Third Quarter 2004 Progress Report
Midwest Roadside Safety Facility
Mid-States Regional Pooled Fund
November 23, 2004

YEAR 12

Development of a Guardrail Treatment at Intersecting Roadways-Year 3

The system, augmented by an anchor placed near the center of the radiused section, will utilize a release mechanism similar to the cable terminal currently being tested under Year 14. This anchor will significantly reduce system deflection during impacts on either side of the radiused section and should still allow the system to capture a vehicle impacting on the “nose”. The system is fully constructed waiting for dryer weather, hopefully in the 4th Quarter.

Portable Aluminum Work Zone Signs

The bogie testing for this project has been completed. A submission to FHWA seeking approval has been sent. Polivka, K.A., Faller, R.K., Holloway, J.C., and Rohde, J.R., ***Safety Performance Evaluation of Minnesota’s Aluminum WorkZone Signs***, Final Report to the Midwest State’s Regional Pooled Fund Program, Transportation Research Report No. TRP-03-107-01, Project No. SPR-3(017)-Year 11, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, January 29, 2002.

Single-Faced Concrete Barrier

Faller, R.K., Sicking, D.L., Larsen, J., Rohde, J.R., Bielenberg, R.W., and Polivka, K.A.,***TL-5 Development of 42- and 51-IN. Tall Single-Faced, F-Shape Concrete Barriers***, Draft Report to the Midwest State’s Regional Pooled Fund Program, Transportation Research Report No. TRP-03-149-04, Project No. SPR-3(017)-Year 12, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, February 18, 2004.

MGS W-Beam to Thrie-Beam Transition Contingency 2000P test and Additional 820C Test

A full-scale test of this system was conducted on July 29th. As shown in the sequential photos below, the pickup penetrated the system, rupturing the rail and came to rest behind the system. Subsequent finite element modeling has shown that the current asymmetrical W-Thrie beam adapter is inadequate to withstand the impact. This current section is simply a modified Thrie section and very little bending capacity. Over the next quarter a new W-Thrie section will be designed and fabricated.

Three-Strand Cable Median Barrier

Additional bogie tests have been performed during the quarter. The objective of this effort was to increase the capacity of the connection of the cable to the posts. Increasing the capacity of this connection will make the cables located on the opposite side of the post effective. Full-scale testing of the modified system is anticipated early in the Fourth Quarter.

Year 13

Generic W-Beam Guardrail with Curb

Polivka, K.A., Faller, R.K., Sicking, D.L., Reid, J.D., Rohde, J.R., Holloway, J.C., Bielenberg, B.W., and Kuipers, B.D., ***Development of the Midwest Guardrail System (MGS) for Standard and Reduced Post Spacing and in Combination with Curbs***, Draft Report to the Midwest State's Regional Pooled Fund Program, Transportation Research Report No. TRP-03-139-04, Project No. SPR-3(017)-Years 10, 11, 12-13, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, February 17, 2004.

Open Railing Mounted on New Jersey Concrete Barrier (2'8")

Currently there is not additional funding for further development so our plan is to report on the two unsuccessful tests and look for recommendations during the next year's annual meeting.

Evaluation of Rigid Hazards in Zone of Intrusion

Previous full-scale TL-3 and TL-4 crash tests of a luminaire pole mounted on top of a single-slope concrete barrier have been acceptable. The final test TL-4 in this project of a luminarie pole mounted on the deck behind the barrier is planned for the 1st Quarter of 2005.

Three-Cable Guardrail

This project is on hold pending results of the post bogie testing being performed under the median cable barrier project in Year 12.

Non-proprietary Guardrail System – Additional Test

Polivka, K.A., Faller, R.K., Sicking, D.L., Reid, J.D., Rohde, J.R., Holloway, J.C., Bielenberg, B.W., and Kuipers, B.D., ***Development of the Midwest Guardrail System (MGS) for Standard and Reduced Post Spacing and in Combination with Curbs***, Draft Report to the Midwest State's Regional Pooled Fund Program, Transportation Research Report No. TRP-03-139-04, Project No. SPR-3(017)-Years 10, 11, 12-13, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, February 17, 2004.

Kansas Temporary Barrier Redesign and Test

Polivka, K.A., Faller, R.K., Rohde, J.R., Holloway, J.C., Bielenberg, B.W., and Sicking, D.L., ***Development and Evaluation of a Tie-Down System for the Redesigned F-shape Concrete Temporary Barrier***, Final Report to the Midwest States Regional Pooled Fund Program, Transportation Report No. TRP-03-134-03, Project No. SPR-03(017)-Year 13, Sponsoring Agency Code RPRP-03-06, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, NE, August 22, 2003.

System for Stiffening New Guardrail System

Polivka, K.A., Faller, R.K., Sicking, D.L., Reid, J.D., Rohde, J.R., Holloway, J.C., Bielenberg, B.W., and Kuipers, B.D., ***Development of the Midwest Guardrail System (MGS) for Standard and Reduced Post Spacing and in Combination with Curbs***, Draft Report to the Midwest State's Regional Pooled Fund Program, Transportation Research Report No. TRP-03-139-04, Project No. SPR-3(017)-Years 10, 11, 12-13, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, February 17, 2004.

YEAR 14

Development of a Four-Strand High-Performance Cable Barrier
Follows work under Year 12.

Evaluation of Transverse Culvert Safety Grate
Additional bogie testing of various configurations is planned for the 4th Quarter. This testing will form the basis of the suspension simulation effort.

Flare Rates for W-Beam Guardrail
The objectives of this research are to evaluate the effect of increased flare rates on impact performance and identify optimal flare rates that minimize total crash costs. A literature review of flare rates, including relevant crash testing and standards, is complete. Additionally, baseline Barrier VII models for the standard W-beam guardrail and for the MGS W-Beam guardrail system have been performed. This effort has resulted in the determination of an impact angle for the initial evaluation of 29.4°. This test is planned for late in the 1st Quarter of 2005.

Approach Slopes for W-Beam Guardrails Systems
No Progress

Concept Development of a Bridge Pier Protection System for Longitudinal Barrier
No Progress

Retest of Cable End Terminal
A modified system with additional breakaway posts has been fabricated. Testing of the system is planned for early 2005 dependent on the weather.

SUPPLEMENTAL PROJECTS:

Transitions and Deflection Limiting Modifications for the Kansas Type F3 Concrete Temporary Barrier

This project was initiated with two goals. First, it was necessary to develop a tie-down system to limit the deflection of the barrier system when placed on an asphalt concrete surface with some sort of restraint mechanism. Second, it was deemed necessary to transition from free standing barrier to barrier bolted to a bridge deck.

On September 27th, a full-scale test of the pinned barrier was performed. The barrier was placed on a 2" asphalt pad 8" in front of a drop off, with the barrier restrained utilizing the three existing holes on the impact face with 1.5" diameter, 3' long A36 pins. The full-scale test met all salient criteria and was deemed a pass. The maximum permanent deflection of the barrier was approximately 12". Before and after photos are shown below. A test of this system in transition from free standing barrier to a bolted bridge section is planned for early next year.

Minnesota Sound Wall Rail

This project was initiated to design and test a railing system for MnDOT's sound wall system in situations where the wall was placed in the clear zone. A glulam rail system was designed, modeled and constructed. A full-scale test of the system was performed on July 16th. The system passed all salient critera and the test was deemed successful. Because of the rail configurations similarity to other systems a small car test was deemed necessary. Photos of the system are shown below.

Pooled Fund Consulting Summary

Midwest Roadside Safety Facility
August 2004-October 2004

This is a brief summary of the consulting problems presented to the Midwest Roadside Safety Facility over the past quarter and the solutions we have proposed.

Problem # 1 – F-shape Temporary Barrier Steel Strap Tie-down Anchors

State Question:

Ron, attached is a PDF for the Type II Guard Fence End Terminal Standard Drawing that we use on divided roadways when the end terminal is outside the clear zone.

Will our Type II end terminal anchorage system provide the required strength to develop the capacity of the rail? My concern is that this may be an item not studied to date based on 350 since the end terminals, temporary barrier, etc have been the main focus so far.

Thanks.

Rod Lacy
KDOT
785-296-3897

MwRSF Response:

Rod:

Bob and I briefly reviewed your detail and made a comparison to a new single, cable anchor post developed for Road Systems, Inc. and for use with the taller MGS in combination with FLEAT and SKT end treatments. In the comparison, the Ks DOT detail uses a shorter tubular post but a larger soil plate area. On the contrary, the Road Systems detail uses a longer wide flange anchor post instead of a tubular foundation member and in combination with a smaller soil plate area than currently used by Kansas.

In the absence of any testing and evaluation of your system, we may be more comfortable with Kansas increasing the length of the single anchor tube by 12 in. Please note that it may be possible that your existing system would meet the NCHRP 350 requirements for longitudinal, strong-post W-beam guardrail systems. However, we cannot make that final determination without full-scale vehicle crash testing. Therefore, in the interim and absence of testing, we recommend that you increase the tube length by 1 ft if you wish to continue the use of a single anchor tube in lieu of the two tube system adjoined with a channel strut.

If you have any questions regarding this information, please feel free to contact me at your convenience. Thanks again.

