Midwest States Pooled Fund Program Consulting Quarterly Summary

Midwest Roadside Safety Facility

07-01-2007 to 10-01-2007

Temporary Barrier Tie-Downs

Question
State: IA
Date: 06-25-2007

My first, broad question is this: Do we have any recommended method for tying down temporary barrier to a concrete pavement/bridge deck that has been overlaid with asphalt? I've read some reports where tying down through an asphalt overlay is not recommended. But I haven't come across any reports that say such practice is allowed.

As a follow-up, do you believe that the asphalt pin tie-down could be used on a concrete pavement that has been overlaid with asphalt, if the pavement was first drilled (say with a 1.625" bit) down to the subbase to allow for pin penetration?

Finally, is it possible to constrain the barrier through the vertical bolt holes with drop-in anchors or screw-in anchors?

Response
Date: 07-02-2007

I have some short answers for your questions.

1. We have not tested any systems for tying down temporary barrier to a concrete pavement/bridge deck that has been overlaid with asphalt. The strap tie-down and the bolted tie-down will not work in this situation due to bending loads on the anchor bolts.
2. We do believe that the asphalt pin tie-down could be used with concrete pavement with an asphalt overlay. This would be stiffer that what we originally tested, but we think it is the best option at this time. The pins should not fracture, but would tend to bend and pull up. We do believe that they will constrain the barriers. Kansas DOT has asked about this previously and we have allowed it.
3. We do not believe that you can constrain the barrier through the vertical holes with drop-in anchors or screw-in anchors. Use of these types of anchors would results in the anchor having approximately 4" exposed inside the vertical hole. This would limit the anchorage depth for the screw-in anchors and would create large bending loads in both types of anchors that will cause them to fail and thus result in a loss of anchorage. The drop-in anchors or screw-in anchors also do not have the capacity of the larger threaded rods used in the bolt through design.

Response
Date: 07-11-2007

Do you have any recommendations on what size of drill bit should be used to pre-drill the concrete for the asphalt pin?

As a follow-up to my previous question " would it be feasible to use the asphalt pin tie-down directly on top of full-depth PCC pavement (no asphalt overlay)?

Response

Date: 07-24-2007

With regards to you first question about the size of the dill bit used for the asphalt pin, I would recommend that it be only 1/16" to 1/8" larger than the pin diameter. This would be a maximum bit size of 1.625". The hole in the pavement needs to be kept as small as possible to make the pin engage as soon as possible during the impact. For installation, it may be easier to set the barriers down and then drill through the existing holes in the barrier as guides to make sure the pins will fit.

Your second question asked if it would be feasible to use the asphalt pin tie-down directly on top of full-depth PCC pavement. We think that this might be acceptable if it was just being used on a roadside installation, but we would rather see you use the bolted tie-down option we developed for concrete. This option has been tested and we know how it will perform. We think that the asphalt pins may work as well, but they will not provide as effective restraint as the bolted tie-down. We would definitely recommend using on the bolted tie-down on a bridge installation.

Transition Replacement Posts

Question

State: SD
Date: 07-02-2007

We would like to use the Wyoming transition to two-tube bridge rail design, but we would like to use wood posts instead of the used 6'-6" W6x9 steel posts used in the design. Is there an acceptable wood post substitute that can be safely used in this transition.

Response

Date: 07-02-2007

I have some answers for your transition post replacement question. You noted that theWyoming transition to 2 tube bridge rail used 6'-6" W6x9 steel posts and you wanted to know what the equivalent wood post would be. The steel posts in question were 6'-6" long with an embedment of 49". It should be noted that the embedment is a little higher than expected due to the use of different blockouts to reduce snag.

TheWyoming transition to 2 tube bridge rail is based off of our previousIowa transition design. This design was made with both steel and wood post options. Thus, we believe that you can substitute 6"x8" wood posts in the design safely. The wood post used in theIowa design that you should substitute into theWyoming design is a 6"x8"x7' long wood post. We believe that this should work.

W-Thrie Transition Question

Question

Date: 08-21-2007

I'm just looking at the "W-beam to Stiff Bridge Transition (MWT-5)" and need confirmation if this is the detail we would apply for a transition to a safety shape or vertical concrete bridge rail, which I assume has also been successfully crash tested. If correct I'm assuming we would show the thrie beam terminal connector (RTE01b) being bolted to the nested 12 ga thrie beams at post 19 (which would actually be the concrete bridge rail similar to STB05).

If similar to STB05, I'm assuming we would also delete post 18. If not correct, I'm assuming we may need to use additional posts at 475mm centres similar to STB06.

One other question with the MWT-5 detail is the use of a half length of 12 ga thrie beam between posts 15 and 13, which also has the thicker asymmetric 10 ga thrie beam on one side and the nested 12 ga thrie beams on the other. This seems a little odd to use a thinner piece of steel (instead of a half length of 10 ga thrie beam) at this location when the intent is to stiffen the system as you approach the bridge rail. I have to ask this question as I'm sure I'll be asked this question by our installers once installations start. My preference would be to specify a half length of 10 ga thrie beam at this location, however if the 12 ga is what is recommended and crash tested, and there is uncertainty about 10 ga, we will specify the 12 ga.

Response

Date: 10-16-2007

We have no problem with you attaching the transition system to a concrete bridge rail as long as the bridge rail is 350 approved, is very stiff and rigid, and has the appropriate flare backs and/or tapers as have been 350 approved previously for approach guardrail transitions. Yes, you would want to attach the thrie beam terminal connector to the nested 12-gauge thrie beam at post 19. There would be no need to remove post 18. We have tested a few approach guardrail transitions to concrete barriers that have been 350 approved if you would like that information. One note...STB05 and STB06 are only 230 approved

At this time, we do not feel that we can recommend 10-gauge thrie beam in place of the 6-ft 3-in. long, single (non-nested) 12-gauge The new approach guardrail transition system has been configured with an additional 6-ft 3-in. long, single (non-nested) 12-gauge thrie beam rail, followed by the new asymmetrical, 10-gauge W-beam to thrie beam transition section. It is our current opinion that all of the prior nested thrie beam transition systems should be modified to include the additional 6-ft 3-in. thrie beam section as well as the asymmetrical transition section. In addition, the existing approach guardrail transition systems will require a longer transition length for which the support posts are installed and using a reduced post spacing. As part of another change, W6x12 steel posts were implemented in order to provide a more gradual change in lateral stiffness of the overall guardrail system

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Existing Guardrail on Slope

Question

State: IL
Date: 08-21-2007

In this contract, we are widening the Tri-state Tollway embankments for the fourth lane to be constructed in 2008 (Southbound) and 2009 (Northbound). The work included topsoil removal, embankment and retaining wall construction. No work was performed on the existing pavement or shoulder. The intent of this first contract was to leave the existing guardrail in place. In 2008 or 2009, the guardrail would be removed and replaced with new.

During construction,the contractor designed mechanically stabilized retaining walls required longer tie-backs than assumed in design. This required additional excavation that extended to the guardrail/back of shoulder and resulted in a need to support the guardrail when the shoulder is reopened to traffic at the end of this contract.

A solution was suggested to drive a new post behind the existing to provide necessary support. Will this work? If not do you have any other options to consider.

They have removed the embankment from around/behind the guardrail posts to a depth of about 2' below the original grade. The existing guardrail is our former strong post system with 6'-9" long posts, and a top of rail height of 27.5", using 6" blockouts.

Does their suggestion to drive additional posts to back up the existing appear feasible? What would we need to determine an appropriate post length and size?

It does not seem likely to me that the back up posts would work. It appears that a vehicle deflecting the rail over the 2' vertical drop might roll or snag on the posts. My suggestion was that they re-establish some fill around and behind the posts. Another thought might be to add a rub rail below the w-beam.

Any comments or other ideas would be welcomed.

Response

Date: 08-27-2007

It is my understanding that your current situation involves the placement of guardrail posts at the slope breakpoint. However, it is unclear to me in the drawing as to whether the side slope is a 2:1 or flatter. If the roadside embankment is 2:1 or flatter, MwRSF has developed two different TL-3 guardrail systems for this situation. The first system was developed several years ago and utilized metric height (27 ¾-in.), strong-post W-beam guardrail with 8-in. blocks and 7-ft long steel posts spaced 37 ½-in. on center (half-post spacing). The second system was recently developed using the MGS technologies. For this MGS W-beam guardrail, a 31-in. mounting height was used with 9-ft long steel posts, 12-deep blockouts, and a standard post spacing (6 ft " 3 in.).

