Midwest States Pooled Fund Program Consulting Quarterly Summary

Midwest Roadside Safety Facility

08-01-2017 to 11-08-2017

Bridge Railing Modification

Question
State: IN
Date: 08-03-2017

Attached to this question are two PDFs, Bridge Railing Modification Detail 1 and Detail 2. In the PDF Bridge Railing Modification Detail 1, can the concrete parapet wall section be reduced to 18" and retain the single steel
tube at a height of 36"? There is a similar railing (PDF Bridge Railing Modification Detail 2) that uses an 18" concrete
parapet, but has 2 steel tubes, top tube height of 42".

Would reducing the height of the concrete parapet and retaining the single steel tube at 36" on the BR27C Flush Mounted Bridge Railing (attached Detail 1) likely
have performance implications? If possible can you comment specifically
related to test levels 4 and 2?

Attachment: https://mwrsf-qa.unl.edu/attachments/80eeda96490baf81373633d693caff0a.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/f1f7102ee13938b423b790ff739843db.pdf

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Response
Date: 08-17-2017
The proposed modification show for the BR27C combination bridge rail does pose some concern if the parapet is shortened 6" as shown.

The original BR27C was tested to AASHTO Guide Specification for Bridge Railings standards and has yet to be evaluated under NCHRP Report 350 or MASH. The design was grandfathered in under NCHRP 350 in an FHWA memorandum. In the previous testing of the BR@&C with the small car vehicle there was evidence of the vehicle contacting and snagging on the support posts of the system with the front corner and fender of the small car vehicle. These tests were conducted at a lower 20 degree impact angle than current test standards.

There is concern that lowering of the parapet could increase vehicle snag on the combination rail support posts and create occupant risk concerns.

In terms of TL-4 performance, the passenger vehicle concerns noted above would exists. Additionally, the railing has not been evaluated to the more recent MASH TL-4 impact conditions with the 10000S vehicle. A 36 in. rail height has shown the ability to safely redirect the 10000S vehicle. However, the effect of the additional vehicle mass and speed on the overall capacity of the BR27C is not known. Only moderate damage was observed in the SUT testing under the AASHTO specifications, so there is potential that the capacity may be sufficient. Further analysis would likely be warranted to determine this.

The performance of the railing under TL-2 poses much less concern due to the reduced impact speeds. However, the potential for snag on the post would exist to a lesser degree.

Field Drilled Connection for F-Shaped Concrete Bridge Railing

Question

State: IN
Date: 08-03-2017

Are you aware of testing or documentation that would support the use of a field drilled connection for f-shaped concrete bridge railing? Attached is a PDF of the proposed field drilled connection.

This question is not MASH specific, but could be for any previous crash testing standard.

Attachment: https://mwrsf-qa.unl.edu/attachments/38abaaf3388ea7092d65b5fa0e4b4196.pdf

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Response

Date: 08-08-2017

Utilizing an epoxy anchor for concrete barriers is becoming more common all the time. We actually did a study for the Wisconsin DOT a few years back detailing the use of epoxy anchors in barriers that included dynamic component testing. You will likely find some useful information in that report- TRP-03-264-12. Additionally, we have regularly used epoxied anchors to attach concrete barriers to the tarmac at our test site for use in full-scale testing and have never had issues.

Just a few things to be aware of for field drilling and epoxying anchoring to bridge decks.
1. make sure you have sufficient distance between your anchors and the edge of the deck to prevent weakening of the system and premature damage to the deck
2. make sure your deck is thick enough for the required embedment of the anchor. we have typically recommended at least 2 inches of concrete thickness below the bottom of the anchor bar.
3. Embedment depths and epoxy strengths should be sufficient to develop the full strength of the anchor bar. Most epoxies have detailed user's manuals to calculate strengths for various configurations. ACI 318 also covers epoxy anchors in Chapter 17.

Precast Concrete Barrier Jersey Shape / Concrete Parapet Jersey Shape Connection

Question
State: UT
Date: 08-03-2017

I was looking through previous tests in order to find out how to best connect Temporary Jersey shape barrier to a concrete jersey shape parapet and closest report to match this circumstance that I could find is report TRP-03-208-10 Development of a Temporary Concrete Barrier to Permanent Concrete Median Barrier Approach Transition.

We have quit a few locations where this type of connection is made on older structures. Historically UDOT has made this connection with two concrete barrier sections installed with stabilization pins to help stiffen up the parapet to barrier connection. Our Structures division has a concern with how to make this connection without interfering with the movement of the structure.

With larger structures we
are experiencing expansion and contraction causing deformation of the connection pins at the parapet / barrier connection.

One thought is to install
a cast cast-in-place barrier section with an open joint between the CIP barrier and parapet. Maybe this is the best way to go.

Are you aware of an option
for this type of connection? Or If not, what
are your thoughts for using the connection detail similar to report TRP-03-208-10?

Response
Date: 08-08-2017

We here at MwRSF had a quick discussion on this topic this morning. We agree that installing a short CIP/permanent parapet on the opposite site of an expansion joint before linking the PCB's is an appropriate solution to eliminate issues with spanning across the joint.

One note: We have previously recommended that open joints in concrete barriers be limited to 4 inches (matching common PCB joints). Open joints wider than 4" may lead to vehicle snag. So, if your expansion/contraction joints will create openings greater than 4", we would also recommend treating that gap with a cover plate to prevent snag.

Let me know if you have any further questions.

Response
Date: 08-09-2017

Thank you for your help. Do you have a barrier foundation design that you could share that would work with a short CIP Jersey barrier design? Also, if the barrier is cast on top of 9 inch thick concrete pavement would vertical steel epoxied into the pavement (P1 Bars) as shown on the attached drawing be acceptable?

You may have already looked at this drawing as it is part of our Standard Drawings that you are currently reviewing.

Attachment: https://mwrsf-qa.unl.edu/attachments/063ba4061b8f682023821ac2a167bae4.pdf

Response
Date: 08-10-2017

I do not have a specific foundation for short installation lengths of concrete barriers. However, a method of developing barrier foundations was previously put together in a TL-5 median barrier report – see TRP-03-210-07 Chapter 9 and Appendix C. Anchoring to an existing 9" thick roadway slab should fine, assuming its much larger in footprint than the barrier.