Ron Faller

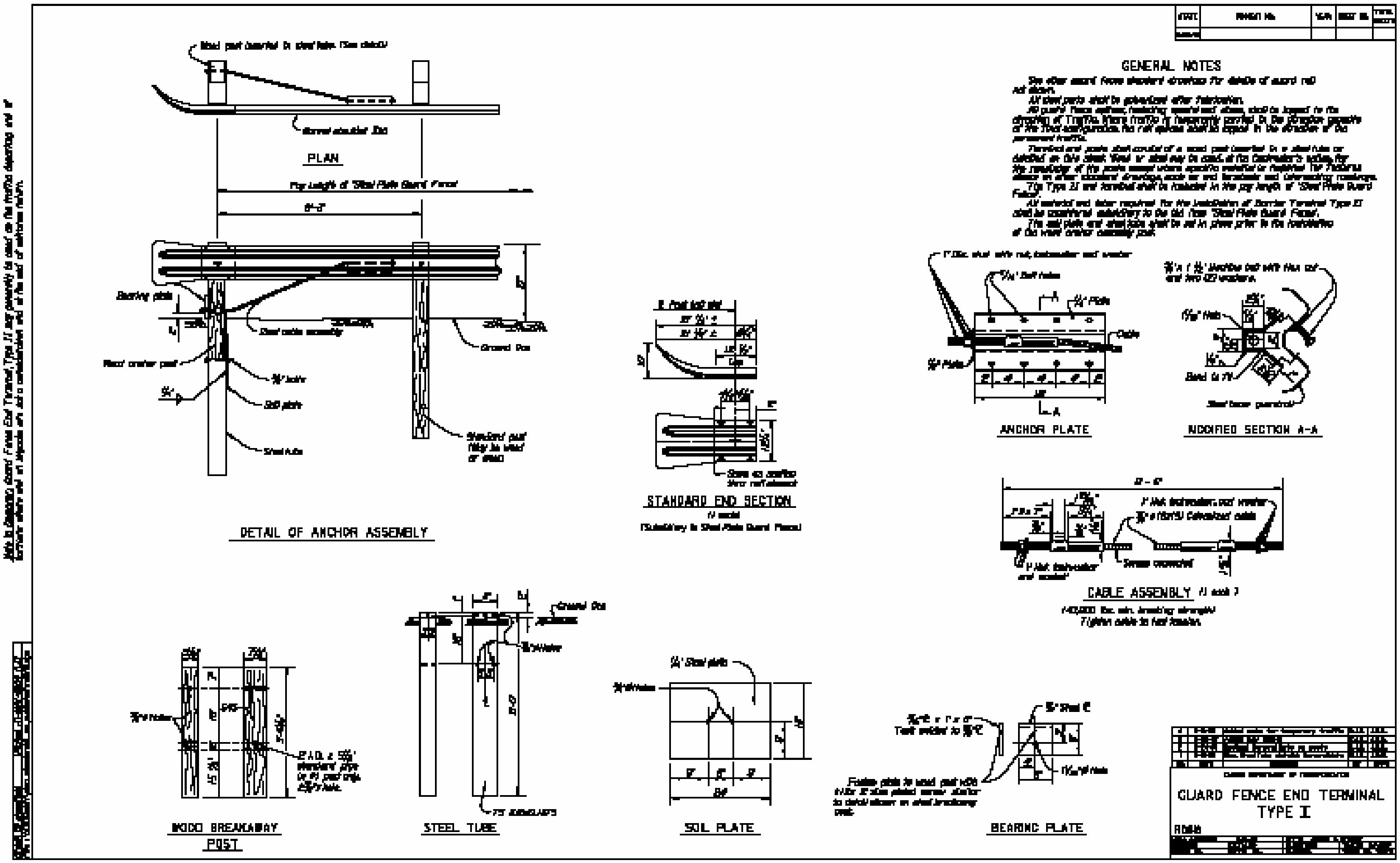


Figure 1. Type II Guard Fence End Terminal Standard Drawing

Problem # 2 – Minnesota Safety Workshop Problems

Note: The following five problems were submitted for a safety workshop given at MnDOT.

Problem # 1: Treatment of a 6-ft deep pond at the edge of the clear zone

It was stated that the clear zone for this obstacle was at or very near to the edge of the 6-ft deep pond. Actually, only the downstream end of the pond was within the clear zone and technically requiring protection based solely on the clear zone concept. However, if one followed that policy and did not protect the upstream end with an appropriate length of need of guardrail protection, would the agency open themselves up to future tort liability? This may be the case since a reasonable engineer and/or designer would likely have protected the entire pond hazard and culvert end with only a small increase in guardrail length.

It was stated that cable barrier was placed down the 10:1 slope in conformance to standards for locating guardrail on slope. Two feet behind the cable barrier posts, the slope changed to a variable slope ranging between 2:1 to 5:1. For the steeper slopes, the three cable barrier may not be capable of safely redirecting the 2000P vehicle at the TL-3 impact condition as it traverses the steeper slopes. Due to this fact, it may have been more appropriate to protect the hazard with strong post W-beam guardrail with an acceptable end terminal. This alternative may have been preferred since the steeper 2:1 slopes on the back side of the posts can be accommodated with this new barrier system.

MwRSF Response:

See attached presentation.

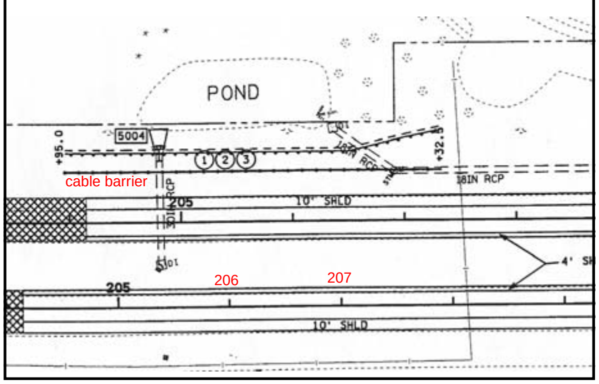
Design Problem No. 1

Dean L. Sicking, Ph.D., P.E.
2004 Roadside Safety Workshop
June 23-24, 2004

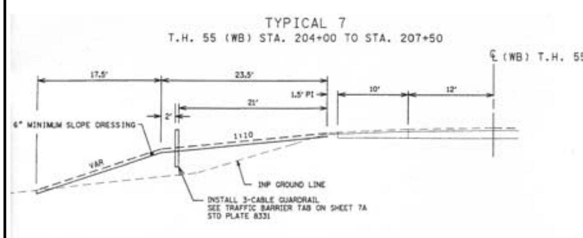
Design Problem No. 1

- Facts
  - 6-ft deep pond near and/or within clear zone
  - culvert at upstream end of pond
  - three cable barrier used to protect entire obstacle, including portions outside of clear zone
  - 10:1 approach slope to cable barrier
  - slope, varying from 2:1 to 5:1, begins 2-ft behind cable barrier posts
  - no accident history

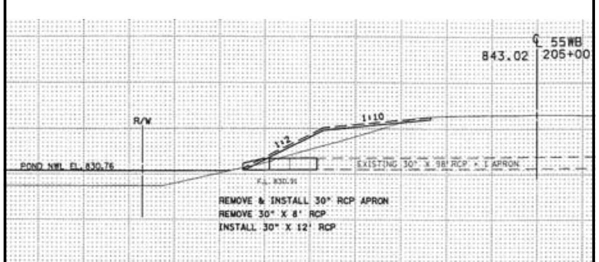
Plan view of pond, culvert, and cable barrier



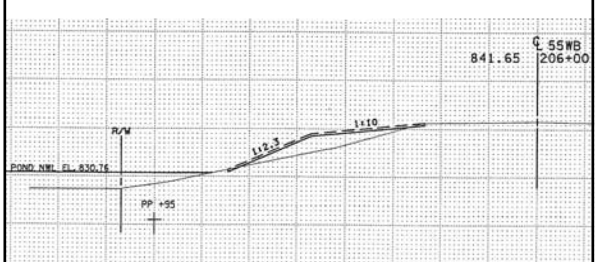
3-cable barrier with 10:1 approach slope and variable fill slope 2-ft behind posts



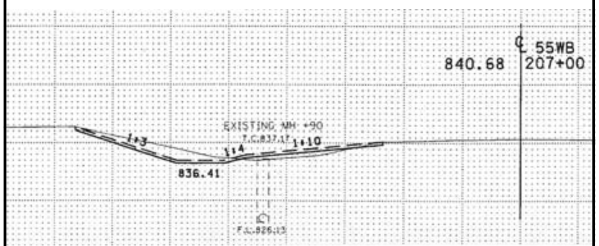
2:1 Fill slope at station 205+00



2.3:1 Fill slope at station 206+00



4:1 Fill slope at station 207+00



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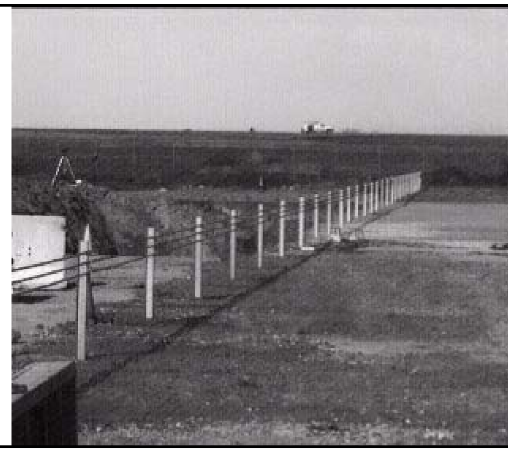
Treatment of Ponds Near Edge of Clear Zone

- Comments
  - three cable barrier incapable of redirecting 2000P vehicle impacting at TL-3 condition of NCHRP 350 when installed adjacent to 1.5:1 slope
  - TL-3 approved, strong-post, W-beam design variations exist when placed near or directly on 2:1 fill slope



Design Problem No. 1 (Continued)

- Conclusions
  - could conduct benefit-cost analysis to determine whether entire hazard required protection
  - extending protection to include entire hazard is reasonable and appropriate due to small increase in guardrail length
  - if MnDOT treats hazards entirely outside of clear zone, agency wide policy should be adopted
  - potential tort risk associated with inconsistent application of clear zone principles

Recommendations

- Cable guardrail may function in this application, but research not yet complete
- Simulation study indicates cable barrier should provide acceptable performance when placed 3' in front of slope break point and post spacing reduced to 4'
- W-beam guardrail with 7' posts on 3'-1.5" centers placed at the slope break point is an NCHRP Report 350 approved alternative

Problem # 2: Transition from PCB to Rigid Concrete Barrier

See attached presentation.

