Midwest States Pooled Fund Program Consulting Quarterly Summary

Midwest Roadside Safety Facility

10-01-2017 to 01-31-2018

Asperities in Concrete Barrier

Question
State: MN
Date: 10-12-2017

We are considering the use of asperities in a concrete bridge rail and have used NCHRP 554 as guidance.

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_554.pdf

The asperities on our barrier design(attached) appeared to fall within the guidelines in the report. The only issue was the guidelines were developed for NCHRP 350 TL-3 requirements while our barrier must meet MASH TL-2. Given the speed of the roadway (30 mph) is much slower than NCHRP 350 TL-3 and the fact that our barrier is vertical was enough to convince the MnDOT Bridge Design engineer to approve it.

Any
additional thoughts on our approach?

Attachment: https://mwrsf-qa.unl.edu/attachments/43919a386db9289590bd9b972cc505af.pdf

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Response
Date: 10-12-2017

A TL-2 test condition will help some to mitigate snag risk. One thing to note is that the NCHRP Report 350 criteria used a small car impacting at a 20-degree angle, while the MASH criteria use a small car impacting at a 25-degree angle. Any snag risk with small car may be accentuated with a 5-degree angle increase.

At the end of the rail near posts, do you have a 2" recess with a sharp 90-degree angle coming forward? Or, do you have tapered ends on upstream and downstream ends of longitudinal recessed region?

Response
Date: 10-13-2017

The 2" projection on the bottom is the MnDOT standard “brush curb" that runs longitudinal with the barrier with no disruptions. The vertical posts are projected 1" at 90 degrees and what I didn't mention in my first email is that we are changing these to include 45 degree bevels on both the upstream and downstream ends to comply with the Caltrans guidelines (included at the end of the NCHRP 554 report).

Response
Date: 10-14-2017

You note that the post face to recessed rail face is only 1 in. where the interface will now include a 45-degree bevel on both side of post. For now, that may be an option until further MASH data comes forth. We may have some Hawaii DOT bridge rail testing in future that may help update on knowledge under MASH. Thanks!

Barrier Plate fro Spanning Gap in Permanent Concrete Barrier

Question
State: MO
Date: 09-21-2017

Can
you comment on using the proposed ½" steel plates on either side of our existing 42" Type C Single Sloped Median barrier will suffice for TL-3 or TL-4 (NCHRP or MASH) as shown in second drawing above “024 SS 104…"?

Plates
will not be recessed into barrier but ends of plate will be beveled. Bolt heads that anchor plate into barrier may or may not be countersunk (is countersinking critical or can bolt heads be exposed?). Length of overlap of plate at each barrier end will be 12" as shown. each end.

The
plan is to remove 4 feet of barrier and replace with the steel plates.

Any
concerns? Any crash reports that cover this?

Attachment: https://mwrsf-qa.unl.edu/attachments/b785e79979987caf87bf664c4d0203d5.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/728544326abd11898dc673cd3a73aba9.pdf

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Response
Date: 09-21-2017

The ½-in. plate strips option does not appear to be close to having sufficient capacity on paper. We may expect up to 70 kips to be imparted to plate when distributed over 4 ft for MASH TL-3. With significant plate bending/deformation and possible fracture, we would likely have high risk for vehicle snag and/or pocketing on downstream end of joint. A 1-in thick plate is getting closer to design requirements. Plate ends would need to be recessed. Anchors would need to be farther from edges and spaced enough apart to not cause capacity reductions.

A prior proposal that remains unfunded in Pooled Fund has been brought up that addresses a similar issue. A CALTRANS system researhc in that proposal is shown but not crash tested to the best of our knowledge.

Attachment: https://mwrsf-qa.unl.edu/attachments/5848cbbe0689e57052092f6c9217e3c4.pdf

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Response
Date: 10-17-2017

Attached is what we came up with where we need to span a 4ft gap in our median barrier curb for drain inlets. I believe our median barrier is NCHRP 350 TL-4, so we are looking at a plate resistance that can match.

We have uncertainty about the type of bolts such that they can be recessed in slotted holes for expansion. The question has come up about slotting and recessing while still maintaining strength. Any help with this would be appreciated. The CALTRAN plate (shown below) in your “Open Joints Proposal" shows some flush bolts. Do you know the type of bolt this is?

The plate will be galvanized with either galvanized or stainless 1" dia steel anchors. The plate thickness is 1" also.

Attachment: https://mwrsf-qa.unl.edu/attachments/6b7129acd757f9efa73b17b39a52dee5.jpg

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Response
Date: 10-18-2017

I want to discuss this system with Scott/Bob but have a few initial questions. Here are a few questions to start:

1. Refresh my memory on test level and barrier height;
2. Will top plate be recessed down to eliminate and/or reduce snag risk of engine hood/quarter panel? If not, can it be? I somewhat thought that it would be recessed if the ends were recast.
3. Is there one directional or two directional traffic at locations where this plate will be used?
4. Will downstream end of plate also be anchored with bolts (front and back) using slotted holes to allow for differential movement?

We will need to look up the other items before commenting.