Dowel bars epoxied into a concrete slab are common practice for anchoring concrete barriers. That said, I do not think that 6" of embedment depth is adequate to develop a #8 bar (your P1 bars). We have conducted previous testing that showed a #5 bar could be developed in 5.5" of embedment, but a #6 bar would pull out (concrete breakout failure). For your 9" slabs and 6" embedment, I recommend utilizing a #5 dowel bar (which matches the stirrup steel size). Also, for short barrier installations (less than 20 ft) , I recommend placing the dowel anchorage bars adjacent to every barrier stirrup. Thus, you would have the same bar size and spacing for both the dowel anchors and the barrier stirrups.

TRP-03-337-17

Question
State: KS
Date: 08-04-2017

I wanted to ask a clarification question on Report TRP -03-337-17, Length of Need and Minimum System Length for F-Shape Portable Concrete Barrier. My understanding from the report is 5 barrier sections are needed downstream of the beginning of the LON for free-standing TCSB intallations. My question is related to reducing or eliminating the need for these 5 sections.

KDOT's previous practice has been to eliminate the barrier sections upstream of the beginning of the LON if the installation is fully restrained. Is that still acceptable?

Additionally, I was curious to know if the 5 sections were still needed if the last 12'-6" section of TCSB was fully restrained or anchored with an impact attenuator, but the

rest of the installation was free standing with the overall length of the installation still meeting the 9 section minimum. Please contact me if you have any questions.

Thanks,

Tom Rhoads

785-296-0322

thomas.rhoads@ks.gov

Response

Date: 08-11-2017

The PCB LON research noted that a minimum of three barriers were needed upstream of the beginning of LON and a minimum of five barriers were needed downstream of the end of the length of need in order to safely redirect vehicles under MASH TL-3 impact conditions.

The potential exists to shorten the no. of required barrier segments on the upstream end using an anchorage system developed previously that was tested to MASH TL-3. See report below.

http://mwrsf.unl.edu/researchhub/files/Report63/TRP-03-209-09.pdf

We have also developed roadside and median transition systems for attaching the ends of the PCB to a rigid parapet. These options could be used on either end of a PCB installation.

http://mwrsf.unl.edu/researchhub/files/Report54/TRP-03-208-10.pdf

http://mwrsf.unl.edu/researchhub/files/Report133/TRP-03-180-06.pdf

Attachment to an impact attenuator or crash cushion might be feasible, but to my knowledge no testing of transitions to those systems has been conducted. Because you are connecting free-standing PCB to a fixed attenuator, some form of stiffness transition between the two systems would likely be needed. It would seem reasonable the one could use a similar stiffness transition to those used to transition from free-standing PCBs to a rigid parapet. However, consideration of the attachment of the PCBs to the attenuator and mitigation of snag at that connection would need to be considered. This may vary depending on the type of attenuator used.

MwRSF has not designed approach transitions to any proprietary attenuators at this time.

W-beam bullnose

Question

State: KS

Date: 08-07-2017

I have a
history question for you. We received a strike to a w-beam bullnose
installation last week and I'm trying to track down the test level and standard
this design successfully passed. In talking to all of our past roadside safety
personnel, they could only conclude it *may* have passed NCHRP 230 at TL-3
but weren't certain. Minnesota and MwRSF were brought up as likely candidates
of historical information on this. Searching MwRSF, I could only find Q/A # 467 but the date wouldn't
be old enough. Could either of you shed some light on the history of this
design?

An example
installation:

https://www.google.com/maps/@40.9637865,-91.5169176,3a,90y,152.25h,78.28t/data=!3m6!1e1!3m4!1sZQxMf9xhDSBTB7s01H0SYQ!2e0!7i13312!8i6656

Thank you!

Response
Date: 08-08-2017

We reviewed the original W-beam bullnose testing in some previous reports.

See below. If you have further questions, let me know.

Thanks

http://mwrsf.unl.edu/researchhub/files/Report122/TRP-03-73-98.pdf

http://mwrsf.unl.edu/researchhub/files/Report308/TRP-03-312-15.pdf

http://mwrsf.unl.edu/researchhub/files/Report288/TRP-03-296-14.pdf

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MGS transition to parapet

Question
State: OH
Date: 08-09-2017

ODOT Standard - Figure 1

Allowable retrofit to preexisting walls/parapets. A contractor would like to use a short 3'-3/4" piece of rail with a splice at post 1 at this location instead of the 14' panel.

Figure 2

Attachment: https://mwrsf-qa.unl.edu/attachments/abeebe3d32074f47741ec2aa0cfb8b6a.jpg

Attachment: https://mwrsf-qa.unl.edu/attachments/762ac69f7ef34d95c25ca53a6494d4db.jpg

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Response
Date: 08-10-2017

We looked at this briefly. Because you are using nested thrie beam in that area and we have the narrow post spacing, there is less concern for high rail loads in the area of the proposed splice and short thrie section.

Thus, we believe it would be acceptable to use the shorter thrie beam piece as long as the nesting is retained.

Updating Roadside Design Practices

Question
State: KS
Date: 07-25-2017

KDOT is working on updating our Roadside Design Practices document. One item that has come up in our discussions is when we would recommend evaluating whether or not to shield a culvert located at or beyond the clearzone.

Currently our guidance states if the culvert has a height greater than 8 feet then it is recommended to conduct an engineering study, which may involve using RSAP, to evaluate whether the culvert should be shielded regardless of whether or not it's located at or beyond the clearzone. I know the 8 foot height selected previously was based on the anticipated crash severity of an accident involving a vehicle dropping greater than 8 feet being greater than the severity of accidents where the vertical drop is less than or equal to 8 feet, but I haven't been able to find any research to support the 8 foot height selection.

Are you aware of any research that may have information regarding anticipated crash severity relative to vertical drops? I've read through the RDG and a few studies MwRSF has completed in the past (e.g. Evaluation of Safety Treatments for Roadside Culverts), but didn't find anything that addressed or provided some type of Severity Index directly related to vertical drop.

Any information you, or someone at MwRSF, can provide would be greatly appreciated.

Thanks,

Tom Rhoads

thomas.rhoads@ks.gov

Response
Date: 08-11-2017
We are not aware of any research that specifically defines the severity of vertical drops.

We did look at cost effective treatments for low-volume roads which included analysis of culverts with various heights.

http://mwrsf.unl.edu/researchhub/files/Report8/TRP-03-222-12.pdf

Thanks

MASH TBR guidance

Question

State: IA
Date: 08-11-2017

With the
publishing of recent TBR-related report TRP-03-337-17, I'm trying to combine available MASH TBR guidance into one place and would appreciate a review by MwRSF to confirm this is the current guidance. I've attached schematics that incorporate my understanding discussed below and have included applicable pages numbers.

