959343a0.pdf>

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## Response

Date: 01-06-2010

I have attached a pdf copy of our prior TRB journal paper for the Midwest Guardrail System (MGS). Within the paper, guardrail placement guidelines are provided for treating hazards. These guidelines pertain to the distance between the front face of the rail to the front face of the hazard. As noted, the minimum recommended distances are 1.25, 1.12, and 0.90 m (49, 44, and 35 in.) for the standard, half-, and quarter-post spacing designs, respectively. It should be noted that the width of the steel-post MGS is 0.54 m (21.25 in.). Using this information, one would need to consider using a clear distance of approximately 0.35 m (13<sup>3</sup>/<sub>4</sub> in.) between the back of the steel posts and the front face of the vertical hazard when utilizing the quarter-post spacing system.

Below, you noted that the available clear distance between the back of the steel posts and the front face of the rigid, vertical concrete foundation is 0.33 m (13 in.). Based on the guidelines noted above, your noted solution to use the MGS quarter-post spacing design and noted placement would result in 20 mm (<sup>3</sup>/<sub>4</sub> in.) less clear distance than that recommended in the paper (as noted above). However, I do not have significant concerns with using the basic <sup>1</sup>/<sub>4</sub>-post spacing MGS configuration to shield the noted hazard nor deem it necessary to use nested W-beam rail to cover the 20 mm (<sup>3</sup>/<sub>4</sub> in.) deficit in provided clear distance.

Finally, the use of the <sup>1</sup>/<sub>2</sub>-post spacing in advance of the <sup>1</sup>/<sub>4</sub>-post spacing MGS seems reasonable and an appropriate transition in stiffness. In addition, I see no reason to utilize a <sup>1</sup>/<sub>2</sub>-post spacing MGS on the departure end if reverse-direction impacts cannot occur.

Attachment: <https://mwrsf-qa.unl.edu/attachments/3db3e4edc03cdf94152d1084e7415673.pdf>

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# TL-2 MGS Curb Placement

## Question

State: WI

Date: 01-12-2010

I would like to know what placement range MwRSF is recommending for MGS behind 6" curb. Is it going to be:  
0-6 for TL2  
6+ for TL2

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## Response

Date: 01-12-2010

We are in the process of documenting the recent test and making recommendations. But our current thinking is that the 37-in. rail height relative to the roadway is valid for TL-2 between 4 and 12 feet behind the curb.

We have no evidence to make any other statements about TL-2. For example, there is no point where the rail makes the change from 31" to 37" because we do not know the valid range for the 31" rail height relative to the roadway.

There are currently no plans, or budget, to determine any other valid scenarios for MGS placement relative to a curb. It is believed that any such determination would require additional full-scale testing.

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# MnDOT Combination Bridge Railing - Alternative Anchors

## Question

State: MN

Date: 01-20-2010

MnDOT inquired regarding alternative anchorage hardware for the MnDOT combination bridge railing.

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## Response

Date: 01-20-2010

Previously, you had inquired into the allowance for alternative anchorage hardware within the bridge railing system noted above. According to the MwRSF test report (No. TRP-03-53-96), four anchor rods were used to attach the upper tubular steel rail, tubular steel posts, and welded base plate to the top of the reinforced concrete parapet. As noted, these anchor rods were modified from ASTM A307 grade material to ASTM A325 grade material. The report also noted that ASTM A193 Grade B7 material was used due to the unavailability of A325 hardware for testing. Therefore, the final crash-tested system utilized 7/8-in. diameter anchor rods configured with ASTM A193 Grade 7 alloy material with the expectation that either A325 or A193 B7 material could be used in the future.

A comparison of structural properties for 7/8-in. diameter fasteners using A193 B7 and A325 material is noted below, along with information for ASTM A449 material.

	Min. Yield (ksi)	Min. Tensile (ksi)	Min. elongation (%)
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ASTM A193 B7	105	125	16
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ASTM A325	92	120	14
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ASTM A449	92	120	14
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As shown above, the structural strength for ASTM A193 B7 material is only slightly greater than that provided by ASTM A325 material. As such, it would seem reasonable that steel anchor rods or bolts meeting the ASTM A325, A449, or SAE Grade 5 material specifications would also adequately retain the rails, posts, and plates to the concrete parapet.

Based on the successful crash testing program, the MnDOT combination bridge railing system was found to provide acceptable crash performance according to the NCHRP Report No. 350 Test Level 4 guidelines. Since higher strength anchors were utilized within the concrete parapet for attaching the metal railing, it would not be appropriate to utilize ASTM A307 anchors in lieu of the higher strength anchors unless deemed acceptable through the use of full-scale vehicle crash testing.

Although the testing program was successful, there was insufficient data collected in order to determine or estimate the actual impact loads imparted to the entire bridge railing system. As such, it is not possible to determine what peak lateral load was actually distributed to the upper metal railing system, including the individual posts, plates, and vertical anchors. Thus, it is difficult to now substitute the use of epoxied, high-strength (HS) anchors for the cast-in-place, high-strength anchors which were used in combination with an embedded steel anchor plate.

If epoxied, HS anchors are desired, it would seem appropriate to construct a short segment of the RC parapet with the alternative vertical anchor systems spaced 6 ft or more apart along the wall. With the posts attached to the parapet, dynamic component testing could be performed at each post location in order to determine the peak load capacity of the various anchored posts when impacted at the upper rail height. If the alternative anchor options are found to provide equivalent or greater load capacity through dynamic component testing, then it would seem reasonable to allow their use within the bridge railing system.

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# Type 10M barrier Design Question

## Question

Date: 01-21-2010

I have the following questions for your consideration and reply related to recent DOT inquiry on *design of Post and Tube Bridge Rail* (see attached typical section). I have also included in attached Figure 1.jpg an excerpt from 2004

AASHTO LRFD Bridge Specifications Section 13, Table A13.2-1: