



March 20, 2009

In Reply Refer To: HSSD/B-189

Mr. Ronald K. Faller, Ph.D.
Research Assistant Professor
Midwest Roadside Safety Facility (MwRSF)
University of Nebraska-Lincoln
527 Nebraska Hall
Lincoln, NE 68588-0529

Dear Dr. Faller:

This letter is in response to your request for Federal Highway Administration (FHWA) acceptance of a roadside safety system for use on the National Highway System (NHS).

Name of system:	Midwest Guardrail System (MGS) for Long-Span Culvert Applications
Type of system:	Longitudinal Barrier
Test Level:	Manual for Assessing Safety Hardware (MASH) TL-3
Testing conducted by:	Midwest Roadside Safety Facility
Date of request:	June 25, 2008
Date of completed package:	February 06, 2009

You requested that we find this system acceptable for use on the NHS under the provisions of National Cooperative Highway Research Program (NCHRP) Report 350 "Recommended Procedures for the Safety Performance Evaluation of Highway Features"

Requirements

Roadside safety systems should meet the guidelines contained in the NCHRP Report 350. The FHWA Memorandum "ACTION: Identifying Acceptable Highway Safety Features" of July 25, 1997, provides further guidance on crash testing requirements of longitudinal barriers.

System Description, Test number LSC-1

The MGS long-span design consisted of 55.25 m (181.25 ft) of standard 2.67 mm (12 gauge) thick W-beam guardrail supported by steel posts and six CRT posts. Anchorage systems similar to those used on tangent guardrail terminals were utilized on both the upstream and downstream ends of the guardrail system.



The entire system was constructed with twenty-six guardrail posts. Post numbers 3 through 10 and 17 through 24 were galvanized ASTM A36 steel W152 x 13.4 (W6 x 9) sections measuring 1,829 mm (72.0 in.) long. Post numbers 1, 2, 26, and 27 were BCT timber posts measuring 140 mm wide x 190 mm deep x 1,080 mm long (5.5 in. wide x 7.5 in. deep x 42.5 in. long) and were placed in 1,829 mm (72.0 in.) long steel foundation tubes. The timber posts and foundation tubes were part of anchor systems designed to replicate the capacity of a tangent guardrail terminal. Post numbers 11 through 16 were 152 mm wide x 203 mm deep x 1,829 mm long (6.0 in. wide x 8.0 in. deep x 72.0 in. long) timber, breakaway CRT posts.

Post numbers 3 through 24 were spaced 1,905 mm (75.0 in.) on center with a soil embedment depth of 1,016 mm (40.0 in.). Three posts were omitted in the center section of the guardrail to create a 7.62 m (25.0 ft) long, unsupported guardrail length in the center of the system. The posts were placed in a compacted coarse, crushed limestone material that met Grading B of the American Association of State Highway and Transportation Officials M147-65 (1990) as found in NCHRP Report Number 350. For post numbers through 24, 152-mm wide x 305 mm deep x 362-mm long (6.0 in. wide x 12.0 in. deep x 14.25 in. long) wood spacer block outs were used to block the rail away from the front face of the steel and CRT posts.

Standard 2.67 mm (12 gauge) thick W-beam rails with additional post bolt slots at half post spacing intervals were placed between post numbers 1 and 29. The nominal top mounting height of the W-beam rail was 787 mm (31.0 in.) with a 632 mm (24.875 in.) center height. The rail splices have been moved to the center of the span location. All lap splice connections between the rail sections were configured to reduce vehicle snag at the splice during the crash test. No nested guardrail sections were used in the MGS long-span design.

For test number LSC-1, a simulated culvert headwall was constructed behind the MGS long-span guardrail in order to simulate any potential vehicle drop off of the edge of the culvert and to simulate the effect of the culvert headwall on the deflection of adjacent guardrail posts during an impact. The design of the headwall was based on a survey of common culvert designs from the sponsoring agencies. The simulated culvert headwall consisted of a 229 mm thick x 1,219 mm tall (9.0-in. thick x 48.0 in. tall) reinforced concrete wall installed 305 mm (12.0 in.) behind the back of the CRT posts in the system or 898 mm (35.35 in.) behind the face of the rail. The headwall ran parallel to the guardrail from 1,219 mm (48.0 in.) downstream of post number 13 until 305 mm (12.0 in.) upstream of post number 14. At 305 mm (12.0 in.) upstream of post number 14, the headwall angled away from the guardrail at a 45 degree angle for 1,805 mm (71.0 in.) to form the downstream wing wall of the culvert. The top of the simulated concrete headwall was installed at the ground height for the guardrail system and a 1,219 mm (48.0 in.) deep pit was excavated behind the headwall to create the necessary drop-off. The soil around the culvert headwall and the top of the headwall itself remained level for this installation in order to simplify the installation. This simplification could be made because crash testing was designed to evaluate the capacity of the system by eliminating any adverse interaction of vehicle and culvert head wall by maintaining an at-grade head wall height.