Response
Date: 10-19-2017

Below

I want to discuss this system with Scott/Bob but have a few initial questions. Here are a few questions to start:

1. Refresh my memory on test level and barrier height;***[Gregory E. Sanders]*** TL-4, 42", Safety shape median barrier we call Type C
2. Will top plate be recessed down to eliminate and/or reduce snag risk of engine hood/quarter panel? If not, can it be? I somewhat thought that it would be recessed if the ends were recast.***[Gregory E. Sanders]*** Yes since ends are recast. We chose to recess 1-1/8" (an extra 1/8") for 1" thick plate in lieu of recessing only 1" and beveling plate ends.
3. Is there one directional or two directional traffic at locations where this plate will be used?***[Gregory E. Sanders]*** One directional. Median divides I-70 in St. Louis.
4. Will downstream end of plate also be anchored with bolts (front and back) using slotted holes to allow for differential movement?***[Gregory E. Sanders]*** Both ends will be secured with bolts. Only one end needs to be slotted, which end may not matter. We need to allow for expansion since the barrier has no open joints. I figure that reducing any compressive force in plates due to expansion is a benefit when impacted.

We will need to look up the other items before commenting.

Response
Date: 10-26-2017

Here are our thoughts on this topic after additional discussion.

1. We had originally thought about this configuration in line with using a 70-kip TL-3 MASH loading condition. Since TL-4 is to be considered, then a 80-kip TL-4 MASH loading condition is now applicable.
2. For a concrete safety shape barrier with a 4-ft long gap, the dual-sided plate needs to continue downward to a point of 3 in. above the road surface (i.e., stop at point of lower vertical toe of 3 in.). The lower portion of the plate would then need to match the second slope of the “F" safety shape (incline from 3 in. to 10 in. heights). The lower portion of plate prevents passenger vehicles from snagging on the exposed barrier at lower toe at downstream side of gaps. Single slope barriers would utilize a constant slope plate on front and back over full height.
3. For wide gaps, the 1 in. plate should incorporate a lateral stiffener welded or bolts between front and back plates at the midpoint (2-ft) to allow both plates to be engaged together when impacted on one side. A plate stiffener of ½ to ¾ in. thick over the plate height should suffice. Other built-up structural sections could also be used.
4. Two columns of bolts would be used on both sides of the gap. Dome head bolts could be used. Tapered head bolts could be used if tapered holes are drilled to allow for flush mounted heads. Dome head would require hex shapes or star shaped to allow them to be tightened.

Please let us know if you have further questions regarding this matter. Thanks!

Response
Date: 11-13-2017

Thanks for your feedback from the group. Much appreciated.

We are hung up on maintenance: ease of removal of the barrier plates for cleaning out the median drains. Using plates on each side worries the resident engineer; cumbersome, clunky, difficult to re-attach eve if removed as a unit (2 plates and a stiffener). Whole metal barrier skin (two straight sides and a welded top plate) may be easier to maneuver routinely. Barrier is 42" single sloped.

So, now we are thinking about using a whole barrier skin rather than plates. Since the skin has to be removable in order to clean the median drains, the resident engineer came up with an idea of how we can construct the new concrete barrier ends more easily by using the skin as formwork. He calls this formwork a “barrier saddle sole" plate" (attached) where this is used to form new barrier ends and then act as connector between barrier ends and removable whole metal skin. It is hoped it will allow for easier routine removal.

His idea prompts me to ask: what is wrong with using a whole barrier skin that can be just dropped in place over the existing barrier ends (after removing 4' of median barrier) with minimal resin anchorage to the concrete. It would eliminate the need to pour new barrier ends; it would overlap 3' at each cut end of barrier and would act to stiffen the cut barrier ends. It weighs over a ton. It would not however be flush with barrier face which is a concern but also presents us with a major problem in trying to overcome. Can we bevel the plate ends to minimize concerns or move to thinner skin say ¾" or ½" since it is whole skin (and we can add more stiffeners)? How can we mitigate this without going to next step of pouring new barrier ends?

We have thirteen of these removable plates/skins to put in place at one site on this rehab job to fix the median barrier drainage openings.

Gregory Sanders, P.E.

Structural Development and Support Engineer

Missouri Dept. of Transportation

Attachment: https://mwrsf-qa.unl.edu/attachments/78b93f2754d57f9d56d2a7e04b9262d8.pdf

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Response
Date: 11-14-2017

See my comments below.

Thanks for your feedback from the group. Much appreciated.

We are hung up on maintenance: ease of removal of the barrier plates for cleaning out the median drains. Using plates on each side worries the resident engineer; cumbersome, clunky, difficult to re-attach eve if removed as a unit (2 plates and a stiffener). Whole metal barrier skin (two straight sides and a welded top plate) may be easier to maneuver routinely. Barrier is 42" single sloped.

****When considering a 4 ft span, I think that you would still want to have an intermediate stiffener regardless as to whether the top horizontal welded plate/cap exists or not. We think that this system would be conservative but necessary in the absence of testing to prove out a more aggressive, cost-effective system.**

So, now we are thinking about using a whole barrier skin rather than plates. Since the skin has to be removable in order to clean the median drains, the resident engineer came up with an idea of how we can construct the new concrete barrier ends more easily by using the skin as formwork. He calls this formwork a “barrier saddle sole" plate" (attached) where this is used to form new barrier ends and then act as connector between barrier ends and removable whole metal skin. It is hoped it will allow for easier routine removal.

****We thought that you may have already been considering the cap variation when you referenced the photo below in the earlier correspondence. I**

agree that the cap variation is heavier than front and back plates only. However, they both seem very heavy to me and painful to remove for cleaning the drain.

His idea prompts me to ask: what is wrong with using a whole barrier skin that can be just dropped in place over the existing barrier ends (after removing 4' of median barrier) with minimal resin anchorage to the concrete. It would eliminate the need to pour new barrier ends; it would overlap 3' at each cut end of barrier and would act to stiffen the cut barrier ends. It weighs over a ton. It would not however be flush with barrier face which is a concern but also presents us with a major problem in trying to overcome. Can we bevel the plate ends to minimize concerns or move to thinner skin say ¾" or ½" since it is whole skin (and we can add more stiffeners)? How can we mitigate this without going to next step of pouring new barrier ends?

****Vehicle snag on plate edges is another big concern. We have rolled a pickup truck in the past when it snagged on a vertical plate that was welded to a steel barrier (i.e., exposed sharp edge). One may need to have an exposed edge (sides and top) less than 1/4 in. thick to resolve this concern. Further, vehicle components can gouge into concrete in advance of the steel plate, which may increase effective plate thickness that could negatively affect vehicle behavior.**

****The concept in general may work if more stiffeners or support posts were added in the large gap when considering thinner side plates. We presented a similar concept a few weeks ago in the Pooled Fund meeting, although it was applicable to free-standing PCBs versus permanent barrier. The States moved toward using a thrie beam system on the sides along with a lower plate on the toes. With rigid barrier ends, the concerns for vehicle pocketing upstream from a barrier end increase, which could result in vehicle snag and/or instability.**

****There has been a Pooled Fund proposal to address this issue, but it was not prioritized last year and remained unfunded. Do you have any space for support posts on or near the drain system?**

Ron

Response
Date: 11-15-2017

Thanks for taking the time to discuss this project. After our phone conversation, I was reminded to bring up two more items.

We must have a drain opening. Can we use up to 6" opening between bottom of plate and ground for our 42" single sloped barrier to account for future overlays and of course to reduce clogging issues?

And, do we need to chamfer the lower part of the exposed barrier if the plate is not full height to reduce snagging? (I highlighted your response in item 2 below)

Gregory Sanders, P.E.

Structural Development and Support Engineer

Response
Date: 11-16-2017

I have enclosed links to our Pooled Fund Consulting website. See the two topics below.

http://mwrsf-qa.unl.edu/view.php?id=228

http://mwrsf-qa.unl.edu/view.php?id=439

I think that a lower plate height is always better. If you are recasting the ends, it may be advantageous to use a tapered toe to reduce any small car wheel snag concerns on the downstream end of the gap.

Connection to Aluminum Railing

Question
State: IN
Date: 10-24-2017

INDOT still has a lot of aluminum railing over bridges and that railing extends outside of the bridge. In addition, normally the aluminum railing terminates with a Type 1 end treatment (or buried end). When certain work is done, INDOT has been removing buried end treatment due to safety issues and encouragement from FHWA. In the case where an end treatment is being replaced with an NCHRP-350 or MASH tested end treatment we have been using the connection shown in the attached pictures, to connect back into existing aluminum railing. What are your thoughts about this connection and do you have any comments on this connection being used to connect an NCHRP-350 or MASH tested end treatment directly to aluminum rail? Thank you
Attachment: https://mwrsf-qa.unl.edu/attachments/2fdd594ca229dc3ba14f02334041a504.jpg

Attachment: https://mwrsf-qa.unl.edu/attachments/b16966f379f8759aceed7ab2c571c91c.jpg

Response
Date: 11-03-2017

While the photos attached don't provide sufficient detail for a full analysis, we would have some concerns with the transition between the two rail systems shown.

A transition between two adjacent barrier systems must account for the change in the geometry of the barriers as well as transition between the lateral stiffness and deflection of the two barrier systems. Failure to account for both factors can result in pocketing barrier in the transition region, increased loads and potential barrier failure, poor vehicle capture, snag on the end of the PCB system, and rapid vehicle deceleration.

For the transition shown, the aluminum railing appears to possess higher stiffness than the attached W-beam rail section. I believe that the railing shown is a system tested at TTI in 1980. The post sections are much larger and the aluminum rail may have more moment capacity than the W-beam. Thus, there would be concerns that an appropriate lateral stiffness transition between the two regions would be required. It does appear that there has been an attempt to prevent snag on the bridge rail and W-beam in both traffic directions. However, you may need to consider the potential for snag on the bridge post itself as well.

Other tubular bridge rail transitions have been developed and tested and may provide insight on how to transition between W-beam guardrail and this bridge rail. These designs would have accounted for snag and lateral stiffness transition and would provide a good starting point. Only one tubular bridge rail transition has been tested to MASH. I have attached it with this response. It may provide a starting point for consideration of the transition you have. Note how the tubes extend behind the rail to prevent snag and steel wedges are also used to prevent snag in the reverse direction. For W-beam, additional consideration of the post snag may be needed. Also note the use of reduced post spacing on the approach.

Attachment: https://mwrsf-qa.unl.edu/attachments/f33aabec6e2a06b21e1fca4486273147.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/e4b7648831e89808a970ba0995e5a89c.pdf

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Foundation Tube Lengths 5 ft or 6 ft

Question
State: NE
Date: 10-24-2017

I have two lengths of Foundation tubes 5' – from older NDOT plan & 6' - from the recent Bullnose testing using thrie-beam.
Is the 5' for w-beam still acceptable with the MASH approved loads?
Or should I switch to the 6' only?

Response
Date: 10-24-2017

We have been using the 6' foundation tube for use with the MGS due to the increased rail height affecting the loading of the anchorage during initial development of the system.

For the bullnose system, we would recommend similar length foundation tubes for anchoring a free end of the system. Note that the BCT posts adjacent to the nose of the system use 8' long foundation tubes as only a single foundation tube is used for anchorage adjacent to the nose.

Thanks

Roadside Concrete Barrier Standard Drawing Review Request

Question
State: UT
Date: 07-11-2017

We
would like to request a review of our Concrete Barrier Standard Drawings to see what needs to be improved upon. I have attached a pdf copy of our
standard drawings and calculations used at the time when they were created.

Along
with the entire set, I do have a couple specific concerns as follows:

TL-3
CIP Barrier Design:

- At this time,
  the TL-3 CIP barrier does not have a foundation design for each end of the barrier. In most cases the CIP barrier is placed on 9 inch thick PCCP concrete roadway panels. At a minimum Standards require a 4 inch thick barrier pad constructed of concrete or asphalt. Will the design as shown on Sheet BA 3A2 require a foundation if placed on concrete of 9 inches or thicker?

- Will the
  barrier function if placed on asphalt, or no pavement at all?

TL-5
CIP Barrier Design:

- BA 1E &
  BA BA 301: The TL-5 barrier has an option to use a foundation end block or P1 bars at the end of the barrier depending on the thickness of the concrete pad it is being placed upon. Foundation end blocks are not required when barrier is placed on PCCP of 8 inch thickness or greater. Do you see any issues with this design?

- BA 3O4:
  Do you see any issues with scuppers used with the TL-5 design?

- BA 2D: This
  is a short stand alone barrier section. My concern is that it does not have a foundation. Currently this design in most cases is installed on PCCP of 9 inch thickness.

Thank
you for your time,

Attachment: https://mwrsf-qa.unl.edu/attachments/ff63314ca50d07420aa3e23f6b84f621.pdf

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Response
Date: 11-01-2017

Scott and I have reviewed you details. Comments and responses to your questions are located below.

For you PCB standards.

1. On sheet BA 1A2, you show two basic PCB details. One is a 42" constant slope barrier and one is a 32" New Jersey barrier. both are 20' long per segment.
    a. To my knowledge, the 32" tall NJ barrier section has not been tested to MASH TL-3. However, 20' long NJ PCB has been tested to MASH TL-3 with a different barrier connection. Thus, the barrier has the potential to meet MASH TL-3.

        i. The connection loops are denoted as ¾" dia. bar and use a 1" radius loop bend for the connection pin. In previous development of the F-shape barrier, MwRSF found that the bend radius and the grade of the loop steel were critical to developing proper load in the connection loops. That research used a 2 ¾" dia. bend radius and specified an ASTM A709 Gr. 70 or A706 Gr. 60 rebar for the loops in order to prevent fracture of the loops under impact loads.

        ii. MwRSF's F-shape PCB also uses double shear loops for the connection loops. This lowers the load in each loop and reduces pin bending. Previous designs of the F-shape PCB found it necessary to use a constraint bolt at the base of the PCB connection pin to prevent the connection pin from bending and pulling through the loops under load. This may be an option to consider for your system as well. You appear to use the double shear loops in the 42" tall single-slope design.

    b. For the 42" single-slope, I don't believe this has been tested to MASH either. Again, it may have to potential to meet TL-3 based on comparison to other tested systems. One concern with that system is the vertical cutouts for the anchorage pins. We have observed vertical asperities of 3/8" or more can contribute to vehicle instability when extended from the barrier. TTI conducted research in NCHRP 554 regarding aesthetic barrier design and the size of vertical asperities allowable for concrete barriers. This research found a range of performance for vertical asperities dependent on the angle, depth, and

the width between asperities. Crash testing conducted as part of this project found that vertical concrete ridges as deep as ½" could result in failure. Further simulation analysis found that vertical steps of ¼" were acceptable. The height of the vertical cutouts and their depth may lead to similar concerns here.

2. On sheet BA 1A2, details are provided for pinning the barrier to reduce deflection. This approach has been used on several MASH tested PCB systems, but the configuration utilized has been a bit different. Currently, the Utah details denote pinning at two locations on the front and back sides of the barrier near the ends of the barrier segment. Previously MASH tested pinned barrier configurations have used three or more pins. Additionally, we have typically recommended not anchoring to the backside of PCB segments in order to reduce the potential for tipping of the barrier about the backside anchors which can promote vehicle climb and instability. However, we have seen a configurations with pins on both sides of the barrier work with NJDOT's 20' long PCB. The F-shape PCB anchorage we developed used three pins on the front face of each segment and the New Jersey system uses 5 anchor pockets on each face of the barrier. Thus, there is potential for your configuration to work, but I cannot provide any definitive recommendation regarding its MASH compliance. It also difficult to determine what the potential deflection reduction might be and how the pin configuration affects the structural loading of the barrier.
3. Currently your details show a deflection area of 1' at 10:1 or flatter and 2' of 8:1 or flatter with steep slope after that initial 3'. For your 20' long PCB which is similar to a PCB we have tested for New Jersey, we would expect MASH TL-3 deflections of at least 40" and they may be higher. In the past, we have not recommended the use of slopes steeper than 10:1 in the PCB deflection region due to concerns with the barrier deflection increasing and tipping of the barriers. For your anchored PCBs, I would think that your 1' offset from the slope is sufficient. However, as noted above, I cannot say for sure as I don't know your deflection reduction due to pinning without more investigation.
4. Your details denote flaring of the ends of the PCB runs, but I could not find the specified flare rates on the plans. This has never been fully defined through crash testing or simulation, but NCHRP 358 provides some guidance on PCB flare rates and is what we typically recommend to states.
5. On sheet BA 1D, you show a curved layout for operations outside the clear zone or low speed applications. There may be concerns for high angle impacts in these curved regions due to occupant risk, but your low speed requirement should limit that hazard. I just wanted to note that this type of installation has not been evaluated to any testing criteria to the best of my knowledge.

6. On sheet BA 2B, you show a sloped end section for the concrete, these sloped ends have been tested at lower test levels and heights for some low profile PCBs under current test standards. However, the 32" height and the slope of the sloped end section would likely promote vehicle instability as shown under TL-3 impact conditions and potentially under TL-2 impact conditions. I note that you recommend them for use in areas with speeds less than 40 mph. However, we have seen research suggesting that speeds over 30 mph have been an issue. We looked at this issue for some of the pooled fund states in the past. See Q&A response - http://mwrsf-qa.unl.edu/view.php?id=778

Similar concerns would apply to the slope end treatment shown on sheet BA 3H.

Safe termination of PCB's is a significant safety issue that has not been dealt with over time, and few options are available other than sand barrels and crash cushions. We have done preliminary work on the length of need, but the issue of safe termination of PCBs likely need more research.

Scott looked at your CIP barrier questions and standards. In response to your questions:

TL-3 CIP Barrier Design:

- At this time, the TL-3 CIP barrier does not have a foundation design for each end of the barrier. In most cases the CIP barrier is placed on 9 inch thick PCCP concrete roadway panels. At a minimum Standards require a 4 inch thick barrier pad constructed of concrete or asphalt. Will the design as shown on Sheet BA 3A2 require a foundation if placed on concrete of 9 inches or thicker?
    - Anchorage to the roadway slab is likely acceptable. We would recommend that you place dowels/ties adjacent to all stirrups in the end section (approximately 12', for the sloped end section approximately 26')
- Will the barrier function if placed on asphalt, or no pavement at all?
    - End sections of CIP barrier placed without anchorage are susceptible to excessive cracking and damage and potential failure. We would recommend anchorage of the end sections.

TL-5 CIP Barrier Design:

- BA 1E & BA BA 301: The TL-5 barrier has an option to use a foundation end block or P1 bars at the end of the barrier depending on the thickness of the concrete pad it is being placed upon. Foundation end blocks are not required when barrier is placed on PCCP of 8 inch thickness or greater. Do you see any issues with this design?
    - Anchorage to the roadway slab is likely acceptable. We would recommend that you place dowels/ties adjacent to all stirrups in the end section similar to the footing design.
- BA 3O4: Do you see any issues with scuppers used with the TL-5 design?
    - Scuppers will reduce barrier strength to some degree, but you have limited their use as shown in your plans and not placed them in the end section, so the effect is not likely a big issue as your barrier is well reinforced. You may observe some additional cracking or damage in those areas.

BA 2D: This is a short stand alone barrier section. My concern is that it does not have a foundation. Currently this design in most cases is installed on PCCP of 9 inch thickness.

Let me know if you have any comments or questions.

Appropriate use of TL-2 barrier

Question
State: VA
Date: 11-03-2017

AASHTO is mostly silent on warrants. It gives some very basic guidance in Chapter 13. The description for TL-2 is specific about “posted speeds are reduced". So VDOT currently restricts the posted speed where we use TL-2 bridge barriers. We chose 40 mph, that may be overly conservative so we are considering increasing the posted speed limit.

The speed for TL-2 testing is 44.x mph.

If I compare 44 to the crash testing that is valid for “high speed arterials" (AASHTO language) they are at 62mph. High speed is clearly above 62 these days (the max limit in Virginia 70, it was 80 in Montana when I visited this year)

Is there somewhere where guidance is provided related to the interpretation of what the high end of “reduced speed" is.

Our speed limits on unposted roads is 55mph. I am
looking for any published guidance about how to consider using TL-2 on a
routine basis and maybe allowing TL-2 for use on the unposted roads.

In addition to the guidance we would consider our current
warrant process which is based on the unpublished report from 1980's or 1990's,
not the unpublished report from 2014.

(http://www.virginiadot.org/business/resources/bridge/Manuals/Part2/Chapter25.pdf
page 17 and following.)

Is there guidance about extending the posted speed above the
crash testing speeds?

Response
Date: 11-04-2017

I am generally aware of three documents that have addressed warrants for bridge railings.

The first document is AASHTO's Guide Specifications for Bridge Railing (1989).

The second document was the draft report for NCHRP Project 22-8. In that document, a figure was provided that guided conditions (speed and traffic volume) under which barrier placement was suggested for TL-2, TL-3, and TL-4. You can also obtain a copy of this figure in **MwRSF report no. TRP-03-98-03**.

Finally, there was a more recent NCHRP 22-12(3) study that led to guidelines for barrier placement on bridges. Roadsafe LLC completed this studied several years ago. I have been waiting to see if AASHTO would adopt these guidelines. However, I have not seen that occur as of yet. The study report is attached. In general, the authors denoted that test level selection is a function of percent trucks, encroachments, and level of risk acceptance.

Now I know that these three reports may not answer your question directly. In terms of speed, the 22-8 plot may actually give some help in seeing that Test Level guidance is not just correlated to impact speed in crash tests. Traffic volumes affect level of risk as well. We could have a high-speed rural road that carries very little traffic volume. In this case, one may argue that the risk is low enough that a TL-2 barrier, or even lower is appropriate, even if highway speeds are 60 mph or higher.

Further, we know that impact speeds with hardware are lower than encroachment speeds (i.e., when an errant vehicle first leaves the traveled way). Even with highway speeds, including excessive driving, we design our hardware for a slightly lower

impact speed based on real-world crash data, which was used to select TL-3 impact speeds in MASH.

In your case, unposted rural roads, often with lower traffic volumes, are known to be 55 mph and would easily be considered TL-2 or less.

Attachment: https://mwrsf-qa.unl.edu/attachments/726476e454e8e3a2b3ac85cc61c9ddda.pdf

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Concrete Parapet Alignment

Question
State: IL
Date: 11-15-2017

Hi Dr. Faller,

I have looked through the AASHTO Design and Construction Manuals and I can't find an acceptable tolerance for the following situation. We have two parapets meeting at an intentional bond breaker and their depths don't align such that there is a smooth surface with the traffic. What would be an acceptable offset such that snag would not be a concern?

Response
Date: 11-17-2017

There were two studies that addressed raised or depressed asperities in the face of concrete barriers. One study was performed by CALTRANS and the other study was performed by TTI as part of a NCHRP study. I think the guidance from those two studies may be applicable for guiding your uneven vertical surfaces in concrete barriers.

We have previously suggested a maximum lateral offset of 1" for concrete. For steel hardware, we have observed problems with a 3/8" offset and thus guided a value of around ¼" or less. With concrete, there may be fracture if short. However, in long solid sections, it could be more problematic. I might suggest the use of 45" bevels or flatter with a 1" maximum offset. It may be better to limit concrete offsets to ½" or less to lower risks.

http://mwrsf-qa.unl.edu/view.php?id=632

http://mwrsf-qa.unl.edu/view.php?id=371

http://mwrsf-qa.unl.edu/view.php?id=374

Attachment: https://mwrsf-qa.unl.edu/attachments/90811ec8804fcb5c3fe99d9178140fdd.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/22020ae2c5b8ea3e5e8bd55b4d123189.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/d9d08d202f11a22448e1e086597216c0.doc

Bent hoop bars on concrete protection barriers

Question
State: NE
Date: 12-04-2017

We are putting together some guidance for our field staff on acceptable damage to concrete worker protection barriers. One of the questions that has come up it – How much damage to the connecting hoop bars is acceptable? Is there any guidance in AASHTO for this?

Attachment: https://mwrsf-qa.unl.edu/attachments/9076d77b64c6ce07d6e137b19f037110.png

Attachment: https://mwrsf-qa.unl.edu/attachments/e1d0f10650d2f01dccd5a1165db51f97.jpg

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Response
Date: 12-04-2017

Section loss is undesirable. I would say that minor surface corrosion is acceptable as long as there is not much section loss. Further, we may not want to see any vertical deformation of the loops or lateral distortion. PCBs are not to be lifted by the loop bars. Finally, one may not want any gouges or nicks that may result in a stress concentration when loaded in tension. Those are my preliminary thoughts.

TL-5 barrier with inlets

Question
State: WI
Date: 12-06-2017

I
got some information from the design team wishing to use the TL-5 MwRSF barrier with a footing and having drainage features near the footing.

Erik

From: Anderson, William - DOT (Project Development)

Sent: Wednesday, December 06, 2017 11:42 AM

To: Emerson, Erik - DOT <Erik.Emerson@dot.wi.gov>

Subject: FW: TL-5 barrier with inlets

Here
is what I got from the Design Team.

From: Johansen, Amanda A - DOT

Sent: Wednesday, December 06, 2017 10:53 AM

To: Anderson, William - DOT (Project Development) <William.Anderson@dot.wi.gov>; Hager, Christopher - DOT <Christopher.Hager@dot.wi.gov>

Subject: RE: TL-5 barrier with inlets

Will:

The existing inlets are mostly Type 1 Manholes, two are Type 3 Manholes and one is a Type 5 Manhole (See attached details):

There is no cone section, all appear to be flat slab tops as shown in the following photo:

The covers are Type V.

Attached is a sketch I drew up showing the new TL-5 Median Barrier next to the existing inlets:

I'm not sure if we can gap the manholes to avoid the steel reinforcement stirrups. Here is a photo of some concrete barrier next to an inlet where the reinforcement is gapped.

Let me know if you need some more information.

Thanks,

Amanda
A Johansen, P.E.

Wisconsin
Department of Transportation

Southeast
Region

141
NW Barstow Street

Waukesha,
WI 53187

262-521-4465

From: Anderson, William - DOT (Project Development)

Sent: Wednesday, December 06, 2017 10:27 AM

To: Hager, Christopher - DOT <Christopher.Hager@dot.wi.gov>;
Johansen, Amanda A - DOT <Amanda.Johansen@dot.wi.gov>

Subject: FW: TL-5 barrier with inlets

Can
you answer Erik's question below?

From: Emerson, Erik - DOT

Sent: Wednesday, December 06, 2017 9:36 AM

To: Anderson, William - DOT (Project Development) <William.Anderson@dot.wi.gov>

Cc: Stertz, David L - DOT <David.Stertz@dot.wi.gov>; Taylor, Rodney - DOT <Rodney.Taylor@dot.wi.gov>

Subject: TL-5 barrier with inlets

Will,

Have you heard from the project team on what type of inlets and inlet covers they would like to use with the TL-5 Midwest barrier?

Erik

Attachment: https://mwrsf-qa.unl.edu/attachments/231b9a409f7e219d4ebb8fcb70d0f791.jpg

Attachment: https://mwrsf-qa.unl.edu/attachments/4fc1a595019cf5a9ae8a77450082c2bd.jpg

Attachment: https://mwrsf-qa.unl.edu/attachments/9e37a5d5eaf0b867e20499539dd913dd.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/c5f4a98e0f91fa397949d5f53a02ca93.pdf

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Response
Date: 12-08-2017

From the drawings and photos you supplied, it appears that the drainage structure will affect the placement of the support footing/slab of the barrier, but not the barrier itself. If this is in an interior section of the barrier (not end sections near barrier discontinuities), I don't see this being a big issue. The length of the drainage structure is limited and the majority of the footing will still be able to be cast. Thus, I would just adjust/shorten the width of the footing/slab to fit around the drainage structure. You should modify the stirrups to fit the new shape of the footing/slab as well (the photo below shows a footing/slab with stirrups in the shortened width region).

If the drainage structure affects the barrier cross section or reinforcement from being properly installed, then we may need to adjust a few more things.

Plate Washers for Wood Posts

Question
State: NE
Date: 12-07-2017

This 4"x4" plate washer is on NDOT standard plan; I don't have details of when/ where to use it.

Is it a holdover from many years ago – not needed today? Should it be eliminated?

What size washer should we be using on the back of wood posts?

Attachment: https://mwrsf-qa.unl.edu/attachments/8958e8e571ad5f3ac6c355a005662c00.jpg

Response
Date: 12-07-2017
We typically use plain round washers on the back side of our timber posts. The square washers don't hurt anything, but I'm sure the round washers are cheaper and easier to obtain.

Front Face Barrier Transition

Question
State: MO
Date: 12-18-2017

A detail
was given to us by a contractor wanting to use ADOT's front face barrier transition for adding light poles on top of barrier in lieu of MoDOT's standard where no transition on front face is required since it (ADOT's) will allow for slip forming the barrier.

Our
barrier will be 42" tall (Type D single sloped 11%) without a light pedestal added.

Is
ADOT's detail with 5' front face transitions from a sloped face to a vertical face at the light pole using MoDOT's 42" barrier without a light pedestal is an acceptable detail and if not how can we make it an acceptable detail?

1st
sheet of attachment – ADOT's detail with 33" barrier and top mounted pedestal

2nd
sheet of attachment – MoDOT's standard lighting blister

I would
appreciate your comments. Thx.

Attachment: https://mwrsf-qa.unl.edu/attachments/24c5b52a6b04d11dcd2d236fa7f3c7cd.pdf

Response
Date: 12-18-2017

For lateral tapers on the front face of concrete barriers, we have started to suggest the use of a 1:10 (lateral to longitudinal) when the shape transition extends over a larger vertical footprint. Note that this suggestion was solely based on LS-DYNA simulations involving vehicle impacts into a lateral shape transitions on rigid concrete buttresses. Full-scale crash testing has not been performed to confirm nor modify these simulation findings.

Previously, MwRSF conducted limited crash testing on luminaire poles attached to 32-in. tall single-slope parapets under TL-4 impacts using NCHRP Report No. 350. A link to the report and crash videos is provided below:

https://mwrsf.unl.edu/reportresult.php?reportId=104&search-textbox=zoi

Are you considering the configuration under MASH TL-3 or TL-4? Also, I would need to see the CAD details to further comment (not attached in prior email). Thanks!

MnDOT Type 31 Guardrail with Reinforced Soil

Question
State: MN
Date: 12-19-2017

MnDOT is updating our Reinforced Soil Slope details and we are looking for guidance relating to MGS (MnDOT Type 31) guardrail and reinforced soil slopes.

Specifically, how much room is needed behind the post when guardrail is in reinforced soil?

Please see attached file: **reinforced_soil_slopes.pdf**

- This pdf includes Standard Plans 5-297.646 thru 5-297.649 which are MnDOT's Reinforced Soil Slope Standards .
- We are looking to update the "Steel Plate Beam Guardrail Detail" on sheet 5-297.649. (The crossed-out detail on 5-297.649 currently shows our old 28" plate beam guardrail.)

Please see attached file: **Updated_Steel_Plate_Beam_Guardrail_Detail.pdf**

- This is the new detail that shows the MnDOT Type 31 guardrail in relation to the curb and reinforced soil.
- Our question is: How much distance behind the 9' post is required , from the back of the post to the PI of the reinforced slope?

Attachment: https://mwrsf-qa.unl.edu/attachments/9e295fbf783d7eaa3c341b00b38ba6e9.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/5cc26a7d9a476b8777f5d1814f349bbf.pdf

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Response
Date: 01-16-2018

Prior to recent testing of the MGS adjacent to slopes, guidance for W-beam guardrail adjacent to slope was typically given that standard W-beam guardrail (including the MGS at standard post spacing with 6' long posts) could be installed with a 2' offset from the back of the posts to the slope break point of a 2:1 slope.

More recent testing of the MGS has by MwRSF and TTI adjacent to slopes has shown that W6x8.5 or W6x9 steel posts ranging from 6'-9' in length and 6"x8" SYP posts ranging from 6'-7.5' in length can be installed at the slope break point of 2:1 slopes. I have attached a paper from the 2017 IRSC conference that outlines that research and the slope guidance. We are also currently working on a synthesis report on MGS adjacent to slope for the Midwest Pooled Fund, but the write-up is still in progress.

Slopes steeper than 2:1 have yet to be analyzed, but research on 1:1 slopes is currently underway at TTI.

If slopes near 2:1 or shallower were used, the reinforced soil slopes shown in your detail should perform similarly to the previously tested MGS configurations adjacent to slope. However, the details suggest slopes as high as 45-70 degrees. There is concern that the 9' post length would be overly stiff for the MGS system if the offset is sufficient to develop the full-strength of the post at that large embedment. This

could lead to rail pocketing and other concerns. Conversely, it is not known what the minimum offset should be for a 9' post on a reinforced slope that steep. Determination of that offset would likely require component testing of the post at various offsets to determine an offset that meets the force vs. deflection performance range of previous MGS systems.

We would recommend using the standard 6' post at an increased offset rather than the 9' post. In order to determine an acceptable offset, we reviewed previous research we conducted regarding installation of the MGS on wire-faced MSE walls, which are similar reinforced soil structures. In that research, we recommended the use of 6' long posts with the MGS with a 4' offset from the back of the post to the edge of a vertical wire-faced MSE wall. We would recommend a similar 4' offset with the standard 6' long MGS post for this installation.

https://mwrsf.unl.edu/researchhub/files/Report26/TRP-03-235-11%20(draft%20final%20to%20FHWA-CFL).pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/f1076f6ca498fddcad34467b4df05e2d.pdf

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Bridge Guardrail

Question
State: MO
Date: 12-27-2017

Can you
tell me if the MoDOT thrie beam guardrail on BRIDGE using a W6x20 post at 6'-3" spa. with or without W6x15 steel blockout is acceptable for MASH TL-3?

I believe
our current system is NCHRP 350 TL-3 compliant which can be utilized with or without a steel blockout.

Gregory
Sanders, P.E.

Structural
Development and Support Engineer

Missouri
Dept. of Transportation

Response
Date: 01-02-2018

I believe that the bridge railing system was crash tested under the NCHRP Report No. 230 criteria. Unfortunately, I am unaware of any crash testing under NCHRP Report

No. 350 on this exact bridge railing. There may have been a grandfather from 230 to 350** on this bridge railing.

***Memorandum on Crash Testing of Bridge Railings, May 30, 1997, File Designation HNG· 14, Federal Highway Administration (FHWA), Washington. D.C ., 1997.*

MASH testing would be recommended for the bridge railing.

The approach guardrail transition (AGT) was largely crash tested under NCHRP 350 and MASH using the Test Level 3 safety performance criteria. The various transition testing programs on similar systems are attached below.

Successful 350 Testing on Similar AGT

https://mwrsf.unl.edu/researchhub/files/Report87/TRP-03-71-01.pdf

Failed 2000P & Passed 820C – Original AGT & Transition Element

https://mwrsf.unl.edu/researchhub/files/Report188/TRP-03-94-00.pdf

Failed 2000P & Failed 2000P – Modified AGT w/ Rubrail

https://mwrsf.unl.edu/researchhub/files/Report186/TRP-03-91-99.pdf

New Transition Element R&D

https://mwrsf.unl.edu/researchhub/files/Report108/TRP-03-167-07.pdf

New Transition Element and Standardized AGT – MASH Testing

https://mwrsf.unl.edu/researchhub/files/Report38/TRP-03-210-10.pdf

New Standardized AGT w/ Curb – MASH Testing

https://mwrsf.unl.edu/researchhub/files/Report295/TRP-03-291-14.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/1cd2809e9aee099a27ac946c6c14b8ad.pdf

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Guardrail terminal connection

Question
State: IL
Date: 01-19-2018

We have a structure with tapered wingwall that ends at the bridge joint. The transition is connected to the bridge crossing the expansion joint. Our district offices don't want to add a parapet due to it not being cost effective. Our question is can we attach the first post as a strong post to the top of the abutment and use a Type 6B Terminal, please see attached. Would this be acceptable? Also do we have any concerns with the transition going over bridge joints to be able to connect it to the bridge parapet?
Attachment: https://mwrsf-qa.unl.edu/attachments/ab423f7759186217949317527 0de7562.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/0a2d80780c2c5c77a07173a12a15548e.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/48c1a1e70ac6507b6bb0cac7bc3c65f3.jpg

Attachment: https://mwrsf-

qa.unl.edu/attachments/bddd028def3b38e4523fc1ba10e8b796.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/a1953369d8e2610e41d2f3a398f2a4c7.jpg

Attachment: https://mwrsf-qa.unl.edu/attachments/d2f535486669871b55d3c6aa477a13ac.zip

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Response
Date: 01-29-2018

I think the best treatment for the area would be to added a short concrete parapet section adjacent to the bridge rail on the other side of the joint. This was previously mentioned by Victor Veliz in the email string attached, and I believe you had noted that IL-DOT currently installs a 15-ft long parapet adjacent to joints for new construction. I will go one step further and recommend using the standardized buttress that shape that was recently developed for thrie beam transitions. The length of the buttress may be only 5-7 ft and the downstream end of the buttress could be made to match the geometry of the existing bridge rail. The thrie beam would attach to the new buttress and the entire system would be crashworthy. I have attached a TRB paper that was written on this standardized transition buttress (the report has not yet been completed). If you are interested in using the buttress, I can work with you on developing the details for this application.

I don't really understand the design being recommended that incorporates a strong post connection to the abutment similar to your standard 630101-10. I pulled that detail from IL-DOT website, and this attachment design is for use on culverts or other locations where the embedment depth for the post is not attainable. Maybe I misunderstood the installation issues you are having, but I don't know how this helps. If you need to attach a transition post using this design, I don't think it would hurt the performance of the transition. However, this attachment does not address the issue of running guardrail across an expansion/contraction joint, which is not recommended.

Parts of the email state that the joints are being “removed/replaced." If the joint is being removed altogether, then there is no issue with spanning guardrail across the old

joint location. If the joint is repaired/replaced and is still expected to allow movement, I would not recommend spanning rail across the joint. Even if the terminal connector (or end shoe) were slotted to allow some movement without loading the thrie beam, this could also allow the thrie beam to deflect significantly prior to building any axial tension and forming the membrane action required to redirect vehicles with guardrail systems. Thus, slots may result in increased system deflections and snag issues on the concrete bridge rail.

Let me know what else I can do to help

Attachment: https://mwrsf-qa.unl.edu/attachments/da3b04f906fa8749748d3b5c1b0ba9b8.pdf

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