Midwest States Pooled Fund Program Consulting Quarterly Summary

Midwest Roadside Safety Facility

01-01-2005 to 04-01-2005

USH 12 Lake Delton Vertical Concrete Barrier

Question

State: WI
Date: 01-18-2005

The attached PDF files show a vertical face barrier design proposed for construction. Since we have limited experience with vertical face, I would like to get your comment on this design. The highway in question is an NHS and we would like the design to meet TL3. Thanks and have a great year

Attachment: https://mwrsf-qa.unl.edu/attachments/2bb2ed413f54c0d9d9f752af8c64a1ef.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/e0609f21d11ea2807c487c52a7b854fe.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/cadf977a0393bdb7fc5c4ccd6ceb6dd8.pdf

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Response

Date: 01-19-2005

Ron and I reviewed you question and came up with the following response. Before I comment on the proposed system, it should be noted that MwRSF has a new Pooled Fund project to develop, test, and evaluate a concrete barrier for use in protecting bridge piers.

The proposed vertical concrete barrier is 15.75-in thick by 42-in. tall and reinforced by three longitudinal No. 4 rebars and anchored to an edge slab with No. 8 vertical dowel bars (10.5 in. in barrier and 7.5 in. in slab). The vertical dowel bars are spaced on 18-in. centers. It is my understanding that the Wisconsin DOT desires to use this barrier to protect bridge piers and needs the barrier to meet Test Level 3 of NCHRP Report 350.

From a very brief review, it is noted that the cross-sectional area of the thick barrier is 661.50 sq. in. Therefore, the approximate shrinkage and temperature steel requirements for longitudinal reinforcement is a minimum of 1.19 sq. in. Thus, approximately six No. 4 longitudinal bars, versus three, would be required for this large cross section in order to prevent significant cracking and gaps from forming in the barrier. Although not determined, it is very likely that a 15.75-in. wide barrier measuring 42-in. tall would be capable of meeting the TL-3 requirements when reinforced with six longitudinal No. 4 bars for interior locations. In addition, if designed using the yield-line analysis procedures, it is believed possible to further reduce the thickness and still not require crash testing. At the present, there exists no vertical reinforcement in the barrier. Although it has been shown on occasion that concrete barriers with limited or no reinforcement have met crash testing guidelines, it is reasonable to utilize a minimum amount of vertical reinforcement for temperature and shrinkage considerations as well as to tie the wall to the dowel bars. Steel reinforcement for the barrier located away from the interior regions, such as at gaps, joints, or end sections, must also be considered since a reduced redirective capacity exists in those regions.

For 42-in. tall vertical walls, it is becoming more known that new designs should address or consider the potential for an occupant's head to extend out of the side window and impact the concrete barrier above the 32-in. height. Thus, setbacks near the top of the wall should be considered although they are not required.

I have provided a few comments and considerations on the proposed design. Please feel free to contact me at your convenience!

Nested W-Beam Long Span Guardrail for Low Fill Culverts

Question

Date: 01-21-2005

I have several questions regarding details on the Nested W-Beam Long Span Guardrail for Low Fill Culverts from the attached acceptance letter I hope you can clarify so we can finalize our drawings and implement the system:

Question No. 1

With a 1450 dynamic deflection, should the 0.6m ledge behind the guardrail posts be increased to (1.0m or 1.5m) to accommodate the increased deflection. I assume the foreslope beyond the ledge can be 2H:1V or flatter? Typically for w-beam guardrail systems, our practice inOntario is to permit the 3H:1V or flatter foreslope behind the guardrail to start immediately behind the posts - 2H:1V slopes not permitted within deflection zone of system.

Question No. 2

With respect to the use of 7,620-mm long, W-beams, would it still be acceptable to use 3,810-mm long, W-beams throughout? If it is necessary to use any 7620mm long w-beams, we would likely specify their use from post 5 through post 18.

Question No. 3

What was the rationale for the 7,620-mm long, W-beam between posts 18 and 22? I would have thought the installation (for the nested W-beam segments) would have been symmetrical about the mid span point between posts 11 and 12?

Question No. 4

What is the size of the holes for Posts 9 to 14?

Question No. 5

Any recommendations on how close post 11 and 12 could be placed to a culvert. We were thinking of specifying 0.5m min. clearance from post 11 and 12 to the culvert, as we understand the posts rotate mainly in a lateral direction in an impact.

Question No. 6

Any thoughts on how you will shift the post spacing to tie into MGS with posts at the 1/4 span points, or will it involve a complete retest of the low fill culvert design at the MGS height of 31"?

Question No. 7

Any chance of obtaining an mpeg of the crash test through e-mail? I have a copy of the 12 minute VHS tape from you on the Ohio Long Span Guardrail which I could convert to a 30 second or 1 minute segment into an mpeg, but if you have an mpeg or avi ready to go, that would be great.

Response

Date: 01-21-2005

Response No. 1

For*standard*, strong-post, W-beam guardrail systems, it is recommended that the guardrail posts be placed in level or mostly level roadside shoulders, say 10H:1V or flatter. Behind the guardrail posts, it is generally recommended that 24 in. of soil fill be provided so that adequate post-soil forces can be generated to ensure the proper vehicle containment and redirection by the barrier system. At this time, we do not have any information indicating that a width of level fill greater than 0.6 m (24 in.) be provided behind the CRT posts used in long-span guardrail systems and adjacent to the unsupported length. Beyond the 0.6 m (24 in.) ledge, a fill slope of 3H:1V or steeper could be located, that of which is shielded by the roadside barrier system.

Response No. 2

MwRSF crash tested the long-span guardrail system using 3,810-mm (12-ft 6-in.) long, W-beam rail sections over the unsupported length as well as directly adjacent to the long span in order to create a worst-case test condition in the middle of the unsupported span. This selection positioned a rail splice at the center of the 7,620-mm (25-ft) long span. In summary, you can choose to either implement or not utilize a rail splice within the unsupported length of nested guardrail.

Response No. 3

For crash testing, the long-span guardrail system was constructed with 30.48 m of nested W-beam rail. On the crash-tested installation, two 7.62-m long, single, W-beam rails or 15.24 m total were placed upstream of the nested region, while one 7.62-m long, W-beam rail was placed downstream of the nested region. This configuration provided an asymmetrical configuration about the centerline of the system which was believed to be more common in actual field installations (i.e., more length on the upstream side than on the downstream side). Typically, longer guardrail runout lengths would be required on the upstream end of the obstruction. The system could be installed in a symmetrical manner with a standard guardrail terminal placed beyond each end of nested W-beam rail. For two-way traffic, a guardrail terminal could be located on the downstream end starting at the nested location. Adequate runout length to accommodate reverse direction traffic would still need to be determined.

Response No. 4

MwRSF uses 90-mm (3 1/2-in.) diameter holes for CRT timber posts.

Response No. 5

The crash tests described in the test report and TRR journal paper were performed on a test installation that did not include a concrete box culvert, headwall, and wingwall. In actual field applications, a concrete headwall would typically extend above the low-fill soil, run parallel to the roadway, and prevent the soil from eroding over the culvert end. In this situation, if the headwall is placed too close to the guardrail, the potential exists for the vehicle's wheel or fractured CRT posts to contact the headwall. If significant wheel contact occurs with the headwall or post debris striking the headwall, vehicular instabilities or rollover may result. Analysis of the OLS-3 crash test results revealed a maximum lateral dynamic rail deflection of 1.45 m. During this event, the vehicle's right-front wheel was also found to protrude under the deformed guardrail. In order to minimize or eliminate the potential for wheel contact on the culvert headwall or post debris wedged between the headwall, the back face of the guardrail should be positioned a minimum of 1.5 m away from the front face of the headwall.

Future research is planned and funded within the Midwest States Regional Pooled Fund Program to adapt the Midwest Guardrail System to long-span applications and determine whether the barrier system can be positioned closer to the curlvert headwall.

Response No. 6

MwRSF researchers believe that the entire guardrail system utilized before, within, and after the culvert structure will consist of the Midwest Guardrail System spaced on 1,905-mm (75-in.) centers. For this taller system with an unsupported length and closer placement near the curlvert headwall, it is believed that full-scale vehicle crash testing with a 2000P vehicle will be required.

Response No. 7

MwRSF has several *.avi files for the successful full-scale vehicle crash test (test no. OLS-3). However, due to the size of those files, I will copy those files to a CD-ROM and mail them to you.

Temporary Concrete Barrier Guidelines

Question

State: FL
Date: 01-26-2005

I need to show on my standards the minimum number of KTB's required for each type of crash tested installation. Disregarding end treatments (crash cushions, end flares, etc.), in order to get the expected performance seen in the crash tests, how many barrier units would be required for:
1. Freestanding installations (I seem to recall we talked about 9 units for transitions)
2. Bolted down installations
3. Staked down installations
4. Back filled installations
I also need to know how many barrier units are needed for each installation type when used in combinations and transitions:
1. Freestanding to bolted or staked down
2. Freestanding to back filled
3. Bolted down to staked down (no transition required?)
I recognize that we won't know some of these numbers for certain until after the transition crash test is conducted.
Using these numbers, I'll develop some drawings showing transitions along with alignment and length of need requirements for both approach and trailing ends. This could get really messy when considering transitioning from say freestanding to bolted down and back to freestanding again. An example could be along a short bridge where we can only bolt down three or four barrier units and then must transition to staked or freestanding units. The three or four bolted down units would not be enough if that's all that was there but when used in combination with the transition or freestanding units at each end, the combination may be okay. See my problem?
I'll put together some drawings that show some expected real world configurations and try and work out how it will all look. It will be after the first of the year before I get to it though.

Response

Date: 01-26-2005
You ask some good questions about the number of barriers required for various barrier installations. Let me preface our discussion by stating that this issue has never been fully addressed through research. Impacts upstream of the length-of need (LON) have not been tested to date. The barriers have traditionally been tested in a certain configuration with a certain number of barriers upstream of the beginning of the LON. Therefore, the numbers I am recommending for the installations you asked about are estimates of the number of barriers upstream of the beginning of LON based on engineering judgment by MwRSF.
Let's tackle the first four installations first, remembering that we are disregarding end treatments.
1. Free-standing barrier installations
- As I stated above, studies of impacts prior to the LON have not been studied at this time. All testing of the free-standing PCB designs has used 7-8 segments upstream of the beginning of the LON. For testing of the MwRSF F-shape barrier, there were approximately 7.5 barriers upstream of the beginning of the LON. Based on these successful crash tests, MwRSF would recommend a minimum of 7.5 F-shape barrier segments upstream of the beginning of the LON.
2. Bolted down installations

- The discussion of the bolted tie-down barriers follows a similar argument. Again, no studies of impacts prior to the LON have been conducted for these types of barrier systems. In reviewing our bolted tie-down test (test no. KTB-1), it was observed that we had movement of 4 of the barriers in the impact region. Based on this movement and the lack of further testing, we believe it would be prudent to use 2.5 bolted tie-down barriers upstream of the beginning of the LON. This number of bolted down barriers would provide for the deflected barrier segments and an additional barrier for upstream anchorage.
3. Staked down installations
- The staked down installation would require 2.5 tie-down barriers upstream of the beginning of the LON as well. Review of the full-scale testing (test no. FTB-1) showed deflection of 4 barrier sections. This number of bolted down barriers would provide for the deflected barrier segments and an additional barrier for upstream anchorage.
4. Back filled installations
- We do not have any test data on back-filled temporary concrete barriers. However, it seems reasonable to assume that this type of installation will perform similarly to the bolted tie-down system. As such, we are recommending 2.5 tie-down barriers upstream of the beginning of the LON for this installation.
You also asked about some transitions and barrier combinations. As stated above, it is very difficult to give an accurate answer to these questions without further testing, but we have made some recommendations below.
1. Freestanding to bolted or staked down
- For a free-standing barrier installation to a bolted or staked down installation, we would recommend the transition design currently under development here at MwRSF. This transition calls for 13 free-standing barriers attached to 4 transition barriers prior to attachment to the bolted or staked tie-down barrier or a rigid barrier. A schematic of this installation is attached. This would make for total of 17 barriers leading up to the bolted/staked or rigid barrier.
2. Freestanding to back filled
- The same type of transition and number of barriers would be required for a free-standing to back-filled installation as the freestanding to bolted or staked down described in no. 1.
3. Bolted down to staked down (no transition required?)
- For an installation of staked tie-down transitioning to bolted tie-down, the transition described above would not be necessary. The only transition needed for this installation would be to install the 12'-6" thrie beam sections across the joint between the staked and bolted barriers as shown in the figures of the full transition design. The use of the thrie beam should prevent rotation of the joint between the differing sections. This may not be necessary, but without further testing or evaluation, we feel we need to be conservative in our recommendations.
I hope this guidance helps answer some of your questions and gives you a start on your standards. These recommendation are our best engineering judgment at this time and could change based on future test results. Again, this is an area that really needs to be further studied through research to give the states better guidelines. The best solution to these issues would be the development of effective termination and end anchorage for temporary concrete barriers. However, that work has been proposed in the past and has not found a champion.