Crash Testing, Test Number LSC-1

The analysis of the crash test results showed that the MGS long-span guardrail adequately contained and redirected the vehicle with controlled lateral displacements of the guardrail. Detached elements and debris from the test article did not penetrate nor show potential for

penetrating the occupant compartment. Deformations of, or intrusion into, the occupant compartment that could have caused serious injury did not occur. The vehicle remained upright during and after collision. Vehicle roll, pitch, and yaw angular displacements were noted, but they were deemed acceptable because they did not adversely influence occupant risk safety criteria nor cause rollover. It is noted that the occupant impact velocities (OIV) and occupant ride down decelerations (ORD) were within the suggested limits provided in the update to NCHRP Report Number 350. After collision, the vehicle's trajectory intruded slightly into adjacent traffic lanes but was determined to be acceptable. In addition, the vehicle exited the barrier within the exit box. Therefore, test number LSC-1 conducted on the MGS long-span guardrail system was determined to be acceptable according to the update to NCHRP Report Number 350 criteria. It should also be noted that this test successfully evaluated the strength capacity of the system through the choice of a critical impact point that maximized the potential for pocketing, wheel snag, and rail rupture and the use of the 2270P vehicle to maximize rail loading.

System Description, Test Number LSC-2

The design of the MGS long-span guardrail remained unchanged for test number LSC-2, but modifications were made to the design of the culvert and the lateral offset between the guardrail and the culvert headwall. Since the purpose of test number LSC-2 was to evaluate the hazard posed by an impact that maximized the interaction between the vehicle and the culvert wall, a more detailed, representative culvert headwall was developed for this test. Additionally, the dynamic deflection and vehicle trajectory of the previous test, test number LSC-1, led the researchers to believe that the lateral offset between the barrier and the culvert headwall could be further reduced.

The culvert design was modified to include both the upstream and downstream wing walls as well as a typical slope profile based on representative culvert designs submitted by the sponsoring agencies. The culvert consisted of a 229-mm thick x 1,219-mm tall (9.0-in. thick x 48.0-in.) reinforced concrete wall installed flush with the back of the CRT posts in the system or 591 mm (23.25 in.) behind the face of the rail. The headwall ran parallel to the guardrail from 305 mm (12.0 in.) downstream of post number 13 until 305 mm (12.0 in.) upstream of post number 14. At 305 mm (12.0 in.) upstream of post number 14 and 305 mm (12.0 in.) downstream of post number 13, the headwall angled away from the guardrail at a 45 degree angle for 1,819 mm (71.61 in.) to form the wing wall of the culvert. The top of the simulated concrete headwall was installed at the ground height for the guardrail system. A 3:1 slope was started 610 mm (24.0 in.) behind the back face of the guardrail posts of the MGS long-span, and the wing walls were modified to match the soil slope. The choice of the slope profile was based on choosing the flattest slope of the typical culvert installations submitted by the sponsoring states. The choice of the flattest slope maximized the potential for vehicle interaction with the wing walls of the culvert during the impact event. A 1,219 mm (48.0 in) deep pit was excavated behind the headwall to create the necessary drop-off.

Crash Testing, Test Number LSC-2

The analysis of the test results for test number LSC-2 showed that the MGS long-span guardrail adequately contained and redirected the vehicle with controlled lateral displacements of the guardrail. Detached elements and debris from the test article did not penetrate nor show

potential for penetrating the occupant compartment. Deformations of, or intrusion into, the occupant compartment that could have caused serious injury did not occur. The vehicle remained upright during and after collision. Vehicle roll, pitch, and yaw angular displacements were noted, but they were deemed acceptable because they did not adversely influence occupant risk safety criteria nor cause rollover. It is noted that the OIV and ORD were within the suggested limits provided in the update to NCHRP Report Number 350. After collision, the vehicle's trajectory intruded slightly into adjacent traffic lanes but was determined to be acceptable. In addition, the vehicle did not exit the barrier within the exit box, but the trajectory of the vehicle was deemed acceptable. Therefore, test number LSC-2 conducted on the MGS long-span guardrail system was determined to be acceptable according to the update to the NCHRP Report Number 350 criteria. It should be noted that this test successfully evaluated the potential for vehicle instability through the choice of a CIP that maximized the impact of the left-front wheel on the upstream wing wall of the culvert. Additionally, the 0-mm (0-in.) offset from the back of the posts to the front face of the culvert headwall did not adversely affect the safety performance of the system and was believed to be a reasonable minimal offset distance for the MGS long-span based on this test. It is not believed that the reduced barrier offset in this test would have had any effect on the outcome of test number LSC-1, which focused on the rail capacity of the system and not vehicle interaction with the culvert.

Findings

Therefore, the MGS for Long-Span Culvert Applications system described above and detailed in the enclosed drawings is acceptable for use on the NHS under the range of conditions tested, when such use is acceptable to a highway agency.

Please note the following standard provisions that apply to the FHWA letters of acceptance:

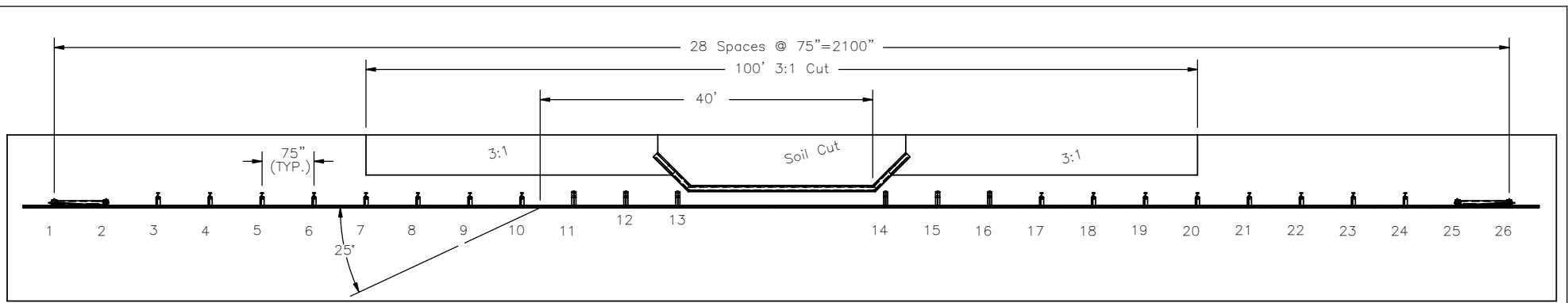
- This acceptance is limited to the crashworthiness characteristics of the systems with respect to at-grade headwall weights only and does not address all other height conditions of an existing headwall.
- This acceptance is limited to the crashworthiness characteristics of the systems and does not cover their structural features, nor conformity with the Manual on Uniform Traffic Control Devices.
- Any changes that may adversely influence the crashworthiness of the system will require a new acceptance letter.
- Should the FHWA discover that the qualification testing was flawed, that in-service performance reveals unacceptable safety problems, or that the system being marketed is significantly different from the version that was crash tested, we reserve the right to modify or revoke our acceptance.
- You will be expected to supply potential users with sufficient information on design and installation requirements to ensure proper performance.
- You will be expected to certify to potential users that the hardware furnished has essentially the same chemistry, mechanical properties, and geometry as that submitted for acceptance, and that it will meet the crashworthiness requirements of the FHWA and the NCHRP Report 350.

- To prevent misunderstanding by others, this letter of acceptance is designated as number B-189 and shall not be reproduced except in full. This letter and the test documentation upon which it is based are public information. All such letters and documentation may be reviewed at our office upon request.
- This acceptance letter shall not be construed as authorization or consent by the FHWA to use, manufacture, or sell any patented system for which the applicant is not the patent holder. The acceptance letter is limited to the crashworthiness characteristics of the candidate system, and the FHWA is neither prepared nor required to become involved in issues concerning patent law. Patent issues, if any, are to be resolved by the applicant.

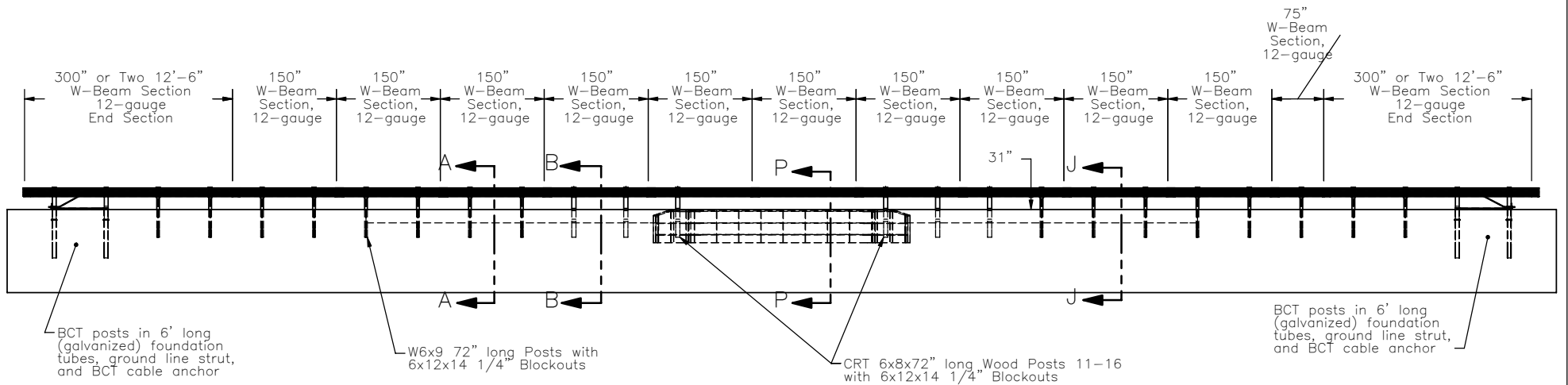
Sincerely yours,



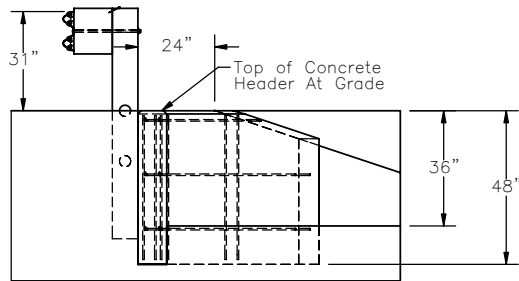
David A. Nicol
Director, Office of Safety Design
Office of Safety



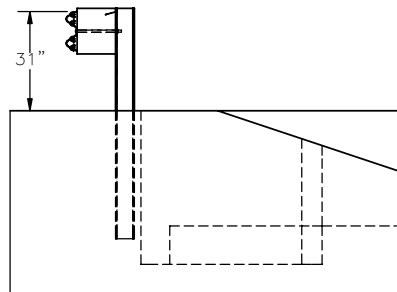
PLAN VIEW



PROFILE VIEW



SECTION P-P



SECTION J-J



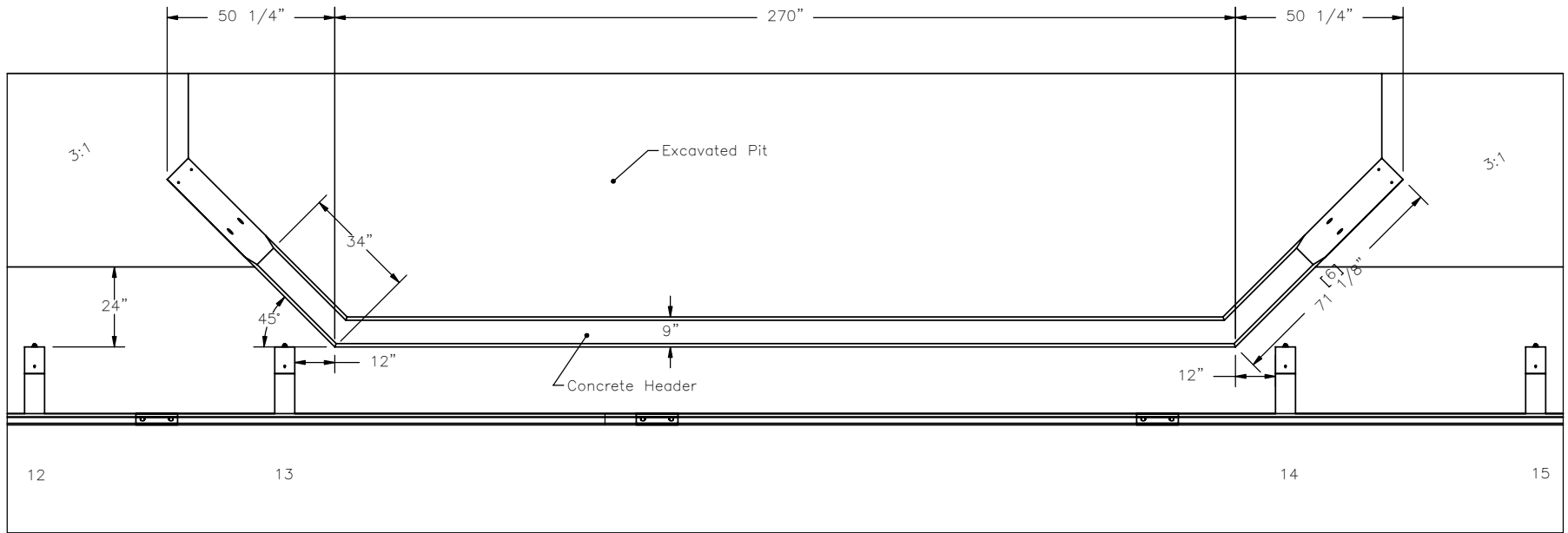
Midwest Roadside
Safety Facility

MGS Long Span LSC-2
System Layout

DWG. NAME:
MGS_Longspan_LSC-2_R2

SCALE: None
UNITS: Inches

SHEET:
1 of 10
DATE:
05/23/2006
DRAWN BY:
GEP
REV. BY:
KAP/CME



PLAN VIEW



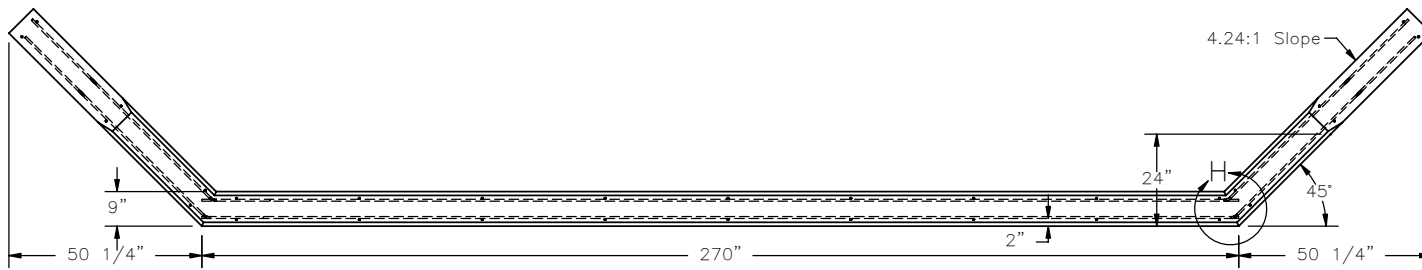
Midwest Roadside
Safety Facility

MGS Long Span LSC-2
Soil Cut Details

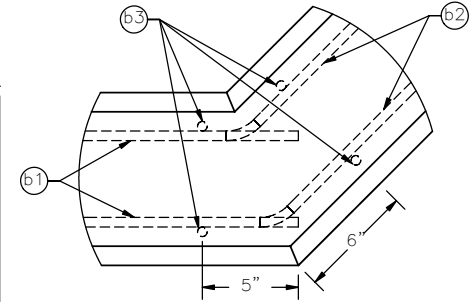
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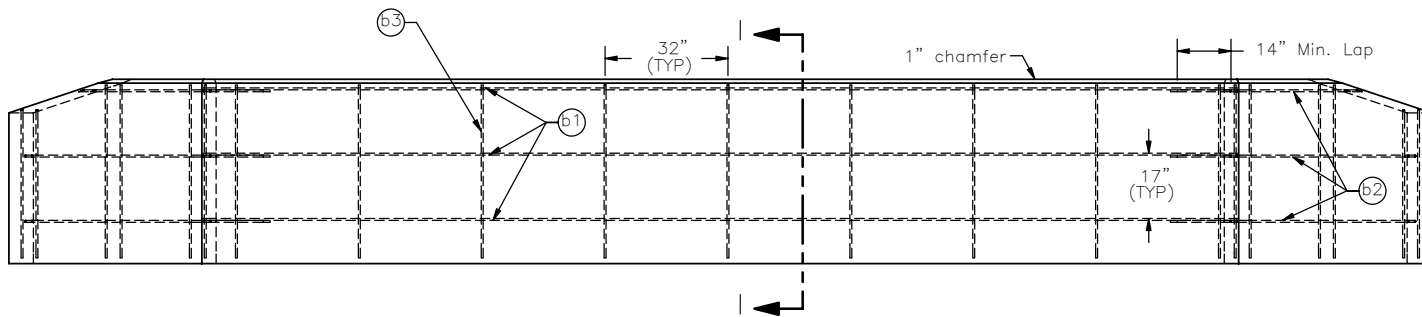
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05/23/2006
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KAP/CME



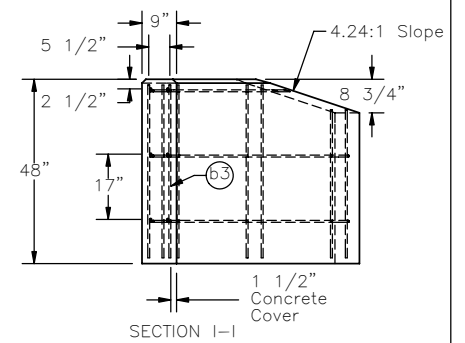
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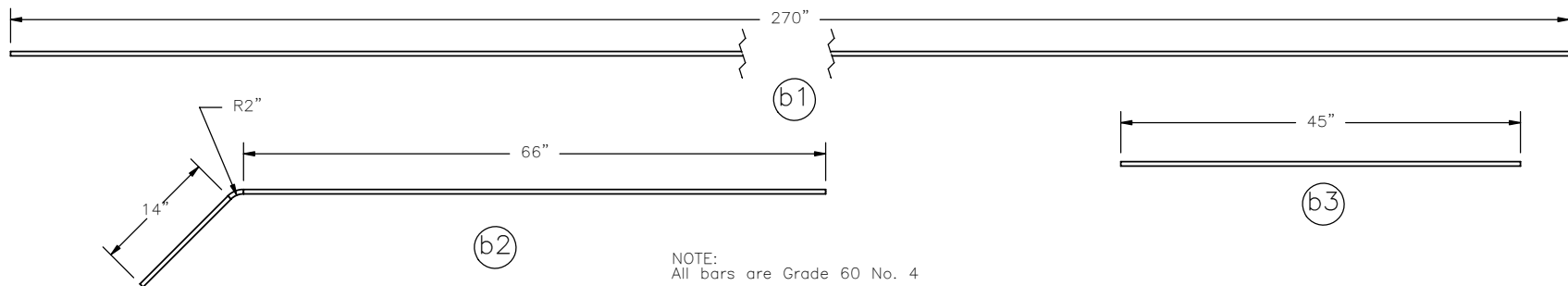
DETAIL H
SCALE 1 : 10



PROFILE VIEW



SECTION I-I



NOTE:
All bars are Grade 60 No. 4

Bill of Bars

Item No.	QTY.	Description	Material Specification
-	1	Concrete Header	f'c=4000 ksi
b1	6	#4 Bar - Longitudinal - 270" long	Grade 60 Steel
b2	12	#4 Bar - Bent Longitudinal - 80" long	Grade 60 Steel
b3	30	#4 Bar - Transverse - 45" long	Grade 60 Steel