Full impact
condition where TBR is adjacent to severe drop-off or missing bridge rail
(pages 1, 2, 3, and 4)

Minimum of five segments of TBR on the approach, which may include flaring from tangent to 6:1 (62.5')

Design-specific number of segments protecting the work area,
where work/equipment storage/etc. may begin 80" from back of TBR

Minimum of seven segments of TBR on the trailing end, which may
include flaring from tangent to 6:1 (87.5')

For two-way protection, both the approach and trailing will be a
minimum of seven segments (87.5')

Notes:

- Iowa has decided that a
  severe drop-off is any longitudinal opening greater than 36" that is at least 3" deep. The 36" value attempts to mimic cross-drain pipe guidance under Section 3.4.2.1 Traversable Designs of the 2011 Roadside Design Guide.

- Iowa has decided that the deflection noted for Region A and Region C (132") will be treated as “unlimited" deflection, thus extending the approach (originally three) and trailing (originally five) sections by two sections. The 132" value comes from TRP-03-337-17, top of page 148 and Figure 113 on page 154.

- The 80" value comes from TRP-03-337-17, top of page 154 and Figure 113 on page 154.

- Iowa currently has the 80" value as 45" based on NCHRP 350 testing from TRP-03-113-03, top of page 14 and originally from TRP-03-64-96 bottom of page 45.

- Five segments on approach end from TRP-03-337-17, Figure 113 on page 154 and Figure 114 on page 155.

- Seven segments on trailing end from TRP-03-337-17, Figure 113 on page 154 and Figure 114 on page 155.

- Five and seven segments were previously eight segments (100') from TRP-03-209-09, middle of page 6.

85th percentile impact condition for all other conditions (pages 1, 2, 3, and 4)

Minimum of five segments of TBR on the approach, which may include flaring from tangent to 6:1 (62.5')

Design-specific number of segments protecting the work area, where work/equipment storage/etc. may begin 68" from back of TBR

Minimum of seven segments of TBR on the railing end, which may include flaring from tangent to 6:1 (87.5')

For two-way protection, both the approach and trailing will be a minimum of seven segments (87.5')

Notes:

- Iowa has decided that the
  deflection noted for Region A and Region C (97") of TRP-03-337-17 will be treated as "unlimited" deflection, thus
  extending the approach (originally three) and trailing (originally five)
  sections by two sections. The 97" value comes from TRP-03-337-17, bottom of page 150 and Figure 114 on page 155.

- The 68" value comes from TRP-03-337-17, top of page 154 and Figure 114 on page 155

- Iowa currently has the 68"
  value as 24" based on NCHRP 350 testing from TRP-03-113-03, top of page 14.

- Five segments on approach
  end from TRP-03-337-17, Figure 113 on page 154 and Figure 114 on page
  155.

- Seven segments on trailing
  end from TRP-03-337-17, Figure 113 on page 154 and Figure 114 on page
  155.

- Five and seven segments
  were previously eight segments (100') from TRP-03-209-09, middle of page 6.

Active
testing to reduce deflection

Through additional testing and redesign, there appears to be a chance for the full impact and 85th percentile deflections to be brought down from 80" and 68" to 41“ and 24" using steel tubes, but that design is still under refinement and an end transition has yet to be developed.

Notes:

- The 41" value comes from TRP-03-295-14, bottom of page 247.
- The 24" value comes from TRP-03-295-14, bottom of page 248.

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Anchoring
(pages 3, 4, 5, 6, and 8)

In cases where the combined lateral space requirement for barrier deflection and needed work area cannot be met, the barrier will need to be anchored. Anchoring the barrier will reduce the deflection down to 6" for both impact conditions.

Notes:

- The 6" value comes from TRP-03-180-06, middle of page 89.

Anchor
Transitions (pages 3 and 4)

In cases where only parts of an installation need to be anchored, an anchor transition can be incorporated. This transition takes places over four segments with 1, 2, 3, and 3 anchors on the traffic side, both sides if used as a traffic separator, approaching fully anchored TBR, permanent barrier, or bridge rail. This anchor transition will also apply to certain crash cushions depending on their anchoring mechanism.

Notes:

- Four anchor transition sections from TRP-03-208-10, Figure 4 on page 15.

Deflections
between anchored sections (pages 3, 4, and 7 but specifically page 9)

One point of
discussion that has risen from this is the expected deflection of unanchored TBR between two sections of anchored TBR. This might occur on bridge maintenance projects where the area of concern is only a couple feet longitudinally (replacing a joint for example), but there may be multiple areas of concern along the bridge. In an attempt to avoid anchoring the entire run of barrier, what deflections should be used within the unanchored portions?

Your assistance
in the matter is greatly appreciated. Since this is a lot to digest, if you feel discussion would be better served with a review followed by a conference call, we'd be more than welcoming.

Attachment: https://mwrsf-qa.unl.edu/attachments/443eafaabf2fb17f2d727019fc8e37ed.pdf

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Response
Date: 09-11-2017

I have reviewed the information you sent and have some comments. In general, the details look good.

I have commented below in red in the appropriate sections and have some separate comments as well regarding the layout diagrams that accompanied the email.

1. On the diagram for ROADSIDE APPLICATION – ANCHOR TRANSITION – OPPOSING TRAFFIC NOT WITHIN CLEAR ZONE, there may be potential to reduce or taper the deflection area in the transition region. We know from

previous testing that the deflection in the region of pinned barriers is significantly less than a free-standing PCB.

2. On the diagram for ROADSIDE APPLICATION – ANCHORED– OPPOSING TRAFFIC NOT WITHIN CLEAR ZONE, I should note that we have never analyzed or tested the use of the pinned transition for anchorage of the end of the PCBs. While there is potential for this to work, there may be further study warranted. Unfortunately, the has not been much in terms of other solutions that have been proposed. The development and evaluation of guidance for this area was noted as a research need in the PCB LON study recommendations.

We did develop a MASH TL-3 upstream anchorage that you may wish to consider. http://mwrsf.unl.edu/researchhub/files/Report63/TRP-03-209-09.pdf

A similar comment would apply to the use of the transition as a downstream anchor on several of the layouts. However, as I noted, there may not be a better alternative at this time…

3. On the diagram for MEDIAN APPLICATION – ANCHORED–TRAFFIC SEPARATOR, the use of barriers pinned on both sides for deflection reduction has not been tested to NCHRP 350 or MASH. There have been concerns in the past that doing so may increase the potential for tipping of the barrier which leads to increased vehicle climb and instability. CALTRANS testes their K-rail segment in this configuration under NCHRP 350 and the results were not encouraging in terms of vehicle stability. This type of installation may potential work and there may not be a better alternative. However, further research is likely warranted. I believe we have noted this in previous Pooled Fund position papers and some states have shown interest. It was never funded.

You had also replied with the following:

However, I'm beginning to wonder if this should be discussed as a conference call amongst the pooled fund instead. I think a lot of states will have TBR-related questions and there isn't a reason for you to answer it sixteen different times. I know Kansas has already asked and I doubt we'll be the last ones. This would buy you a little more time and

would (selfishly) help us know what the other DOT's intentions are. Is everyone adopting the larger deflections? Is everyone moving to the tubed rail? Any interest in in-service evaluations of current deflections? I think this would be a great group discussion such that we all proceed as a complete group rather than sixteen different entities.

While I do see the value of getting all of the states on the same page, I am a little reluctant to turn this into a group wide discussion due to the fact that each state tends to have different concerns or preferences on these items. In addition, MwRSF does not typically wish to dictate hardware policies to states, and in many cases, states don't want us to. That is generally better served by the RDG. As such, the discussion you are proposing would need to be more of a discussion of your proposed guidance and MwRSF could provide input and recommendations.

I will be putting this on the consulting web site to help distribute it unless that is an issue for you. If you really feel the desire to have that discussion with the group, I can try to set something up.

I don't know how many states are implementing the reduced deflection system we did for WisDOT. Currently, the transition between that system and the free-standing PCB needs to be completed, so I don't believe it has been widely adapted.

I do believe that several states are working towards implementing the larger barrier deflections as part of the MASH implementation efforts. I also believe this has caused some stress, and this has led to the development of an NCHRP problem statement to develop a MASH TL-3 PCB. We have proposed something similar in the Pooled Fund for several years, but it has not moved to the forefront.

In-service evaluation of work zone devices has been limited, but it would be interesting. I know that a study of work zone encroachments has been proposed several times but has not received funding.

Let me know what you think.

Thanks

Good morning!

With the publishing of recent TBR-related report TRP-03-337-17, I'm trying to combine available MASH TBR guidance into one place and would appreciate a review by MwRSF to confirm this is the current guidance. I've attached schematics that incorporate my understanding discussed below and have included applicable pages numbers.

Full impact condition where TBR is adjacent to severe drop-off or missing bridge rail (pages 1, 2, 3, and 4)

Minimum of five segments of TBR on the approach, which may include flaring from tangent to 6:1 (62.5')

Just a reminder that 6:1 flares were never crash tested or evaluated. This was a recommendation from NCHRP 358.

Additionally, flaring of the barriers outside of the LON may reduce their effectiveness in providing barrier tension in the LON, which would result in potentially larger barrier deflections. However, the research in TRP-03-337-17 required only 3 barrier segments in that region. As you have included an additional two barrier segments, this concern is much less.

Design-specific number of segments protecting the work area, where work/equipment storage/etc. may begin 80" from back of TBR

Minimum of seven segments of TBR on the trailing end, which may include flaring from tangent to 6:1 (87.5')

For two-way protection, both the approach and trailing will be a minimum of seven segments (87.5')

Notes:

- Iowa has decided that a severe drop-off is any longitudinal opening greater than 36" that is at least 3" deep. The 36" value attempts to mimic cross-drain pipe guidance under Section 3.4.2.1 Traversable Designs of the 2011 Roadside Design Guide.

> There is no hard data on vertical drop severity in terms of full-scale testing. Several studies have looked at cost benefit ratios of vertical drops based on ADT. I have attached two studies done at TTI. They may provide additional guidance on what level of vertical drop would be acceptable.

> Additionally, I should note that the 36" lateral opening you note above was based on research and testing of culvert pipes at TTI. Those evaluations were based on a vehicle traversing 36" pipes. If a vehicle attempts to traverse a similar lateral gap at an angle, the actual distance it must traverse becomes greater. Thus, there may be a need to lower 36" gap size.

- Iowa has decided that the deflection noted for Region A and Region C (132") will be treated as "unlimited" deflection, thus extending the approach (originally three) and trailing (originally five) sections by two sections. The 132" value comes from TRP-03-337-17, top of page 148 and Figure 113 on page 154.
- The 80" value comes from TRP-03-337-17, top of page 154 and Figure 113 on page 154.

> The deflection for barrier segments AS1 and AS2 in your "ROADSIDE APPLICATION – UNANCHORED – OPPOSING TRAFFIC NOT WITHIN CLEAR ZONE" detail may be slightly higher than the 80" value listed due to their proximity to the upstream end of the PCB system. Because these barriers are within 7 barriers of the end of the system, the deflection may be closer to the 91" deflection shown for a 14 barrier system in Figure 110 and 113.

- Iowa currently has the 80" value as 45" based on NCHRP 350 testing from TRP-03-113-03, top of page 14 and originally from TRP-03-64-96 bottom of page 45.
- Five segments on approach end from TRP-03-337-17, Figure 113 on page 154 and Figure 114 on page 155.
- Seven segments on trailing end from TRP-03-337-17, Figure 113 on page 154 and Figure 114 on page 155.
- Five and seven segments were previously eight segments (100') from TRP-03-209-09, middle of page 6.

<u>85th percentile impact condition for all other conditions (pages 1, 2, 3, and 4)</u>

Minimum of five segments of TBR on the approach, which may include flaring from tangent to 6:1 (62.5')

Design-specific number of segments protecting the work area, where work/equipment storage/etc. may begin 68" from back of TBR

Minimum of seven segments of TBR on the railing end, which may include flaring from tangent to 6:1 (87.5')

For two-way protection, both the approach and trailing will be a minimum of seven segments (87.5')

Notes:

- Iowa has decided that the deflection noted for Region A and Region C (97") of TRP-03-337-17 will be treated as “unlimited" deflection, thus extending the approach (originally three) and trailing (originally five) sections by two sections. The 97" value comes from TRP-03-337-17, bottom of page 150 and Figure 114 on page 155.
- The 68" value comes from TRP-03-337-17, top of page 154 and Figure 114 on page 155
- Iowa currently has the 68" value as 24" based on NCHRP 350 testing from TRP-03-113-03, top of page 14.
- Five segments on approach end from TRP-03-337-17, Figure 113 on page 154 and Figure 114 on page 155.
- Seven segments on trailing end from TRP-03-337-17, Figure 113 on page 154 and Figure 114 on page 155.
- Five and seven segments were previously eight segments (100') from TRP-03-209-09, middle of page 6.

Active testing to reduce deflection

Through additional testing and redesign, there appears to be a chance for the full impact and 85th percentile deflections to be brought down from 80" and 68" to 41“ and 24" using steel tubes, but that design is still under refinement and an end transition has yet to be developed.

Notes:

- The 41" value comes from TRP-03-295-14, bottom of page 247.
- The 24" value comes from TRP-03-295-14, bottom of page 248.

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Anchoring (pages 3, 4, 5, 6, and 8)

In cases where the combined lateral space requirement for barrier deflection and needed work area cannot be met, the barrier will need to be anchored. Anchoring the barrier will reduce the deflection down to 6" for both impact conditions.

Anchoring the barrier will not bring the barrier deflection down to 6". The 6" number refers to the edge distance from the back of the barrier to the drop-off that was tested. From page 89, “The asphalt tie-down system for use with F-shape temporary concrete barriers was tested with a clear gap of 152 mm (6 in.) between the back side of the barriers and the edge of the vertical drop-off. Therefore, this distance is recommended as the minimum safe distance that the barrier system should be installed from the edge of the asphalt roadway. This

152-mm (6-in.) distance from the back side of the barrier does not reflect the distance for safe installation of the tie-down system adjacent to a rigid hazard. For this type of installation, designers must consider the working width of the system obtained during the full-scale testing."

The 6" number also refers to the asphalt pin tie down. The concrete bolted tie-down uses an edge offset of 1". This system was recently tested to MASH and was successful (Working width = 36.75", dynamic deflection = 14.25", static deflection = 8.25"). The asphalt pin testing to MASH is in que.

Notes:

- The 6" value comes from TRP-03-180-06, middle of page 89.

Anchor Transitions (pages 3 and 4)

In cases where only parts of an installation need to be anchored, an anchor transition can be incorporated. This transition takes places over four segments with 1, 2, 3, and 3 anchors on the traffic side, both sides if used as a traffic separator, approaching fully anchored TBR, permanent barrier, or bridge rail. This anchor transition will also apply to certain crash cushions depending on their anchoring mechanism.

I should note here that the transitions we have developed were never evaluated with crash cushion systems. There may be potential for them to work with the crash cushions, but snag and load transfer to the crash cushion have not been evaluated. As you note, some designs may have better performance than others.

Notes:

- Four anchor transition sections from TRP-03-208-10, Figure 4 on page 15.

Deflections between anchored sections (pages 3, 4, and 7 but specifically page 9)

One point of discussion that has risen from this is the expected deflection of unanchored TBR between two sections of anchored TBR. This might occur on bridge maintenance projects where the area of concern is only a couple feet longitudinally (replacing a joint for example), but there may be multiple areas of concern along the bridge. In an attempt to avoid anchoring the entire run of barrier, what deflections should be used within the unanchored portions?

The value of the deflection between anchored sections has never been defined, it would depend on the length and proximity of the unanchored PCBs to the anchored segments. In TRP-03-208-10, we impacted the upstream end of the transition from free-standing PCB's to concrete median barrier at a location approximately 1 m upstream of the downstream end of the first unanchored barrier segment (barrier no. 5 in that test). The dynamic deflections in that MASH TL-3 test was 44.3 in. at the upstream end of barrier no. 5. Thus, this would be a conservative starting point. As an impact was moved farther from the anchored sections we would expect the deflections to increase to the free-standing PCB deflection of 80". I think it would be reasonable to assume that that increase in deflection occurs over 3-4 barrier segments. This has not been formally analyzed, but it is likely the best answer I have without further analysis.

Your assistance in the matter is greatly appreciated. Since this is a lot to digest, if you feel discussion would be better served with a review followed by a conference call, we'd be more than welcoming.

Attachment: https://mwrsf-qa.unl.edu/attachments/eaa4741b698b71ff77300cd3605f894e.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/e5e8ac9d774ea4ec9c83c0e6458095d3.pdf

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End Terminal Rail Height Determination With Curb

Question
State: NJ
Date: 08-16-2017

NJDOT Standard Construction Detail “CD-609-8A.3 Rail Height Determination" shows rail height where GR is flush with the gutterline to be measured from gutterline. A guide rail offset of 4 feet or greater from curb will be measured from top of curb. There will be a problem connecting to a 31" MASH terminal where guide rail is flush with curb. The terminal height would be measured from top of curb since we cannot bury/lower the terminal. We would have to do a 25' long height transition to connect GR to terminal.

Based on the MASH research and Midwest questions/answers,
can 31" MGS be measured from top of curb where it is flush with 4 inch high curb. What about a lower curb?

I do understand that all MASH terminal manufacturers
(Softstop, SKT, Fleet, etc.) are currently mum on what to do with their terminals with curb. We may have to change our curb height guidelines/details as info comes out. But we need to address the issue above now to the best of our knowledge.

Response
Date: 08-17-2017

I have a few thoughts. Typically, guardrail heights adjacent to curbs with small offsets are measured from the gutterline, while larger curb offsets tend to be measured from the top of curb as noted below.

First some background information. We did a simulation project looking at curbs placed adjacent to energy-absorbing end terminals (http://mwrsf.unl.edu/researchhub/files/Report338/TRP-03-358-17.pdf). The simulation showed some promise that a 4" tall sloped curb (1:1 slope) utilized with a 31" tall MGS measured from the top of the curb (i.e. 35" above the gutterline) would not significantly affect the performance of the end terminal when impacted end-on (MASH tests 3-30, 3-31, 3-32, 3-33). However, none of the simulation models with curbs were validated due to lack of curb traversal tests and full-scale crash tests with end terminals in these configurations. Curbs lower than 4" should further minimize the effect of the curb. For example, Wisconsin uses a 1.5" tall gently sloping curb near end terminals to minimize the effect of the curb on the end terminal performance. Additionally, this study only looked at impact on the end of the terminal. Redirective impacts were not evaluated.

One option is to use no soil backfill behind the curb, but this is usually not desired. This was also not simulated, so the curb may present a snag hazard, especially for eccentric impacts (like test 3-30) where the vehicle yaws significantly.

Although the 27 ¾" height end terminals have not been tested to MASH with this rail height, placing a 27 ¾" height end terminal (measured above the top of the curb) attached to a 31" tall MGS (measured from the gutterline of the curb) would somewhat rectify the problem you are seeing as the terminal groundline features would remain at groundline. However, the 27 ¾" tall end terminals may be a problem if you are trying to meet MASH implementation.

Another research study was done regarding the maximum mounting height for the MGS (http://mwrsf.unl.edu/researchhub/files/Report1/TRP-03-255-12%20(revised).pdf). In that study, 1100C vehicles were safely redirected with guardrail heights of 36". However, not 2270P vehicle testing was done in hat study and it was noted that the increased height could affect the system anchorage.

Thus, to answer your questions below, 31" MGS has only been evaluated with small cars at increased heights like mounted above a 4" curb. The performance of the

increased height system was never fully evaluated under MASH. Thus, the increased heights have not been implemented at this time.

Omission of the curb or the use of lower curbs is likely a better option.

As we see it, there are several options, but some are preferred. I have listed these below in order to preference.

1. The best option with our current knowledge would be to terminate the curb prior to the end terminal. This allows the terminal and MGS to be used at their as-tested heights and provides the best potential for the barriers to perform as designed. As noted in the study above, in lieu of omitting the curb, one could use a minimal or short curb in the area of the terminal to reduce the effect of the curb in that area. Sloped curbs are preferred to vertical ones. For minimal curb heights, some transitioning in height to the standard 31" MGS would be needed after the end of the terminal.
2. The next option would be to install the MGS at 31" relative to the gutterline and use a 27 ¾" terminal. This would minimize the height difference between the terminal and the MGS. The performance of the MGS would be consistent with previous testing. However, the performance of the terminal in this type of installation is unknown, and they have not been evaluated to MASH.
3. A third option would be to install a 31" terminal on top of the curb and then transition in height to 31" MGS relative to the gutter after the terminal. Here the MGS would again be installed at its nominal height for the majority of the installation. However, the performance of a 31" terminal relative to the top of curb has not been tested. The best guidance we have on that application would be the preliminary work noted above.
4. A fourth and least desirable option would be to install both the MGS and the terminal at 31" with respect to the top of the curb. For this option, the performance of both the terminal and the guardrail has not been evaluated.

Please let me know if this addresses your question or if you have further comments.

Thanks

Response
Date: 08-18-2017
Another thought. If we had 2 inch curb at the terminals that were less than or equal to 4 feet from the curb. MGS measured from gutter line and terminal height measured from top of curb. The flared and tangent end terminals are in effect the same as MSG guide rail beginning at the point of redirection at post #3. Could we not do the vertical transition in the last 12.5 feet of the tangent or flared terminal? Instead of doing the vertical transition after the terminal. If yes, we can transition the curb height back to 4 inches within the last 12.5' of the terminal.

This may also be another question for the terminal company.

Response
Date: 08-19-2017

It would be preferred to extend a 2" tall curb the whole length of the terminal (37.5' or 50') and not do the rail height transition until after the whole terminal length so that the transition in curb height and rail height does not affect end-on impacts into the terminal. In some end-on crash tests, the vehicles deflect 50' into the terminal longitudinally. Additionally, in the end-on terminal impacts where the vehicle starts yawing (5 degrees, 0 degrees with a ¼ point impact, etc.), the curb will affect the vehicle and terminal performance some (although we don't really know how much of an effect it will have). Having a rail height transition and a curb height within the first 50' or within the terminal length could further compromise the vehicle and terminal performance, although we don't know how much.

MGS Trailing End Terminal

Question
State: VA
Date: 08-22-2017

A quick question.. There seems to be variations on the size of the bolt and hole in the foundation tube for the wood post support. The original details had a 7/8" diameter bolt with a 1" diameter hole. Some of the later details depicted a 5/8" diameter bolt (also with a 1" diameter hole). Our supplier indicated that the standard configuration that they manufacture is with a 5/8" dimeter bolt with a 7/8" hole. Is this format acceptable.

Response
Date: 08-23-2017

For the trailing end terminal, there may be a couple sets of holes in the foundation tube depending on the drawings you are referring to.

The original hardware guide details for a trailing end terminal with foundation tubes have a hole for a through bolt near the top and a pair of holes for mounting a soil plate farther down. These details show 5/8" bolts and ¾" holes for both. The BCT post has a 7/8" hole in it for reception of the upper bolt hole and bolt in the foundation tube.

We evaluated an updated version of this trailing end anchorage with the MGS (TRP-03-279-13). In that testing and evaluation, the trailing end anchorage used increased foundation tube length and no soil plates. The upper hole in the foundation tube remained ¾" and used a 5/8" through bolt. This hole again for the bolt that goes through the BCT post and serves to bolt the ends of the groundline strut to the foundation tube. A single hole was placed in the lower portion of the foundation tube to prevent the broken post from falling all the way to the bottom of the tube and make removal of the base of the post easier. This hole had a 1" diameter and a 7/8" bolt. The lower bolt on the foundation tube does not serve a structural purpose, and I would not see any reason it couldn't be made a ¾" hole for a 5/8" bolt as well.

Let me know if this addresses you question or if you need more information.

Attachment: https://mwrsf-qa.unl.edu/attachments/85a88d276fc8bbb58d24c9acc19582e6.jpg

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PCB Transition from Freestanding to Anchored

Question
State: FL
Date: 08-22-2017

Has there been any testing or evaluation of portable concrete barrier, specifically the PCB developed by MwRSF, under MASH where it goes from a freestanding to anchored configuration? The detail below shows what FDOT has been doing for several years prior to MASH considerations.

Attachment: https://mwrsf-qa.unl.edu/attachments/b01e4bbb67e3211ab79bc176e65beeaa.jpg

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Response
Date: 08-23-2017

I believe that we did the original development of the NCHRP Report 350 roadside transition from free-standing to anchored PCB with Florida's help under Charles Boyd. It used the pin configuration shown below and thrie beam.

http://mwrsf.unl.edu/researchhub/files/Report133/TRP-03-180-06.pdf

The roadside version has not be re-evaluated under MASH TL-3. We did develop a median version of the transition through the Midwest Pooled Fund that was tested to MASH. See below.

http://mwrsf.unl.edu/researchhub/files/Report54/TRP-03-208-10.pdf

We are also currently evaluating the use of the bolted tie-down for concrete surfaces and the asphalt tie-down for the F-shape PCB under MASH TL-3 in cooperation with Wisconsin. The bolted tie-down met MASH TL-3 and the asphalt pin tie-down is being constructed currently and should get tested this fall.