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Attachment: https://mwrsf-qa.unl.edu/attachments/0239ad1dff2d58065f017371f27d8879.jpg

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Very Shallow Guardrail Post at Subsurface Obstruction

Question

State: MO
Date: 02-10-2005

The following is a description of my guardrail repair situation. Location photos are attached.
Object being shielded is an existing retaining wall 2 feet off right edge of roadway shoulder.
Existing guardrail totally destroyed in vehicle crash.
Existing rail was offset 5 to 10 feet behind curb and "U-shaped" gutter.
New guardrail will be installed along edge of shoulder with posts through the "U-gutter" and face of rail blocked out in front of curb face.
"U-gutter" behind curb and guardrail will be filled with rock to provide smooth transition from pavement to roadside without a dropoff behind curb.
New guardrail will attach to wall with a thrie-beam shaped bridge anchor section, then thrie beam/w-beam transition section, then 87.5 feet of w-beam guardrail, then 50 foot crashworthy guardrail end terminal (ET-2000).
A new 10 foot section of concrete barrier was poured at end of retaining wall to provide solid attachment for new bridge anchor section.
Approximately 50 feet upstream from the wall is a 48 inch drainage pipe that crosses at right angles to the roadway approximately 24 inches deep.
Guardrail post falls directly on the pipe (we drilled into pipe).
We are unable to offset post due to equipment mobilization issues which preclude us from drilling any more holes through concrete "U-gutter".
I would like to either skip this conflicting post or use a short post on top of the pipe. Please review and provide a response for how best to handle the conflicting post.

Attachment: https://mwrsf-qa.unl.edu/attachments/ab8714ef18a871ae99343e79ff4e597d.JPG

Attachment: https://mwrsf-qa.unl.edu/attachments/990e5c8d53f640843976851be1d66b0c.JPG

Attachment: https://mwrsf-qa.unl.edu/attachments/27ce35cd04236fa7d214f8d1eafb1ba1.JPG

Response

Date: 02-11-2005
As we discussed on the phone, one short post in the middle of a run of guardrail should not need any other treatment. In order to be safe, you should consider nesting the W-beam for 25 ft over this region.
I noticed that there is a curb all along this section. The current recommended treatment for curbs is to incorporate nested rail throughout the entire area where there is a curb.

Temporary Concrete Barrier LON

Question

State: KS
Date: 03-09-2005

Do you have any guidance on appropriate LON for temp. concrete safety barrier. We typically use the RDG guidelines which seems excessive. Would this be a good candidate for a pooled fund project?

Response

Date: 03-15-2005
There are really two related issues at work when we look at the LON for PCB installations. First, there is the amount of barrier required to effectively shield the hazard. This is specified by the RDG. Dr. Sicking came up with some more reasonable guidelines for LON in the past and we feel very comfortable with these as well. The second issue deals with the beginning of the LON for PCB's. Because PCB's do not have a standard end termination with anchorage, it is difficult to determine where safe redirection of impacting vehicles begins. However, we can make some suggestions based on past testing and experience. FLDOT requested recommendations on this issue earlier this year and I have copied our response to them below. Basically, these recommendations layout the number of barriers needed to effectively redirect a vehicle impacting at the beginning of the LON.

Therefore, the answer to you LON for PCB questions is that the basic LON can be determined by either the RDG or Dr. Sicking's LON recommendations. Then it becomes necessary to install a number of barriers upstream of the beginning of LON in order to insure effective redirection along the entire LON. Our best recommendations for these upstream barriers are given in the email to FLDOT below.

This has been a big issue for a while now and there is no well researched effective answer. These issues could possibly be resolved through further research and testing to determine a more exact number of barriers for both the LON and the barriers upstream of the LON. The best solution for this problem would be the development of an effective anchorage and end termination for PCB's. This would provide safe termination of the barriers and would allow us to more accurately determine the LON in a manner similar to the guardrail recommendations.

I do believe that this would make an excellent pooled fund project. It is a question that needs to be answered for many state DOT installations. Dean has suggested this as a possible topic for this years pooled fund meeting. I would recommend discussing this issue with some of the other states to get their support. I do know that FLDOT has expressed a great deal of interest in this topic and might be willing to contribute if necessary.