Design Problem #2
Transition From PCB to Permanent Concrete Barrier

Dean L. Sicking
2004 Roadside Safety Workshop
June 23-24, 2004

Midwest Roadside Safety Facility

Problem

- Portable Concrete Barrier (PCB) connection to rigid structures
  - Concrete bridge rails
  - Bridge piers
- PCB's have significant deflection
- High potential for snag at the connection between the PCB and rigid hazard

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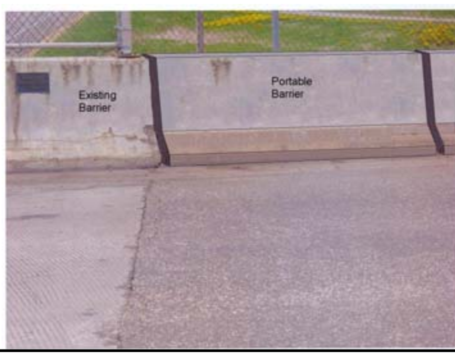
Problem



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Problem

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Disclaimer

- No current proven solutions to this problem
- The following is our best estimate based on available research and engineering judgment
- Further research is underway

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Limited Deflection PCB Options

- Concrete surface
  - Strap tie-down for F-shape PCB's
  - Bolt through tie-down for F-shape PCB's
- Asphalt Surface
  - Asphalt pin tie-down in development at MwRSF

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Strap Tie-Down

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Bolt Through Tie-Down

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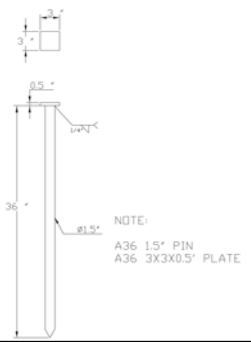
Asphalt Pin Tie-Down Concept

- Three pins per barrier on the front face
- Testing mid-summer 2004
- May be a future option



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Current Recommendation

- Tangent three barrier transition region using the bolt through tie-down
  - 1st barrier upstream of rigid hazard has bolts in all three holes
  - 2nd barrier upstream of rigid hazard has bolts in the two outside holes
  - 3rd barrier upstream of rigid hazard has bolt in the downstream hole only

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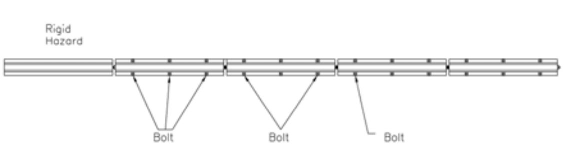
Current Recommendation



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Potential Issues

- Snagging at rigid hazard due to translation and rotation of PCB
- Pocketing of PCB's due to short length of the transition
- Excessive barrier damage to partially pinned/ bolted barriers
- For use on concrete only

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Improved Solution

- In order to reduce the potential problems, an improved concept has been developed
  - Lengthen the transition region using an additional barrier with three bolts
  - Apply 10 gauge thrie beam guardrail with end shoes across the final PCB and the rigid hazard to reduce snag potential

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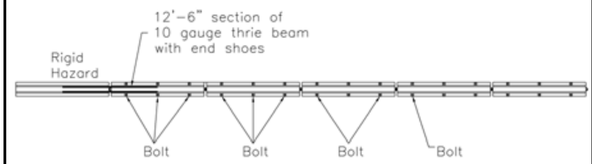
Improved Solution



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Disclaimer

- Previous slides represent the best judgment available at this time
- Not suitable for use on asphalt road surfaces
- Recommendations for asphalt surfaces will become available after testing this summer
- Further analysis will be done as part of funded research in the next 12 – 24 months

Problem # 3: Concrete Median Barrier

See attached presentation.

Design Problem No. 3

Dean L. Sicking, Ph.D., P.E.
2004 Roadside Safety Workshop
June 23-24, 2004

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Design Problem No. 3

- TH 169 criteria
  - Rural 4-lane divided highway
  - Depressed median
  - ADT = 13,900
  - Design speed = 70 mph
  - Posted speed = 65 mph

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Design Problem No. 3 (Continued)

- Bridge replacement scheduled for 2006
- Bridge length = 1,100'
- CMB separates NB and SB traffic
- North end bridge, CMB ties into existing CMB
- South end bridge, CMB terminates (depressed median)

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Design Problem No. 3 Question

- Which barrier system would work best between the CMB attenuator and the depressed median section meeting clear zone requirements?

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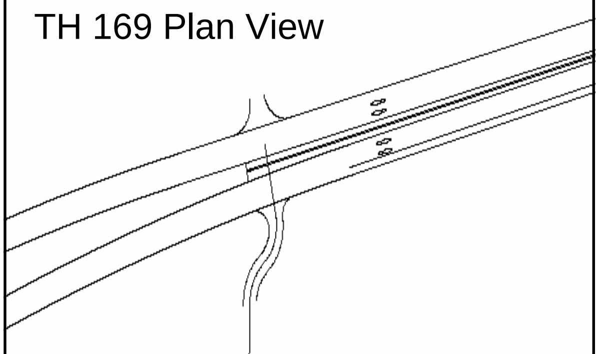
TH 169 Plan View



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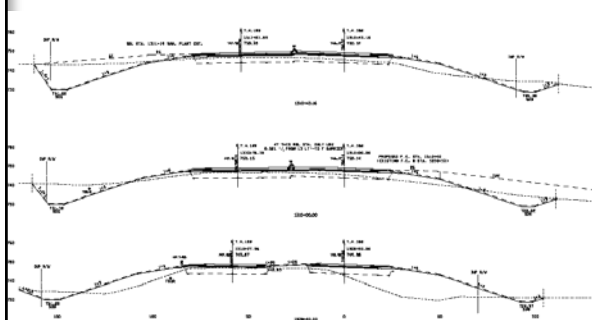
TH 169 Cross Sections



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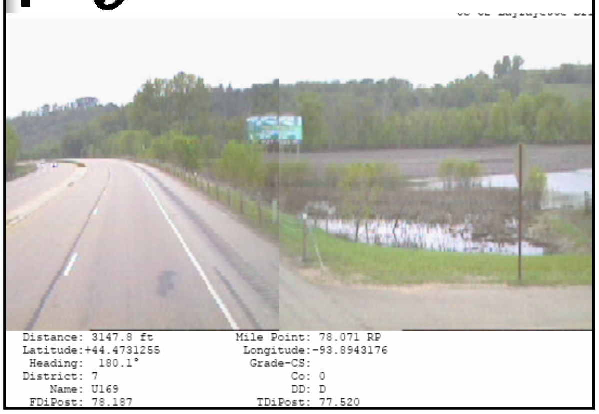

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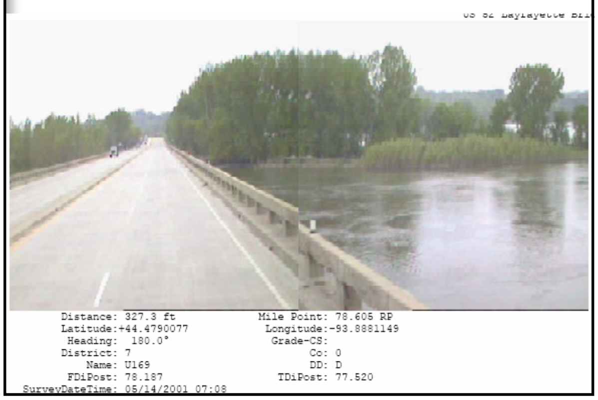

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Barrier Options for Depressed Medians

- Cable Median Barrier
  - Normally limited to 5:1 side slopes or flatter
  - Recent testing has demonstrated some problems with 6:1 slopes when barrier placed 3-10 ft. from ditch bottom - barrier performance acceptable when placed at ditch bottom
  - Double barrier option can be used when steeper side slopes, but barriers must be placed 10 or more ft from ditch bottom
  - Crash experience has shown that cable barriers do allow some penetrations

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Barrier Options for Depressed Medians

- W-beam/Thrie-beam Median Barrier
  - Acceptable for 8:1 slopes or flatter
  - Easily transitioned to concrete median barrier
- Concrete Barrier Extended Along Shoulder
  - Costly
  - High barrier accident frequency

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Cable-Concrete Median Barrier Transition

- Transition Concrete to W-beam Median Barrier
  - Add backside railing to standard approach guardrail transition
  - Transition to median barrier instead of W-beam guardrail
- Cable to W-beam Transition – Option 1 – Preferred
  - Separate Median Barrier into 2 guardrails at standard flare rate
  - Flare departure side guardrail until it is 8 ft. from face of approach side guardrail
  - Utilize cable to W-beam transition on approach side
  - Install downstream terminal on departure side

Cable-Concrete Median Barrier Transition

- Cable to W-beam Transition – Option 2 for Narrow Median
  - Install FLEAT-MT
  - Extend flared section of FLEAT-MT until 4' flare achieved
  - Utilize breakaway steel posts in extension
  - Install Cable to W-beam transition to FLEAT-MT
  - This option not crash tested, but only available solution for narrow medians

W-beam with Cable – BCT Transition

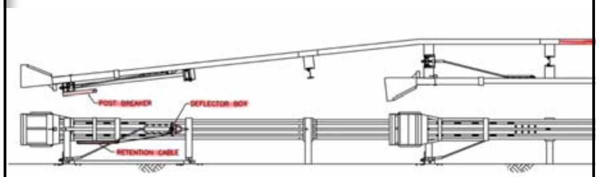
W-beam with Cable – BCT Transition

W-beam with Cable – FLEAT

W-beam with Cable – FLEAT

FLEAT-MT

FLEAT-MT



Problem # 4: Cable Guardrail on Slope

See attached presentation.

Design Problem No. 4

Dean L. Sicking, Ph.D., P.E.
2004 Roadside Safety Workshop
June 23-24, 2004

Design Problem No. 4

- TH 4 criteria
  - Rural 2-lane undivided highway
  - 12’ lanes
  - 10’ shoulders (2’ bit., 8’ aggr.)
  - ADT = 2,100
  - Design speed = 60 mph
  - Posted speed = 55 mph

Design Problem No. 4 (Continued)

- Resurfacing scheduled for 2005
  - 3” mill & 3” overlay
- Guardrail upgrades
  - West of bridge 46003 are straightforward
  - Between bridges 46003 and 932 are less clear

Distance: 4186.7 ft   Mile Point: 10.940 RP
Latitude:+43.6483803   Longitude:-94.7584686
Heading: 79.3°   Grade-CS:
District: 7   Co: 0
Name: M4   DD: I
FDiPost: 10.111   TDiPost: 10.990
SurveyDateTime: 05/27/2003 14:58

Bridge 46003

Distance: 4237.5 ft   Mile Point: 10.950 RP
Latitude:+43.6484070   Longitude:-94.7582779
Heading: 79.6°   Grade-CS:
District: 7   Co: 0
Name: M4   DD: I
FDiPost: 10.111   TDiPost: 10.990
SurveyDateTime: 05/27/2003 14:58

Distance: 4485.8 ft   Mile Point: 10.997 RP
Latitude:+43.6485252   Longitude:-94.7573471
Heading: 79.7°   Grade-CS:
District: 7   Co: 0
Name: M4   DD: I
FDiPost: 10.111   TDiPost: 10.990
SurveyDateTime: 05/27/2003 14:58

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Distance: 4584.6 ft Mile Point: 11.015 RP
Latitude:+43.6485748 Longitude:-94.7569885
Heading: 80.0° Grade-CS:
District: 7 Co: 0
Name: M4 DD: I
FDiPost: 10.111 TDiPost: 10.990
SurveyDateTime: 05/27/2003 14:58

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Distance: 293.4 ft Mile Point: 11.056 RP
Latitude:+43.6487160 Longitude:-94.7558746
Heading: 80.1° Grade-CS:
District: 7 Co: 0
Name: M4 DD: I
FDiPost: 10.990 TDiPost: 11.979
SurveyDateTime: 05/27/2003 14:59

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Bridge 932

Distance: 541.7 ft Mile Point: 11.103 RP
Latitude:+43.6488342 Longitude:-94.7549515
Heading: 79.5° Grade-CS:
District: 7 Co: 0
Name: M4 DD: I
FDiPost: 10.990 TDiPost: 11.979
SurveyDateTime: 05/27/2003 14:59

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Distance: 688.3 ft Mile Point: 11.130 RP
Latitude:+43.6488991 Longitude:-94.7544098
Heading: 81.1° Grade-CS:
District: 7 Co: 0
Name: M4 DD: I
FDiPost: 10.990 TDiPost: 11.979
SurveyDateTime: 05/27/2003 14:59

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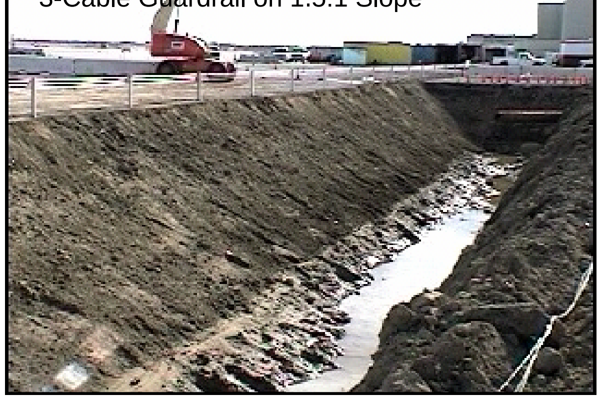
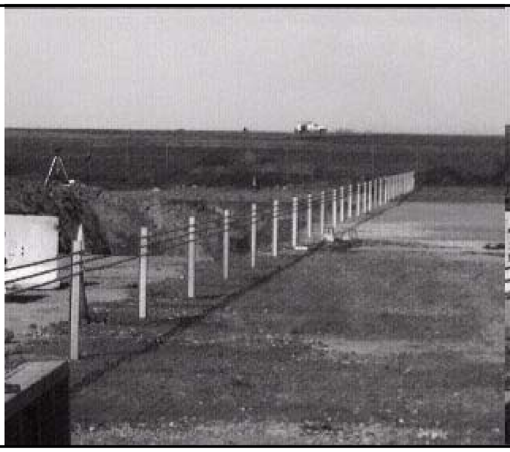
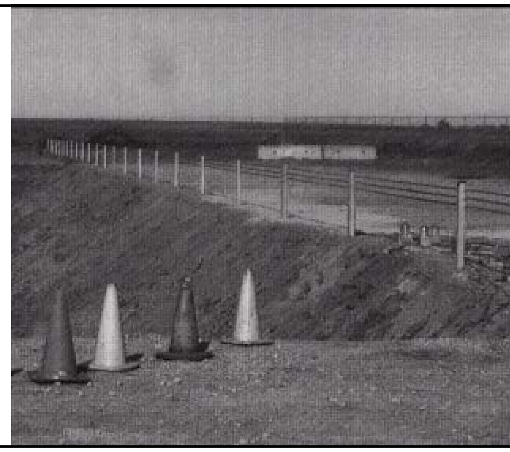
Design Problem No. 4 (Continued)

- Existing guardrail
  - 3-cable guardrail
  - Protects deep ditch adjacent to highway
  - 2:1 slope
- What type of guardrail would work best between bridges 46003 and 932?

3-Cable Guardrail on 1.5:1 Slope







Computer Simulation Results

- Reduced post spacing to 4’
  - Increased lateral stiffness
  - Reduced lateral barrier deflections
- Increased barrier offset to 4’ from breakpoint
  - Limited vehicle penetration on slope
  - Reduced vehicle c.g. drop

Design Problem No. 4 Conclusions

- Cable guardrail not acceptable within 1’ of 1.5:1 slope
- For steep slopes use 4’ post spacing and install barrier atleast 3’ from slope breakpoint
- Rounding slope breakpoint will improve barrier performance

Problem # 5: Bullnose Alternatives

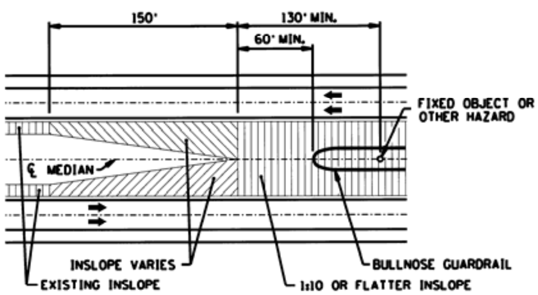
See attached presentation.

Design Problem No. 5

Dean L. Sicking, Ph.D., P.E.
2004 Roadside Safety Workshop
June 23-24, 2004

Design Problem No. 5

- Facts
  - 5-ft radius W-beam bullnose systems upgraded when significantly damaged
  - use MwRSF thrie beam bullnose (350 approved)
  - thrie beam bullnose requires 10:1 front slope upstream of nose
  - significant costs to upgrade system, including materials, installation, grading, and drainage
  - What alternatives exist?
  - How are they different from the thrie beam bullnose option? (cost, grading, maintenance, etc.)



GRADING AT BULLNOSE
(DEPRESSED MEDIAN)

Thrie Beam Bullnose

Cedar Avenue

Cedar Avenue

5-Ft W-Beam Radius

5-Ft W-Beam Radius

Midwest Roadside Safety Facility

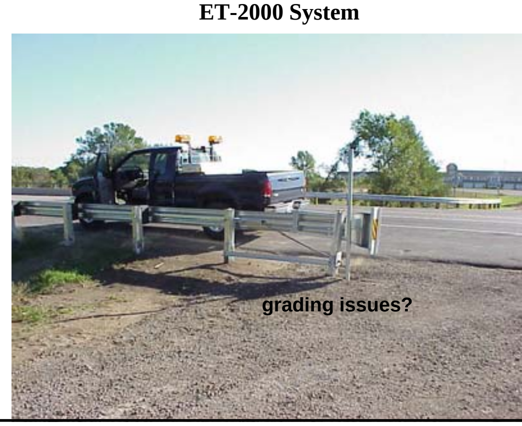
Alternatives

- CAT System (cost/grading?)
- Guardrail End Terminals (cost/grading?)
  - Kansas Example
  - Missouri Example
- BEAT – BP (cost/grading?)
- MwRSF Bullnose (cost/grading?)
- Inertial Barrels (cost/grading?)
- Other Crash Cushions (cost/grading?)