TCSB Condition Inspection

Question
State: KS
Date: 08-23-2017

I've been working on developing some KDOT guidelines for
TCSB condition inspection to help KDOT's engineers in the field determine whether or not to accept or reject TCSB on KDOT projects. The attached guidance is based on information available from ATSSA/MwRSF/FHWA. Can you, or someone at
MwRSF, please review this and provide your thoughts/feedback as needed? It's only a few pages with pictures/bullet points so hopefully it won't be too onerous…

Attachment: https://mwrsf-qa.unl.edu/attachments/20707c78b19fe95d9639792ea02477df.pdf

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Response
Date: 09-07-2017

I looked through your document and think it looks pretty good in general. This is an issue for many states, and no formal research has been done to provide consistent guidance from state to state. We have proposed this in the past, but it has never received enough traction to get funded.

My main concern is that the guidance may not be detailed enough that someone will be able to clearly denote whether the barrier needs to be replaced or not. Of course you have no hard data to support that type of detail either, so it is a bit of a catch 22. However, things such as clarifying crack width and length, critical locations of damage, and other details may allow for easier determination of adequate barrier condition for use.

I have some other comments below.

1. Under the marginal TCSB guidance:
    a. You note that the cracks should not propagate through the both sides of the barrier. You may want to be more stringent and note that superficial or surface cracks are preferred and that cracks should not extend more than ½ way through the section.
    b. I would maybe note to limit the disengagement of concrete around the toes to less than a 3" triangular section in order to maintain the interlock of the barrier segments as they rotate when impacted. We believe that disengagement or loss of the toe section of the barrier can increased barrier deflection significantly.
    c. I would not want to have any exposed rebar on a system due to concerns with the lack of effectiveness of the reinforcement without engagement of the concrete and corrosion.
2. In the Q&A section on the final page, there may be some concerns with having an unacceptable barrier on one face and acceptable on another. For example, if the toes are disengaged on the non-impact side face, there would still be concerns for increased barrier deflection. Similar concerns would exist for concrete damage near the loop connections.

Many other states have similar details. You may want to look at the attached files. One of them contains a summary of guidance from many states and may be useful to get a consensus on what guidance others have been using.

Let me know if that helps or if you need more information.

Attachment: https://mwrsf-qa.unl.edu/attachments/1b7cb80b34c246781f5b2fb42bcc05a2.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/de87e74bef0d2eb9d4fde93dd761c863.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/13885b6dcc89cfbb7e3f06d77d89d49f.pdf

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Tall median barriers and appropriate levels of dynamic load

Question
State: VA
Date: 08-25-2017

Gentlemen:

As part of our pooled fund tech support from MWRSF, I have
some questions related to median barriers, but I want to have the new research out of TTI related to TL-4/TL-5 moment slabs be considered so I have sent this to both TTI and MWRSF to get a more broad perspective… I hope that is OK.

Our roadway folks would like to have a median barrier on our
bridges that performs as both a bridge barrier and a glare screen. They want it to be a minimum of 50" high and be suitable for a TL-4 impact. We do not have bridge barrier details for barriers taller than 42" except for our 54" TL-5 pier protection barrier (nobody wants to build that barrier because of the high levels of reinforcing we have required details in the attachment).
They want a much lighter level of reinforcing because TL-4 has a much smaller horizontal load. They have proposed 2 alternatives from another state (details in the attachment). There is such a great difference between the two barriers that I think I need some questions answered.

So…

I have attached a file that collects some of our details in coherent fashion (I hope). And I am asking a few questions related to how we might accomplish everyone's deepest desires for this project. Some of these questions may be more of a best practices approach than what is specifically required in the AASHTO LRFD Spec in Chapter 13.

1. Is there a problem with having an F shape barrier transition to a vertical face above 32" (or 36" for MASH) as is shown on page 1 of the attached.

2. If we call something a “split median barrier" shouldn't it still be treated as 2 barriers? I don't have a combination barrier do I? The 2 separate barriers each needs to meet all crash testing and design criteria. In other words, I can't treat the pair of disconnected barriers as a single element and I can't just design the top of the barrier to fail and be propped up by the barrier in the other direction.

3. From a best practices perspective (i.e. Justified by testing but not in the LRFD Specification), if I increase the height of a TL-4 F-shape barrier from a MASH

minimum of 36" (required by testing) to 50" (or more) for the purposes of glare, it will absorb a much bigger load when hit by the design vehicle. And to perform as intended when hit by a TL4 sized box truck, it should be designed for a higher load (based on the new TTI research).

4. To be safe, and not to potentially snag the design vehicle, and to not to leave a big failed region of concrete at the top of the tall barrier, I should increase the dynamic force being applied to the barrier and detail reinforcing to resist that increase dynamic force. (In other words, there is no free pass to arbitrarily increase the height of any barrier; increases in height are followed by commensurate increases in load. The increases are currently identified in stepwise fashion in the yet to be published NCHRP report and are proposed for inclusion in the LRFD specification but are not currently part of the specification.)

5. Under the existing LRFD Specification (including direction outside of Chapter 13) is there any language requiring an increase in force as the height of the barrier is increased? I don't see it, but I don't want to miss it if it is there.

6. Is there a recommended minimum thickness of concrete for either TL-4 or TL-5? (what thickness should the top of the barrier be, is there a number below which we should not go)? One of the issues that I am concerned about is that the top just fails due to shear as the thickness gets smaller and smaller, especially if the FDOT style U shaped bar is used with the straight tips at the top of the barrier where there is limited development length and a thin section as is proposed on pages 6 and 7.

7. Is
a single layer of rebar appropriate at the top of a barrier or should the top always have enough thickness to have 2 layers of bars? (this is related to how thin is too thin above).

Thank you for your time in advance. I think the answers are mostly straight forward but I can't be 100% sure. I hope that you can help me out.

Attachment: https://mwrsf-qa.unl.edu/attachments/feac671e87537b340f4dcab15695717f.pdf

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Response
Date: 09-07-2017

Please see my comments below!

. Is there a problem with having an F shape barrier transition to a vertical face above 32" (or 36" for MASH) as is shown on page 1 of the attached.

There have been a few transitions between F-shape and vertical barriers. Often, a bridge rail or roadside barrier are transitioned to a buttress where an approach guardrail transition connects to the a vertical-face barrier.*[andy.zickler]* so this detail will provide safe and smooth redirection as long as the steel detailing and concrete mass are sufficient to hold the barrier together?