As an alternative, it would be acceptable to re-establish the 2 ft of compacted roadside fill behind the posts in order to allow for the installation of standard, strong-post W-beam guardrail systems. However, it would seem to me to be much more costly to redo the earthwork than to place one of the two recommended guardrail systems described above.

Finally, I am not in favor of utilizing the second backup post behind another one as we would not know how this combination would perform under full-scale testing.

P.S. " If your other guardrail system is already in place, it may be possible to drive intermediate posts measuring 7-ft long in order top account for the half-post spacing posts. Then, the rail would likely need to be raised to the metric rail height of 27 ¾ in. along with the replacement of 6-in. blocks with 8-in. blocks. With this system, the only non-standard part would be every other post would be 3-in.

shallower than designed using system no. 1 noted above. I will see whether Bob or Dean have anything to add to this comment or if they disagree with this last possible alternative.

Multiple Questions

Question

State: IA
Date: 08-23-2007

I've been saving up some of my questions for you and I figure now I've got enough to shoot you an email. But before I get into the real nuts-and-bolts questions, I was wondering if you have any knowledge regarding an email list the pooled fund states requested at the last meeting. We requested that MwRSF send out some sort of an "update" email periodically to all the states in order to share questions that had been asked and answers you had provided. Do you remember this? If so, do you know what the status is?

Okay, on to the "real" stuff:

1. We've had several questions/issues come up recently regarding bridge end sections:

    a. The amount of reinforcing required in our "standard" end section is believed to be contributing to voids in the concrete (this is only speculation). Would it be feasible to reduce the amount of steel without affecting the crashworthiness of the guardrail connection? If so, what is the minimum strength requirement for the end section?

    b. How much variability are we allowed when it comes to the shape of an end section? Specifically " how much can we vary the overall length of the end section and the angle of the leading chamfer? Looking at other states' standards, there appears to be quite a variety of shapes used. Am I to assume they have all been crash tested?

    c. Due to the proximity of our first guardrail post to the leading edge of our end sections, some contractors have complained that they cannot drive that post and must instead excavate and backfill by hand. Is it possible to increase that gap distance or must it stay constant?

    d. I have seen other states lengthen or shorten the "overlap" of the guardrail connection at the bridge end based on some conditions. Do you know what this is accomplishing? What are your thoughts on this practice?

2. Are you aware of any research regarding what effect, if any, low temperatures would have on the crashworthiness of steel bridge rails?

3. On some of our construction jobs I have seen where a contractor has overlapped freestanding Temporary Barrier Rail directly in front of a permanent concrete barrier or bridge rail as a means of terminating the TBR. Typically this has been accomplished with only one or two sections of TBR resting in front of the permanent barrier. Would you consider this an approved practice? If not, would there be a minimum number of TBR sections that would need to be overlapped in front of the permanent barrier in order for it to function properly?

4. Finally, do you have a method for attaching the MGS directly to a paved sidewalk or through the top of an intake? If not, are we able to develop our own based on a current design with standard guardrail?

Hopefully this is not too much for you to digest all at once. If so, please tell me and I will send any future

questions individually. Of course, if you need copies of any of our current standards referenced above, just let me know. I appreciate your help.

Response

Date: 08-27-2007

With regard to your first question, I am not aware of the email list being prepared by Amy or Jodi and for dealing with State DOT questions. For some reasons, I do not recall this discussion. However, the discussion that I do recall involved setting up a email group for addressing correspondence on the "Implementation of the MGS" project using consulting funds. I have yet to obtain an email list for this effort from Amy/Jodi but will remind them that we asked for this at the spring meeting. Maybe my mind is going out and I cannot remember the other issue that you raised. However, that same list could be used for these State DOT questions as well.

Now, I will attempt to address your real issues. As such, my responses will be contained below and following the individual questions.

1. We've had several questions/issues come up recently regarding bridge end sections:

    a. The amount of reinforcing required in our "standard" end section is believed to be contributing to voids in the concrete (this is only speculation). Would it be feasible to reduce the amount of steel without affecting the crashworthiness of the guardrail connection? If so, what is the minimum strength requirement for the end section?

    ** TL-3/TL-4 bridge end sections have traditionally been designed to withstand lateral impact loads of approximately 100 to 120 kips and longitudinal impact loads of approximately 90 to 110 kips. From your question, it appears as though the IA DOT would like to reduce the number of vertical bars near the end sections, although I am making this assumption. This can be completed as long as the the structural capacity remains the same use different combinations of bar sizes and/or more or larger longitudinal bars. A yield-line analysis at the end of the barrier would need to be performed to replicate your capacity of the crash worthy design. We likely cannot reduce its strength and obtain approval of the design without testing unless it provides equivalent or greater capacity.

    b. How much variability are we allowed when it comes to the shape of an end section? Specifically " how much can we vary the overall length of the end section and the angle of the leading chamfer? Looking at other states' standards, there appears to be quite a variety of shapes used. Am I to assume they have all been crash tested?

    ** When making changes to the shape of the end section, one should follow accepted crashworthy details such as the slope of the toe (could be flatter but not steeper), the coping or cutback at the end to reduce wheel snag on corners, etc. Yes, other variations may be acceptable, but one should discuss with us your proposed changes first so that we can provide feedback in advance of making such changes. It may also be helpful for your staff to provide to us the desirable details used by other states so that we could determine whether they have been crash tested or not.

    c. Due to the proximity of our first guardrail post to the leading edge of our end sections, some contractors have complained that they cannot drive that post and must instead excavate and backfill by hand. Is it possible to increase that gap distance or must it stay constant?

    ** There are other transition designs available that do not use the 18.75-in. post spacing and a short span from post 1 to the buttress end. If desirable, we show provide the IA DOT with a list of other crashworthy transition details that may eliminate with field installation problem. It is not recommended to change post locations of the crashworthy designs without testing.

    d. I have seen other states lengthen or shorten the "overlap" of the guardrail connection at the bridge end based on some conditions. Do you know what this is accomplishing? What are your thoughts on this practice?

** I have a personnel opinion that some states are providing extra overlap of the thrie beam guardrail (part of the transition) onto the concrete buttress end because they may feel that there reinforced ends have insufficient strength if impacted directly in this region. If adequate structural capacity of the RC buttress exists, there is no reason to have significant overlap of the concrete end other that to bolt the terminal connectors in place and have adequate steel placed around this connection to prevent its pullout and premature wall fracture.

2.Are you aware of any research regarding what effect, if any, low temperatures would have on the crashworthiness of steel bridge rails?

** Unfortunately, I am not aware of any specific research into this topic.

3.On some of our construction jobs I have seen where a contractor has overlapped freestanding Temporary Barrier Rail directly in front of a permanent concrete barrier or bridge rail as a means of terminating the TBR. Typically this has been accomplished with only one or two sections of TBR resting in front of the permanent barrier. Would you consider this an approved practice? If not, would there be a minimum number of TBR sections that would need to be overlapped in front of the permanent barrier in order for it to function properly?

** I would not consider acceptable the practice of using two free-standing, 12-ft long, TBR sections for downstream anchorage near and directly in front of a permanent barrier installation. Instead, our best engineering judgment would be to overlap at least 8 TBRs past the end of the permanent barrier and maintain a clear gap of 24 in. between the barrier bases. Our concern with freestanding TBRs directly in front of permanent barriers is that the freestanding barrier could pocket at the end of the permanent barrier. Thus, the provision for 24 in. allows for some normal deflection without pocketing over the first 2-ft of barrier translation.

4.Finally, do you have a method for attaching the MGS directly to a paved sidewalk or through the top of an intake? If not, are we able to develop our own based on a current design with standard guardrail?

** At this time, we have not considered how to attach the MGS to paved sidewalks, but it is reasonable that rectangular leave-outs placed around the posts would allow for adequate post rotation, similar to what was used for the MwRSF post in rock study and the TTI guardrail in paved mow-strip study. Second, it would be acceptable to span over the intakes if they are 25-ft long or less. Recall that the MGS was adapted to long-span culvert applications using 3 CRT posts on each side of the long span.