CAT System

ET-2000 System

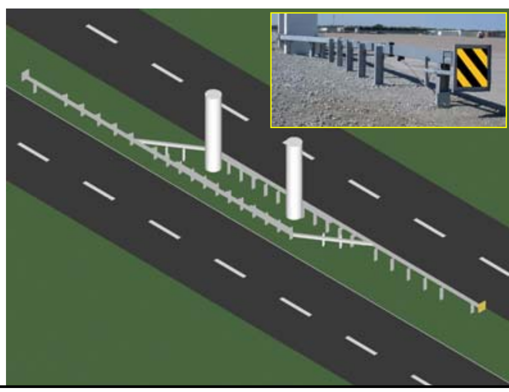
ET-2000 System



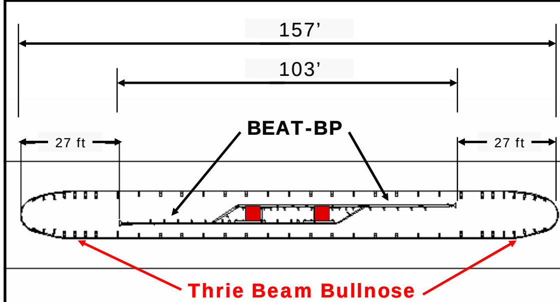
Kansas Example

Missouri Example

BEAT-BP



BEAT-BP



Comparison of BEAT-BP & Thrie Beam Bullnose

Comments

- All treatments require grading
- Cost analysis must include hardware, grading, drainage, and maintenance
- Actual cost data difficult for MwRSF to obtain
- Maintenance costs must be considered when determining best solution
- Length of system and distance from travel way is best surrogate for maintenance cost

Estimated Costs

- All treatments require grading
- Cost analysis must include hardware, grading, drainage, and maintenance
- Actual cost data difficult for MwRSF to obtain
- Maintenance costs must be considered when determining best solution
- Length of system and distance from travel way is best surrogate for maintenance cost

Recommendations

- Conduct a benefit-cost analysis to determine preferred alternatives and develop generic guidelines
- Research study can be funded to develop these guidelines

Problem # 3 – End Treatment Gaps

State Question:

Ron:

MoDOT has a situation where the roadway guardrail and the ramp guardrail come close together at the nose of the gore. Have you any experience or knowledge of what is the required or recommended gap between the two end treatment (ex. ET 2000) to work properly?

MwRSF Response:

Two different approaches are available for treating the situation described above. First, one could install end treatments that bring both guardrails into a single terminal system, such as used in the FLEAT-MT and CAT. Second, one could use any of the energy-asborbing guardrail end terminals on each guardrail end but with ending the back-side system approximately 50 ft downstream of the first system. If option two is used, all guardrail posts exposed on the back side of the first terminal must be treated with breakaway guardrail posts in order to avoid excessive wheel snag concerns and the potential for vehicle rollovers.

Problem # 4 – Temporary Barrier Deflection Limits for Reduced Speeds

State Question:

What is your opinion of reducing the deflection spacing behind a temporary barrier, if the speed limit is marked at lower speeds than the test speed of 62 mph? Right now we are following the criteria from your group in the deflection recommendation report of 45 inches unless used on road ways with 10 foot lanes or greater and then we reduce the deflection to 24 inches.

MwRSF Response:

The original Iowa temporary concrete barrier was crash tested to the TL-3 criteria of NCHRP Report No. 350. In that test, dynamic barrier deflections of approximately 45 in. were observed. Later, MwRSF published a report which stated that when the barrier is positioned near a bridge deck edge using the freestanding configuration, the clear distance between the deck edge and the back-side barrier base should be 45.3 in. However, for all other applications, the design deflection limit should be set at 600 mm or 24 in. This distance coresponds to the distance that the Iowa temporary barrier could be expected to deflect under the 85th percentile impact for passenger cars and light trucks. The 85th percentile impact condition was determined to be a 3/4-ton pickup truck impacting at a speed of 58 km/hr (36 mph) and 27.1 degrees.

Problem # 4 – Temporary Barrier Transitions

State Question:

One of the issues I know ODOT is behind the curve on is PCB connected to permanent longitudinal barrier in construction zones. I have an opportunity now to solve a current problem for a designer, and then to set an ODOT standard for the future.

This designer is proposing using the attached design in two MOT phases. Phase 1 involves a PCB flared through a removed section of guardrail with a w-beam attached. Phase 2 shows a PCB flush against a permanents concrete barrier. We need to have a connection that could meet 350.

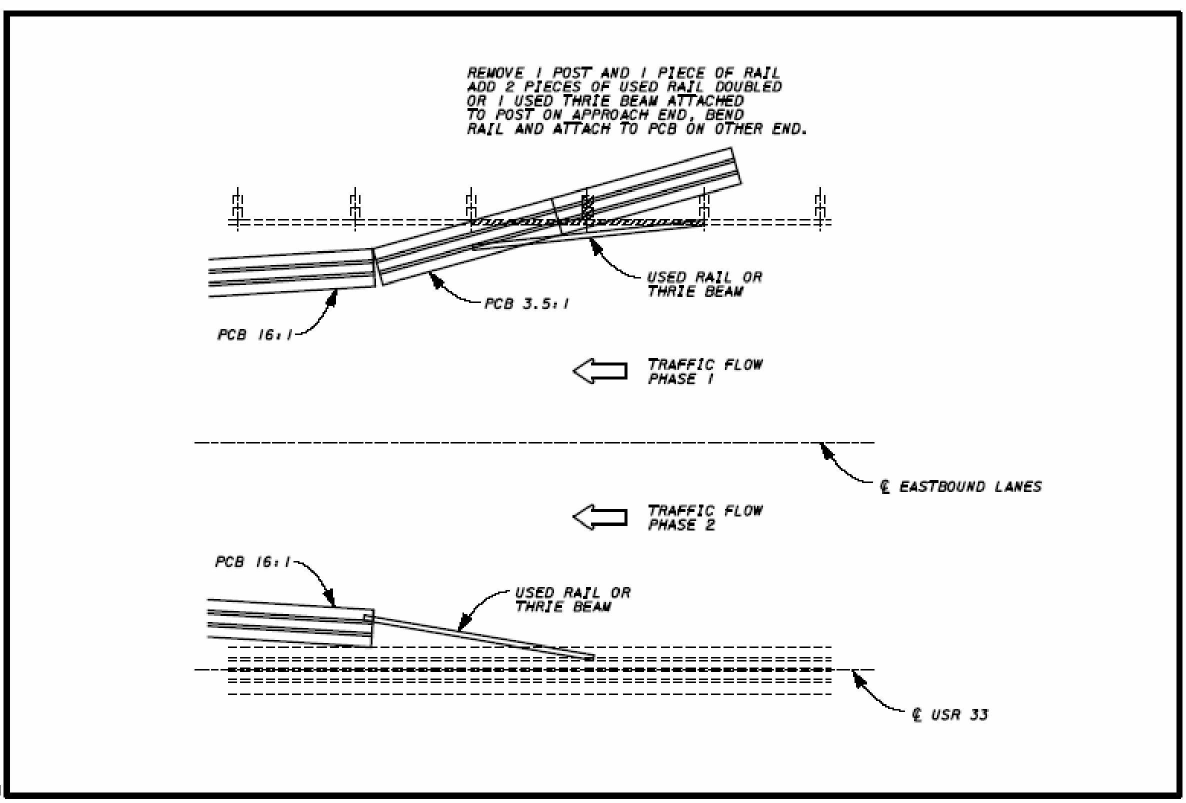
My proposed solution to Phase 1 would be to anchor the PCB in the last two sections (12.5' x 2 =25'), and to use a nested w-beam section connect the old and the new. I would not see much a snagging issue. But maybe a steel wedge should be used at mid-span of the rail element and fastened to the PCB. Your thoughts would be appreciated.

For Phase 2, I have seen other designers use an impact attenuator at the end of the PCB and flush with the existing barrier. That would work, I assume. But I wonder if you have other ideas?

We use NJ PCB and Single Slope for permanent. but this project will tie into existing NJ barrier.

I could poll the states, but I think their designs are probably just jury-rigged designs like ours.

Thanks,
Dean



MwRSF Response:

Hi Dean

A couple of quick responses to your temporary barrier transitions questions.

I see several problems when looking at your Phase 1 option. Transitioning from the PCB to the guardrail would prove difficult on many levels. First, there is not enough of a transition in the relative stiffness between the two systems. Your anchored PCB's would essentially be rigid, while your guardrail would be much more flexible. Thus, even though the potential for snagging in not great, there is still a significant potential for vehicle instability. In order to make that concept function, significant work would need to be done to transition between the stiffness of the flexible rail and the stiff PCB's. You nested W-beam section is a start, but I don't believe it is sufficient to insure vehicle stability. The second issue with the Phase 1 transition is the anchorage of the guardrail. I have not looked into it sufficiently yet, but I am not sure you can get the necessary anchorage out of the PCB's.

Your Phase 2 option is closer to what we would recommend, but it would need to be modified as well. In order to alleviate snag concerns and stability problems, the guardrail section would need to approach the temporary barriers at a 15:1 flare at most. That would likely mean using a longer transition section of guardrail than you have drawn. In addition, a rubrail of some for would need to be installed below the regular rail, and special spacer blocks would have to be installed on at least 3'-1 1/2" spacing.

I have attached a pdf of a presentation that we recently gave in Minnesota regarding this issue. It shows our current recommendation for attaching temporary barriers to rigid barriers. It consists of using tie-downs on the temporary barriers as the approach the rigid rail. Then a 10 gage thrie beam section with end shoes is used to bridge across the PCB and rigid barrier connection. For now, this is our best alternative. We are currently working on a project with the Florida DOT to further research this issue.

Let me know if you have further questions/concerns. Thanks for the questions.

Bob Bielenberg

Problem # 5 – Temporary Barrier Deflection and Tie-Down Options

State Question:

I talked to you about this subject on Tuesday. Thanks for the report.

We have a note on our current standard detail that requires the TCB to be anchored when the clear space behind the barrier is 2'-0" but no anchoring is required if that space exceeds two feet. In addition to the 2'-0" clear space, we also require that the drop-off exceed 2'-0" deep   The decision for the 2' clear space and 2' drop-off was based on the fact that most locations where anchoring would be required are generally old bridge decks in 1st stage of construction. There is usually minimal space on these bridges. On some bridges we can't even get the 2 feet. The second reason was travel speed is usually reduced at these locations.

I have consulted a few other states and found a good number of them don't even anchor the TCB and those that require anchoring, have no definite minimum distance requirement. North Carolina requires anchoring whenever the clear space is less than 6 feet and the drop-off is deeper than 3 feet on bridge decks. We don't have that kind of space in Wisconsin, especially on the low volume local and state highways. Incorporating speed introduces other complication so we dropped the idea.

What in your judgement would be the appropriate clear space given the facts I mentioned above.

Thanks

Peter Amakobe

MwRSF Response:

Hi Peter

I believe that you recommendations for anchoring of temporary concrete barrier are acceptable assuming you are referring to the F-shape temporary barrier design developed here at MwRSF. As stated in the report I gave you previously, the F-shape PCB can be safely used unanchored with 2' of clear space behind the barrier based on the 85th percentile impact. For distances less than this or installations with a sharp drop at the end of the clear space, an anchored PCB is more appropriate. This is basically agrees with what you have told me about the Wisconsin standard. Therefore, I would recommend that you stick with your current guidelines for now.

The difference between our recommendations for the F-shape barrier as opposed to what some other states may recommend is likely due to the use of different PCB systems. Different PCB designs have vastly different deflections based on the type of section, the length of the section, and the connection between the barriers. North Carolina uses a 10' long NJ shape barrier with little reinforcement and a relatively weak connection when compared to the F-shape developed here. It will experience higher deflections than the F-shape and thus they have likely used more forgiving clear areas behind the barriers.

Hope this help you out. Let me know if you have more questions.

Bob Bielenberg,

Problem # 6 – Concrete Surface Drains at Structural Approach.

State Question:

Bob;

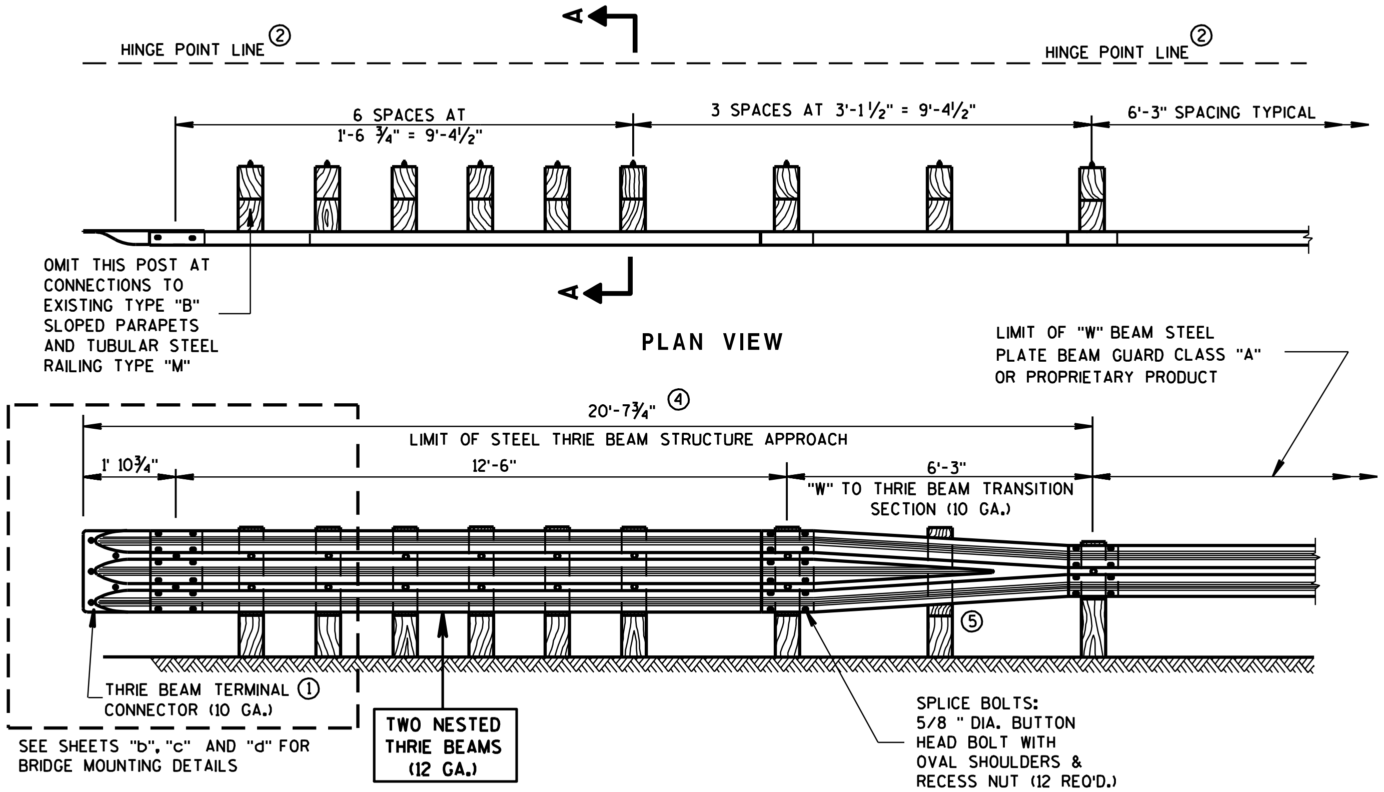
The attached Standard Detail Drawings (SDD), 08d2-4 & 08d3-4, show our current layout configurations for concrete surface drain flume and drop inlet at structure approaches. SDD 14b20-6a also (attached) is our typical thrie beam structural approach used at such locations. When SDD 14B20-6a is used with a flume or surface drain, post number 5 is usually eliminated as shown on SDD 08d2-4 and 08d3-4. Our concern is the elimination of this post compromises performance.

We are proposing using 8" x 8" x 7' posts for the two posts on either side of the flume or drop inlet. Another design change would be to move the flume or drop inlet further away from the structure or provide multiple flumes. We are aware of design flows with the surface drain details, especially on superelevated structures. Field review shows that they are not effective for high flows.

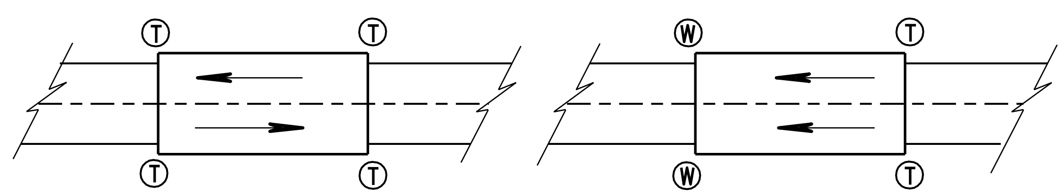
Would you please review the attached SDD and provide us with your opinion or suggestion. Thank you for your input

<<08d2-4.pdf>> <<08d3-4.pdf>> <<14b20-6a.pdf>>

Peter Amakobe



FRONT VIEW

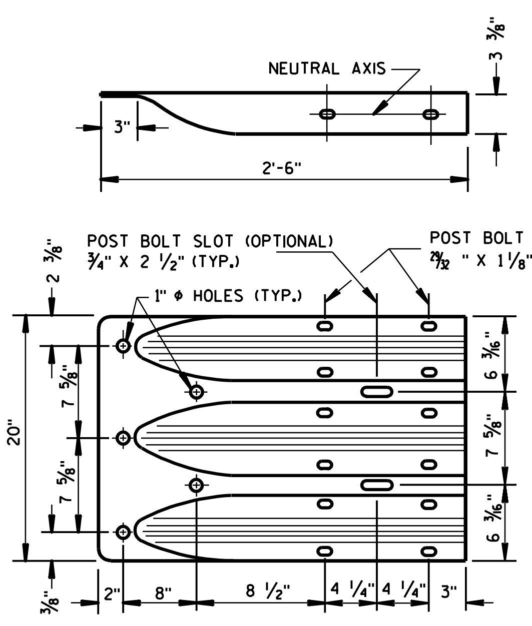


TWO WAY TRAFFIC   ONE WAY TRAFFIC

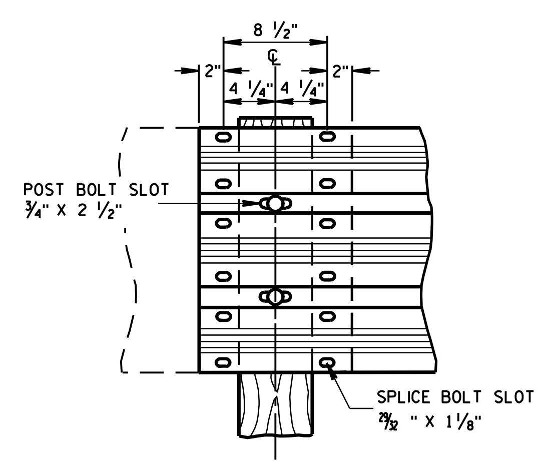
Ⓣ THRIE BEAM CONNECTION

Ⓦ W-BEAM CONNECTION WHEN REQUIRED

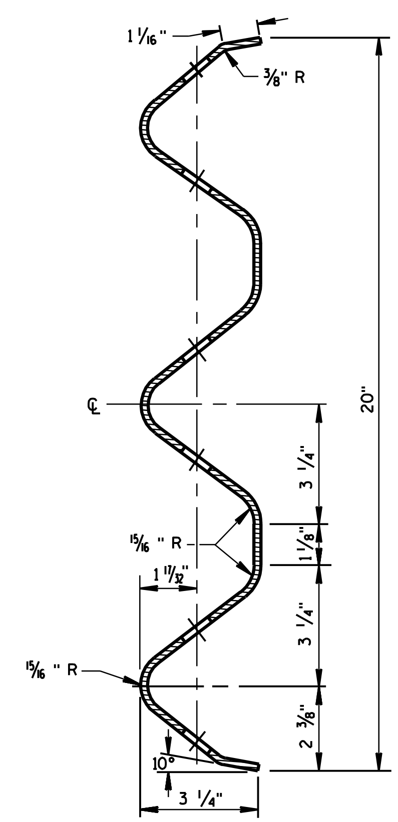
TYPICAL LOCATIONS OF THRIE BEAM AND W-BEAM CONNECTIONS TO BRIDGE



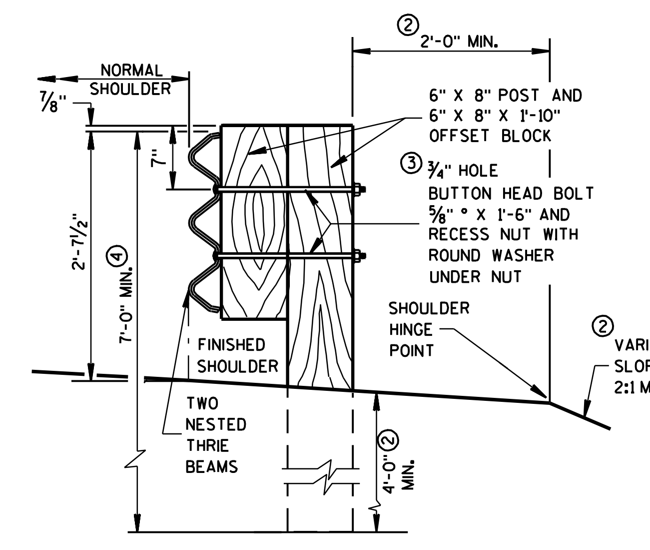
THRIE BEAM TERMINAL CONNECTOR



THRIE BEAM SPLICE



SECTION THRU THRIE BEAM RAIL ELEMENT



SECTION A-A

GENERAL NOTES

DETAILS OF CONSTRUCTION, MATERIALS AND WORKMANSHIP NOT SHOWN ON THIS DRAWING SHALL CONFORM TO THE PERTINENT REQUIREMENTS OF THE STANDARD SPECIFICATIONS AND THE APPLICABLE SPECIAL PROVISIONS.

FURNISH AND CONSTRUCT THRIE BEAM STRUCTURAL APPROACH ACCORDING TO THE REQUIREMENTS OF SECTION 614 OF THE STANDARD SPECIFICATIONS. THRIE BEAM SECTIONS SHALL CONFORM TO THE REQUIREMENTS OF AASHTO DESIGNATION M180, CLASS "A", TYPE 2.

BOLT THE THRIE BEAM TO ALL POSTS AND BLOCKOUTS. DRILL OR PUNCH BOLT HOLES IN THE BEAM IF THE POST SPACING IS LESS THAN 6'-3.

DO NOT USE STEEL POSTS AND NOTCHED PLASTIC BLOCKOUTS IN THE STEEL THRIE BEAM STRUCTURAL APPROACH AND THE TRANSITION SECTION OF STEEL PLATE BEAM GUARD, CLASS "A" INSTALLATIONS.

IF ROCK IS ENCOUNTERED DURING EXCAVATION, THE ENGINEER MAY APPROVE USING A 12 INCH DIAMETER POST HOLE EXTENDING 20 INCHES DEEP INTO THE ROCK. PLACE GRANULAR MATERIAL IN THE BOTTOM OF THE HOLE APPROXIMATELY 2½ INCHES DEEP. CUT THE POSTS TO LENGTH AND PLACE IN THE HOLE. BACKFILL WITH MATERIAL EXCAVATED FROM THE HOLE AND COMPACT ADEQUATELY. (SEE SDD 14 B 15-4a).

① BRIDGE RAILING TYPE "W" DOES NOT REQUIRE A TERMINAL CONNECTOR.

② MINIMUM EMBEDMENT SHALL BE 4'-0". WHERE EXISTING CONDITIONS DO NOT PERMIT THE APPROPRIATE EARTHWORK SHOWN ON THE PLAN TYPICAL SECTIONS OR DETAILS, THE ENGINEER MAY ALLOW THE REDUCTION OR ELIMINATION OF THE 2 FOOT DISTANCE TO THE HINGE POINT. OTHERWISE BUILD AS THE PLAN SHOWS OR AS THE ENGINEER DIRECTS. IF THE 2 FOOT DISTANCE TO THE HINGE POINT IS REDUCED OR ELIMINATED, INCREASE THE POST EMBEDMENT DEPTH TO 4'-6" OR MORE.

③ BOLTS SHALL CONFORM TO THE REQUIREMENTS OF ASTM F-1554, GRADE 55. NUTS SHALL CONFORM TO THE REQUIREMENTS OF ASTM A-563 DH.

④ ALL WOOD POSTS MUST BE 6" X 8" AND AT LEAST 7'-0" LONG.

⑤ DO NOT ATTACH POST IN "W" TO THRIE BEAM TRANSITION SECTION.

6

STEEL THRIE BEAM STRUCTURE APPROACH

STATE OF WISCONSIN
DEPARTMENT OF TRANSPORTATION

S.D.D. 14 B 20-6a

Standard Detail Drawing 14B20-6a

References: FDM Procedure 11-45-1
AASHTO Roadside Design Guide
NCHRP Report 350 Test 3-21 of the Thrie Beam Transition to Wisconsin Type "M" Tubular Steel Bridge Rail, January 2003

Bid items associated with this drawing:

Item #	Title
614.0200	Steel Thrie Beam Structure Approach (L.F.)
614.0250	Steel Thrie Beam Structural Approach Temporary (L.F.)
614.0305	Steel Plate Beam Guard, Class A (L.F.)

Standardized Special Provisions associated with this drawing: None

STSP #	Title

Other SDD's associated with this drawing: 14B15 & 14B20

This drawing must be supplemented with at least one additional sheet, 14B20-6b, 14B20-6c or 14B20-6d when this drawing is called for in the plans. This drawing consists of four sheets.

Design Notes: Consider surface runoff from a structure when installing thrie beam structural approach. Excessive run-off will scour beam guard posts in the structural approach affecting the performance of the system. Include appropriate protection for these areas by providing concrete surface drains.

It may be necessary to increase post length to accommodate steeper slopes.

Contact Person: Peter Amakobe (608) 266 - 2842

March 26, 2004

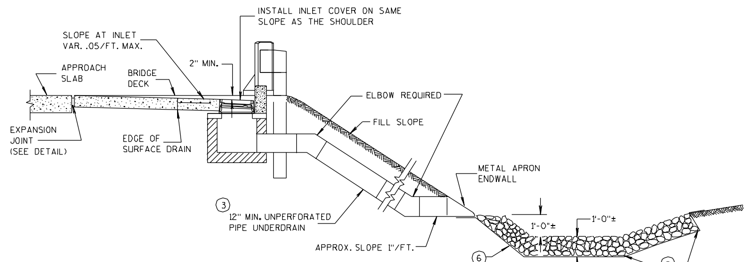
REVISION DATE: 5-18-90
PLOT NAME: S8D304
PLOT SCALE: 30
FILE NAME: S8D304
ORIGINATOR: MEL ZEMLICKA 6-2782
LEVELS ON - 1. 5.

APPROVED
DATE — STATE MAT. ENGINEER FOR HWYS

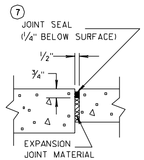
APPROVED
DATE — STATE MAINT. ENGINEER FOR HWYS

APPROVED
DATE — STATE CONST. ENGINEER FOR HWYS

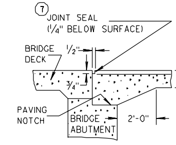
S.D.D. 8 D 3-4



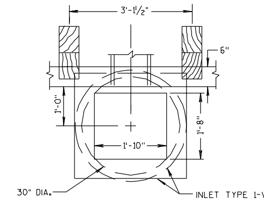
SECTION B-B



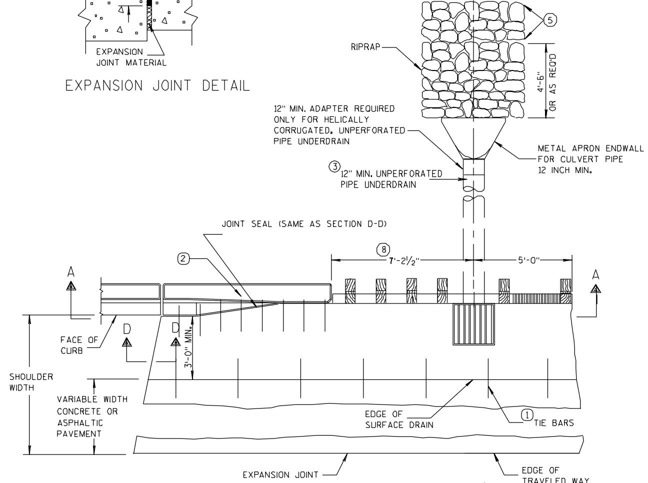
EXPANSION JOINT DETAIL



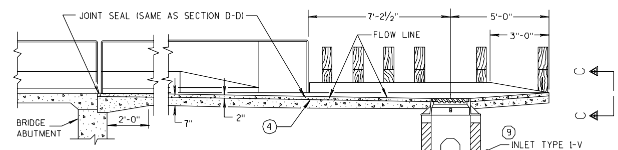
SECTION D-D



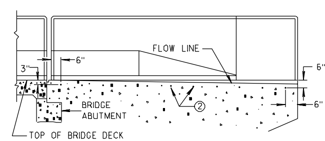
PLAN VIEW



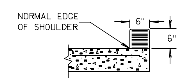
PLAN VIEW



SECTION A-A



LOCATION OF TIE BARS IN WINGWALL



SECTION C-C

GENERAL NOTES

DETAILS OF CONSTRUCTION, MATERIALS, AND WORKMANSHIP NOT SHOWN ON THIS DRAWING SHALL CONFORM TO THE PERTINENT REQUIREMENTS OF THE STANDARD SPECIFICATIONS AND APPLICABLE SPECIAL PROVISION.

(1) NO. 4 X 2'-0" TIE BARS SPACED AT 3'-0" CENTERS TO BE USED ONLY WHEN ADJACENT TO P.C. CONCRETE.