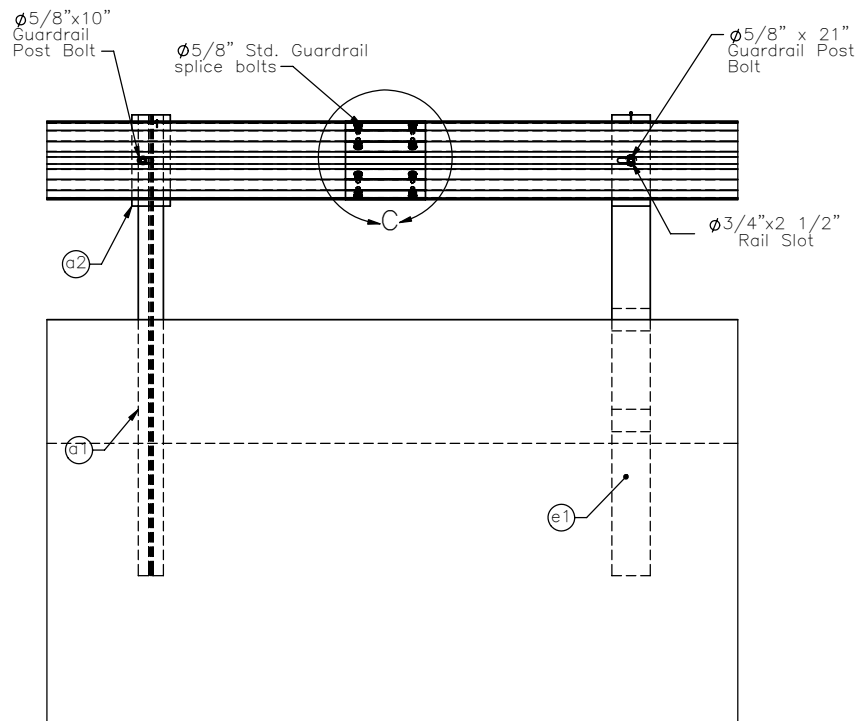
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Safety Facility

MGS Long Span LSC-2
Concrete Header Details

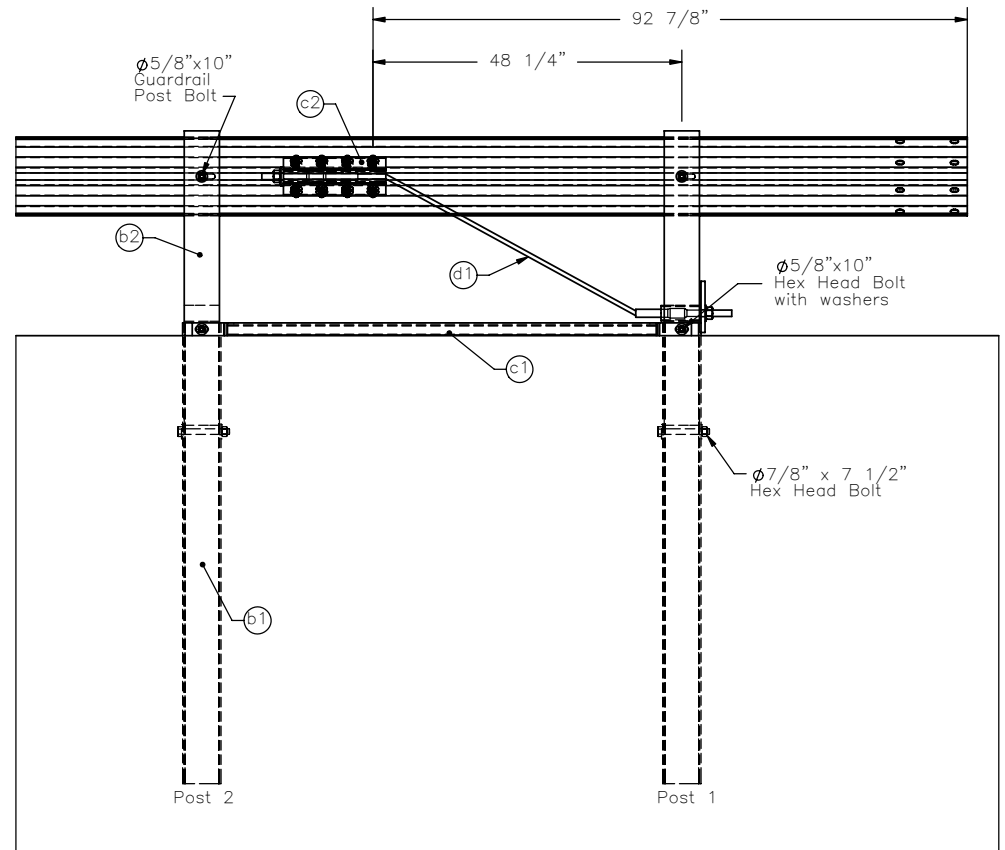
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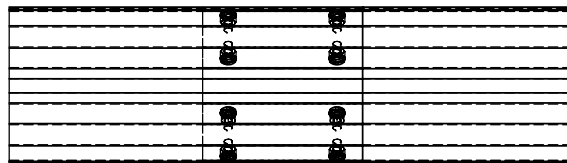
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SPLICE DETAIL