Guardrail Post in Concrete and other Urban Considerations

Question

State: WI
Date: 08-23-2007

Is the following correct interpretation of the current state of research on guardrail? When guardrail posts are installed with in a sidewalk (see picture1 and 2) the concrete prevents the post from pivoting like it is suppose to. Therefore, a guardrail installed as in the picture does not meet 350 requirements. Would this also be true for asphalt installed around guardrail?

Second question:

If you have a narrow median, higher design speeds, high ADT, and urban section. How does a designer end a barrier with a crash cushion or EAT and not leave a large median opening (need mountable curb to EAT or cushion correctly see pictures: plan view and east London rd)?

Response

Date: 08-27-2007

With regard to your first question on guardrail systems installed within concrete pads, we recommend that States do not place guardrail posts within rigid pavements for several reasons. First, wood and steel posts are designed to rotate laterally in the soil for a specified distance while providing a soil resistive force on each post. The work done by the rotating posts in soil allows for a portion of the impacting vehicle's kinetic energy to be dissipated as well as helps the guardrail provide for a smooth vehicle redirection. When guardrail posts are placed in rigid pavements, the expected post-soil interaction is altered. For example, wood posts placed in concrete may cause premature post fracture and a significant reduction in the post's energy absorption capacity. As such, guardrail installations requiring asphalt or pavement surfacing under the guardrail must consider special leave-outs around the posts where surfacing allows for the proper post translation in the soil. Both MwRSF and TTI have developed special guardrail systems and recommendations for these applications. First, MwRSF researchers developed design guidelines for placing steel posts in holes where subsurface rock is encountered. Second, TTI researchers later developed recommendations for the blocked-out region surrounding posts when mow strips are needed under guardrail systems. In both systems, consideration for the allowance of post rotation was deemed critical.

In your second question, the details of the median situation make it appear as though continuous barrier protection is likely warranted (i.e., narrow median, higher design speeds, and high ADT). However, you note that large median openings exist in combination with use of guardrail end terminals and crash cushions. From the photographs, it appears that these attenuation devices are located therein in order to shield rigid obstacles and not to prevent crossovers along the entire median length. You describe the need for openings in this median application, what are the specific needs - intersecting streets, etc.? It would be helpful to have additional information on this second topic in order for us to better assist you.

Response

Date: 08-28-2007

The problem I see is the need for end treatments (energy absorbing terminals, and crash cushions) and the cross sectional/operational problems the flat or near flat approaches can cause on urban projects (e.g. the picture with the crash cushion and the signal). Would it

be possible to to design some type of end treatment that could be used behind vertical curb? For an example, (probably would not work in a median

We are currently in the process of updating the guidance on beam guard to require an opening for the post to rotate. Thanks for your help. Has MwRSF had a chance to adapt Illinois's MGS drawings? I would like to get some test projects using the MGS system in our state.

Response

Date: 08-28-2007

From your clarification, it is my understanding that you desire a means by which you can effectively prevent vehicles from crossing the narrow, flat, paved medians in urban region and in advance of impact attenuation devices. You suggested using curbs to perform this roadway delineation and to prevent unwanted, intentional crossovers. The use of curbs in combination with and in front of crash cushions and guardrail end terminals is not recommended at this time due to the expected vehicular instabilities that would occur in advance of the vehicle to barrier impact. In the past, the Pooled Fund group has asked for a proposal for studying this problem. However, this project was not funded. At this time and following the summer TRB meeting, a NCHRP problem statement is being prepared on this topic. Hopefully, it will be selected and funded for an upcoming research project.

With regard to the MGS implementation project, I anticipate starting this effort in late September.

Long Span Guardrail with Curb

Question

State: IA
Date: 08-27-2007

Does the long-span MGS function properly when installed flush with a standard 6" curb? For some reason, I was thinking the area directly below and behind the long-span system had to be free from any snag points or obstacles.