(2) NO. 4 X 2'-0" TIE BARS SPACED AT 12" CENTERS TO BE PLACED BY BRIDGE CONTRACTOR, OR PAVEMENT TIES PLACED AS DIRECTED BY THE ENGINEER.

(3) THE PIPE UNDERDRAIN MAY BE ANY ONE OF THE SIX MATERIALS LISTED IN THE STANDARD SPECIFICATIONS SECTION 612.2 (EXCEPT SECTION 612.2.3 DRAIN TILE).

(4) MINIMUM REINFORCEMENT SHALL BE 6" X 6" - W4.0 X W4.0 OR NO. 3 BARS LONGITUDINAL AND TRANSVERSE SPACING 12" C-C.

(5) LIMITS OF ADDITIONAL RIPRAP WHEN SPECIAL DITCH IS REQUIRED.

(6) GEOTEXTILE FABRIC, TYPE 'R'

(7) HOT POURED SEALANT UNLESS OTHERWISE SPECIFIED.

(8) THIS DIMENSION MAY VARY DEPENDING ON THE SPACING OF POSTS FOR THE STEEL PLATE BEAM GUARD. THE TYPICAL LOCATION FOR THE SURFACE DRAIN IS WHERE THE POST SPACING WIDENS TO 3'-1 1/2".

(9) SEE CURRENT STANDARD DETAIL DRAWINGS 8A5 AND 8C1 FOR DETAILS.

DESIGN NOTE: (WILL NOT APPEAR ON CONTRACT PLANS)
WHEN TIE BARS (2) ARE NOT SHOWN IN THE BRIDGE DRAWINGS, INCLUDE IN THE PLAN AS "PAVEMENT TIES".

CONCRETE SURFACE DRAIN DROP INLET TYPE AT STRUCTURES

STATE OF WISCONSIN
DEPARTMENT OF TRANSPORTATION

APPROVED
DATE — STATE DESIGN ENGINEER FOR HWYS
FHWA

Standard Detail Drawing 8D3 - 4

References:

Bid items associated with this drawing:

Item #	Title

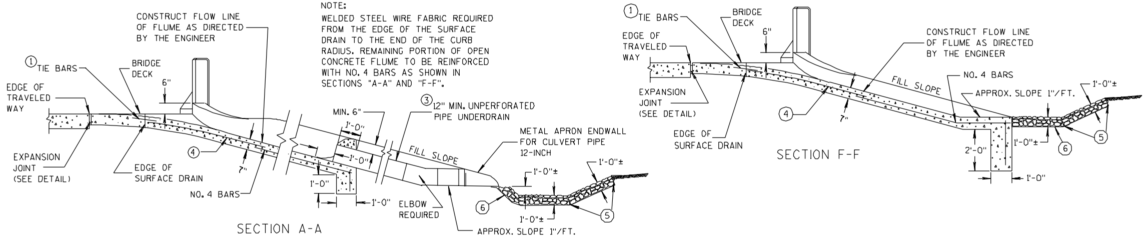
Standardized Special Provisions associated with this drawing:

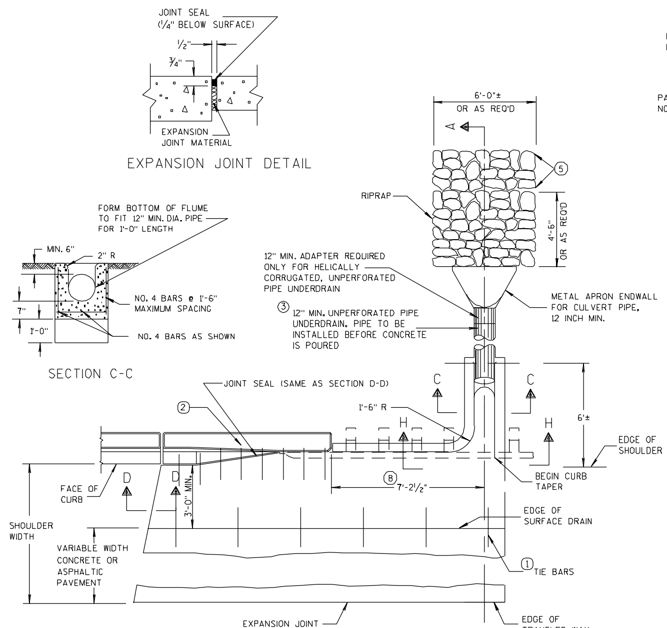
STSP #	Title

Other SDD's associated with this drawing:

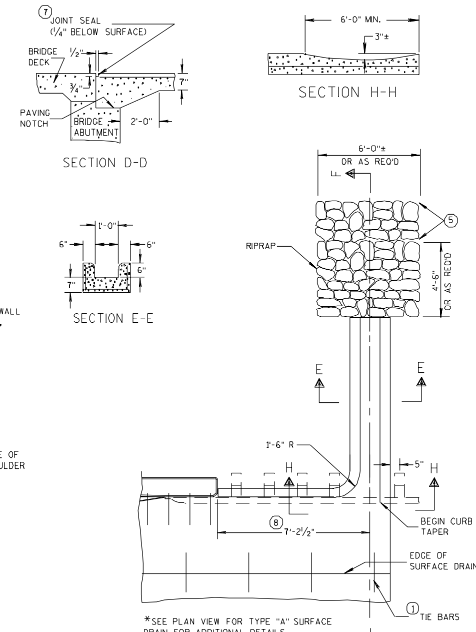
Design Notes:

April 18, 2003





PLAN VIEW
SURFACE DRAIN WITH PIPE
TYPE "A"



*PARTIAL PLAN VIEW
SURFACE DRAIN WITHOUT PIPE
TYPE "B"

GENERAL NOTES

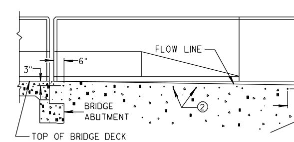
DETAILS OF CONSTRUCTION, MATERIALS, AND WORKMANSHIP NOT SHOWN ON THIS DRAWING SHALL CONFORM TO THE PERTINENT REQUIREMENTS OF THE STANDARD SPECIFICATIONS AND APPLICABLE SPECIAL PROVISION.

1. NO. 4 X 2'-0" TIE BARS SPACED AT 3'-0" CENTERS TO BE USED ONLY WHEN ADJACENT TO P.C. CONCRETE.
2. NO. 4 X 2'-0" TIE BARS SPACED AT 12" CENTERS TO BE PLACED BY BRIDGE CONTRACTOR, OR PAVEMENT TIES PLACED AS DIRECTED BY THE ENGINEER.
3. PIPE UNDERDRAIN MAY BE ANY OF THE MATERIALS LISTED IN SECTION 612.2 OF THE STANDARD SPECIFICATIONS EXCEPT DRAIN TILE.
4. MINIMUM REINFORCEMENT SHALL BE 6" X 6" - W4.0 X W4.0 OR NO. 3 BARS LONGITUDINAL AND TRANSVERSE SPACING 12" C-C.
5. LIMITS OF ADDITIONAL RIPRAP WHEN SPECIAL DITCH IS REQUIRED.
6. GEOTEXTILE FABRIC, TYPE 'R'
7. HOT POURED SEALANT UNLESS OTHERWISE SPECIFIED.
8. THIS DIMENSION MAY VARY DEPENDING ON THE SPACING OF POSTS FOR THE STEEL PLATE BEAM GUARD. THE TYPICAL LOCATION FOR THE SURFACE DRAIN IS WHERE THE POST SPACING WIDENS TO 3'-1 1/2".

DESIGN NOTE: (WILL NOT APPEAR ON CONTRACT PLANS)

SPECIFY THE TYPE OF SURFACE DRAIN REQUIRED AT EACH STRUCTURE.

WHEN TIE BARS ② ARE NOT SHOWN IN THE BRIDGE DRAWINGS, INCLUDE IN THE PLANS AS "PAVEMENT TIES".



LOCATION OF TIE BARS IN WINGWALL

CONCRETE SURFACE DRAIN
FLUME TYPE
AT STRUCTURES

STATE OF WISCONSIN
DEPARTMENT OF TRANSPORTATION

APPROVED
DATE — STATE DESIGN ENGINEER FOR HWYS
FHWA

APPROVED — DATE — STATE MAT. ENGINEER FOR HWYS
APPROVED — DATE — STATE MAINT. ENGINEER FOR HWYS
APPROVED — DATE — STATE CONST. ENGINEER FOR HWYS

ORIGINATOR: MEL ZEMLICKA 6-2782
REVISION DATE: 5-18-90
PLOT NAME: S8D204
PLOT SCALE: 1
FILE NAME: S8D204
LEVELS ON: 5.

S.D.D. 8 D 2-4

Standard Detail Drawing 8D2 - 4

References:

Bid items associated with this drawing:

Item #	Title

Standardized Special Provisions associated with this drawing:

STSP #	Title

Other SDD's associated with this drawing:

Design Notes:

April 18, 2003

MwRSF Response:

Hi Peter,

I received your question regarding the approach transition and drainage. Looking at your standards and your email, it appears you are proposing one of two options.

1. Removal of post no. 5 and using larger 8" x 8" posts for post nos. 4 and 6.

2. Moving the flume.

We would suggest that you not remove post no. 5 from the transition region. It is not certain how the existing transition will perform with that post removed, but there are concerns that removal of the post would create an area with significantly less stiffness than the tested design. Even if you increase the size of the adjacent posts to 8" x 8" the stiffness will not match the design with post no. 5 included.

As such, we would recommend that you use the second option, which is to move the flume. It appears from you drawing that the flume could be moved 37.5" so that it sits between post nos. 6 and 7. This would provide room for your flume while not adversely affecting the transition.

Thanks

Bob Bielenberg