2. If we call something a “split median barrier" shouldn't it still be treated as 2 barriers? I don't have a combination barrier do I? The 2 separate barriers each needs to meet all crash testing and design criteria. In other words, I can't treat the pair of disconnected barriers as a single element and I can't just design the top of the barrier to fail and be propped up by the barrier in the other direction.

   In general, both barriers would need to be treated separately unless you ensured that they behave as one barrier throughout the length.*[andy.zickler]* I am not sure how I could get them to “behave as one barrier". I would like to discuss further.

3. From a best practices perspective (i.e. Justified by testing but not in the LRFD Specification), if I increase the height of a TL-4 F-shape barrier from a MASH minimum of 36" (required by testing) to 50" (or more) for the purposes of glare, it will absorb a much bigger load when hit by the design vehicle. And to perform as intended when hit by a TL4 sized box truck, it should be designed for a higher load (based on the new TTI research).

   At 39 to 42", we would design the barrier for 80 kips using the new NCHRP 22-20(2) loads. If at 50 to 54", our TL-4 design loads would be higher, say 93.3 kips.*[andy.zickler]* so say 95kips as a load to consider for the yield line analysis. As these numbers go up I get concerned about punching through, especially since failures in the field tend to look more like punching shear issues than flexural failures.

4. To be safe, and not to potentially snag the design vehicle, and to not to leave a big failed region of concrete at the top of the tall barrier, I should increase the dynamic force being applied to the barrier and detail reinforcing to resist that increase dynamic force. (In other words, there is no free pass to arbitrarily increase the height of any barrier; increases in height are followed by commensurate increases in load. The increases are currently identified in stepwise fashion in the yet to be published NCHRP report and are proposed for inclusion in the LRFD specification but are not currently part of the specification.)

   As noted above, the taller MASH TL-4 barrier would resist an 93.3-kip load but at 39 – 42" resist 80 kips. Punching shear near the top of the barrier may be the only other minor concern. However, I am not overly concerned with it if you use 93.3 kips on a tall barrier.*[andy.zickler]* following up on your last sentence about not being overly concerned… is that because the “d" required to exceed the moment requirements would result in a section that is thick enough to withstand a punching shear failure?

5. Under the existing LRFD Specification (including direction outside of Chapter 13) is there any language requiring an increase in force as the height of the barrier is increased? I don't see it, but I don't want to miss it if it is there.

   NCHRP 22-20(2) provided this guidance, as noted in prior emails from TTI and attached.*[andy.zickler]* I am looking for direction inside of the LRFD specification. I have design build contracts that require the designs to meet the specification but they don't have to exceed it. I am looking for spec language that would help us to require parapet designs with forces greater than 54kips when the parapets are very tall.

6. Is there a recommended minimum thickness of concrete for either TL-4 or TL-5? (what thickness should the top of the barrier be, is there a number below which we should not go)? One of the issues that I am concerned about is that the top just fails due to shear as the thickness gets smaller and smaller, especially if the FDOT style U shaped bar is used with the straight tips at the top of the barrier where there is limited development length and a thin section as is proposed on pages 6 and 7.

   **For the top of a TL-4 barrier, I might say that a 7 to 8" top thickness may be close to a minimum width to fit bent and straight bars in region with adequate cover. Slightly thicker that 7 to 8" would be preferred. We are working on a similar effort and will be showing preliminary results soon. I will ask for Jeremiah Dixon to add any comments based on his current research. This is good news.

7. Is a single layer of rebar appropriate at the top of a barrier or should the top always have enough thickness to have 2 layers of bars? (this is related to how thin is too thin above).

   We have worked toward always providing a dual layer of vertical reinforcement near the top of the barrier. However, there could be scenarios where only one layer would work with the load imparted lower on the barrier face.*[andy.zickler]* you seem to be leading to something like “but when the load is applied higher two layers of rebar will be required to be most effective or efficient.

   **Once you review the comments, we may want to further discuss over the phone, if desired.

Vegetation Behind Barrier Systems

Question
State: NE
Date: 09-05-2017

At what point would the
vegetation behind the guardrail be too thick that it may change the way the guardrail works?

Varying degrees of …

Trees: 4"+ as in the
roadside design guide.

Evergreen bushes: Does size of
the braches or height have guidance?

Shrubs: ?

Grasses: ?

Attachment: https://mwrsf-qa.unl.edu/attachments/3f519827d30bf504408d9e28ee0238df.JPG

Attachment: https://mwrsf-qa.unl.edu/attachments/05348da38e92f062496ac8a452c1e4f7.JPG

Response
Date: 09-06-2017

Here is my first impression:

I would expect small annual and perennial flowers to be acceptable and not drastically change vehicle-barrier performance.

I would expect small to medium, largely-spaced bushes (shrubs) or medium to tall, moderately-spaced natural grasses to be acceptable and not drastically change vehicle-barrier performance.

I may expect large, largely-spaced bushes or tall, closely-spaced, clumped, natural grasses to be acceptable and minorly change vehicle-barrier performance.

I may expect large, closely-spaced bushes to be marginally acceptable and cause concern for vehicle-barrier performance.

I may expect small, largely-spaced trees to create marginal safety performance and moderately change vehicle-barrier performance.

I would expect presence of 2 to 4" diameter trees near barriers to cause concerns: ramping, excessive OIV, etc.

Nebraska transition using synthetic blockouts

Question
Date: 09-18-2017

Do you have any suggestions for blockout materials on the Nebraska transition you guys came up with? We need an alternative to wood blockouts in some cases, such as in wet climates where rotting is an issue.

Attachment: https://mwrsf-qa.unl.edu/attachments/29553f4b24b8d6fbec3f72bc17103e0a.pdf

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Response
Date: 09-20-2017

For a replacement to wood blockouts in approach guardrail transitions, one could use steel sections. In the mid to late 1990s and later in mid 2000s, we used a steel tube shape (TS7x4x3/16) with sloped top for blockouts that matched up to W6x9 steel transition posts.

http://mwrsf.unl.edu/researchhub/files/Report84/TRP-03-47-95.pdf

NCHRP 350

http://mwrsf.unl.edu/researchhub/files/Report61/TRP-03-69-98.PDF

NCHRP 350

http://mwrsf.unl.edu/researchhub/files/Report148/TRP-03-175-06.pdf

MASH

For W6x15 posts, one might use (1) a steel tube section of similar depth to wood section and shortened length or (2) a WF section of similar depth to wood section and shortened length with a backup plate between rail and block. The shortened blocks have been used in the stiffened thrie beam region.

Let us know what option you like best so that we can suggest a few options. 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

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!

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!

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

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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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