Response

Date: 08-30-2007
We had not originally envisioned a 6-in. curb placed in advance of the long-span MGS. As such, we do not have crashworthy details for leaving a post out of a MGS design that is also placed behind a curb. Using our best engineering judgment, it may be possible to consider using the long-span design where 3 CRT posts span each side of the 12-ft 6-in. gap. The one unknown is whether the pickup truck will ride up the unsupported guardrail length after impacting the curb and twist the rail enough to allow vehicle climb and vaulting of the system. However, I do not believe that this undesirable behavior would result.

Short Radius Guardrail

Question

Date: 09-20-2007

Last week we learned from Dean that the latest test of the short-radius guardrail failed the test with the 2000P under TL-3 conditions. Dean also mentioned that he would have no doubt that the same design would pass TL-2 conditions.

The State of Delaware has a situation where they need a short radius barrier. The specific question I was asked related to the NCHRP Report 230 design discussed in our Technical Advisory 5040.32:

http://www.fhwa.dot.gov/legsregs/directives/techadvs/t504032.htm

The drawings are attached. The question was "The 8-foot design notes that the washer should be removed from the center post. Should the washers also be removed from the two posts closest to the center in the other designs?"

Now, my questions are:

1) Does your testing of the "new" short radius designs support removing those washers?

2) Should we scrap 5040.32 entirely and go with the MWRSF design even though it has not yet met Report 350?

Response

Date: 09-20-2007

With regards to your first question about the posts in the 8' nose section, I have a couple of comments. First, we would not recommend any the center post in the nose of the system because it is not mounted in a foundation tube. Thus, even though it is a CRT post, it will rotate in the soil about its strong axis and create a ramp that increases the potential for impacting vehicles to override the system. We have removed the center post in our current TL-3 design for that reason. As far as the two posts at the edge of the nose section, we have used extra strong post-rail connections at those posts in the current version of the TL-3 short-radius. We have increased the post-rail connection strength in the current design in order to keep the posts attached to the rail and prevent them from becoming debris under the wheels of the truck that can cause the vehicle to override the rail. We have observed that vehicles impacting short-radius systems display significant yaw motion as they are captured due to the geometry of the system. Breakaway posts in the system that become detached from the guardrail has been observed to get under the wheels of the vehicle as it yaws and allow the vehicle to override the rail. Thus, we would recommend that the washer be left on the post rail connection at those posts.

Your second question was whether or not we believe that the old design should be abandoned in favor of our current design. We believe that the old design should be abandoned for several reasons, and I will list a few of the most pressing. First, we do not believe that a W-beam system is capable of capturing both the small car and pickup truck size vehicles effectively. Second, we do not believe that the W-beam design has sufficient capacity to contain the pickup truck vehicle. Third, we do not believe that the system has sufficient anchorage to redirect vehicles along the side of the system.

As Dean mentioned, our current short-radius system has not met the TL-3 impact conditions at this time, however, we believe the system is much better than the older W-beam and thrie beam short-radius systems currently available. We are also confident that this design will meet TL-2. We would be willing to submit the details of the current design so that states could use it as a best available alternative as long as the following caveats are recognized.

1. The MwRSF short-radius design is still under development and should not be considered the final version of the design. Further development of the system is planned and design details for the system may change in the future.
2. Not all of the required TL-3 tests have currently been evaluated on the MwRSF short-radius design. We have been approaching the design of the system in a manner that addresses the most critical impacts

first, so some tests in the required matrix remain to be resolved. Thus, the overall system behavior has not been entirely quantified at this time.

3. The current MwRSF short-radius design places the bridge rail and approach transition on the TL-3 or primary roadway side of the system and uses an end terminal on the TL-2 or secondary roadway. This configuration was chosen based on engineering judgment as the most critical installation for testing purposes. Some installations may be different than the tested system in that they may have the bridge rail and end terminal on the opposite sides or some other configuration. These alternative configurations have not been thoroughly evaluated at this time and their behavior is not known.
4. The performance of the MwRSF short-radius to date leads us to believe that it will certainly meet TL-2 impact criteria as designed due to the lower impact speeds and corresponding kinetic energy levels.

Hopefully this answers your questions as to our thoughts. Please contact me with any further comments and questions.