END RAIL DETAIL



DETAIL C
SCALE 1 : 15



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MGS Long Span LSC-2

End Rail Detail
Splice Detail

SHEET:
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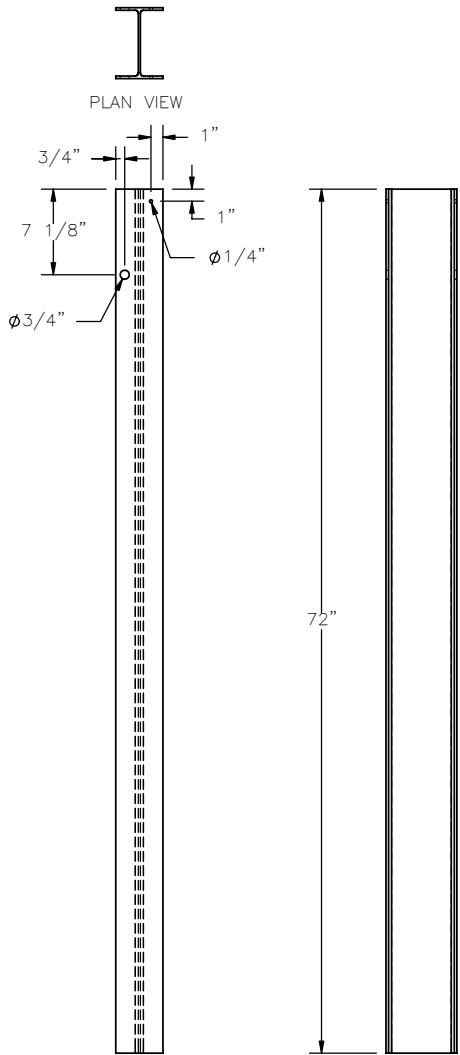
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05/23/2006

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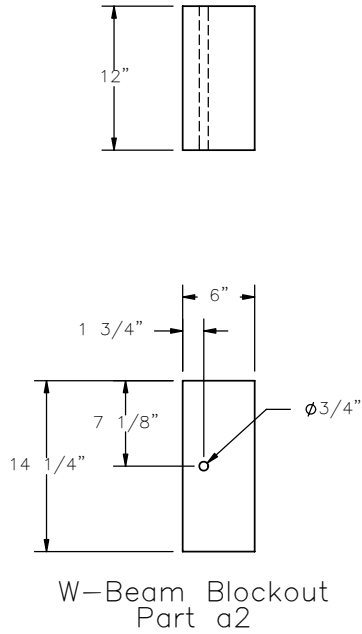
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KAP/CME



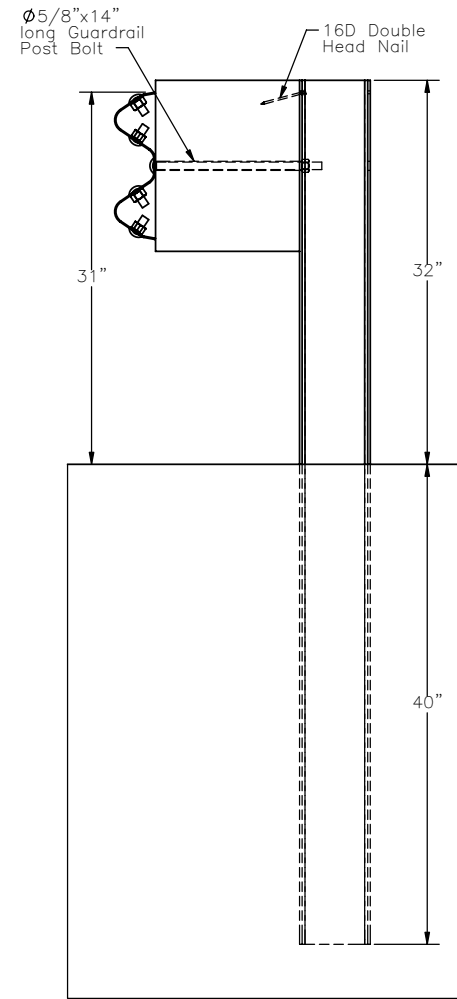
PROFILE VIEW

SIDE VIEW

W6x9-Beam Post
Part a1



W-Beam Blockout
Part a2



SECTION A-A



Midwest Roadside
Safety Facility

MGS Long Span LSC-2

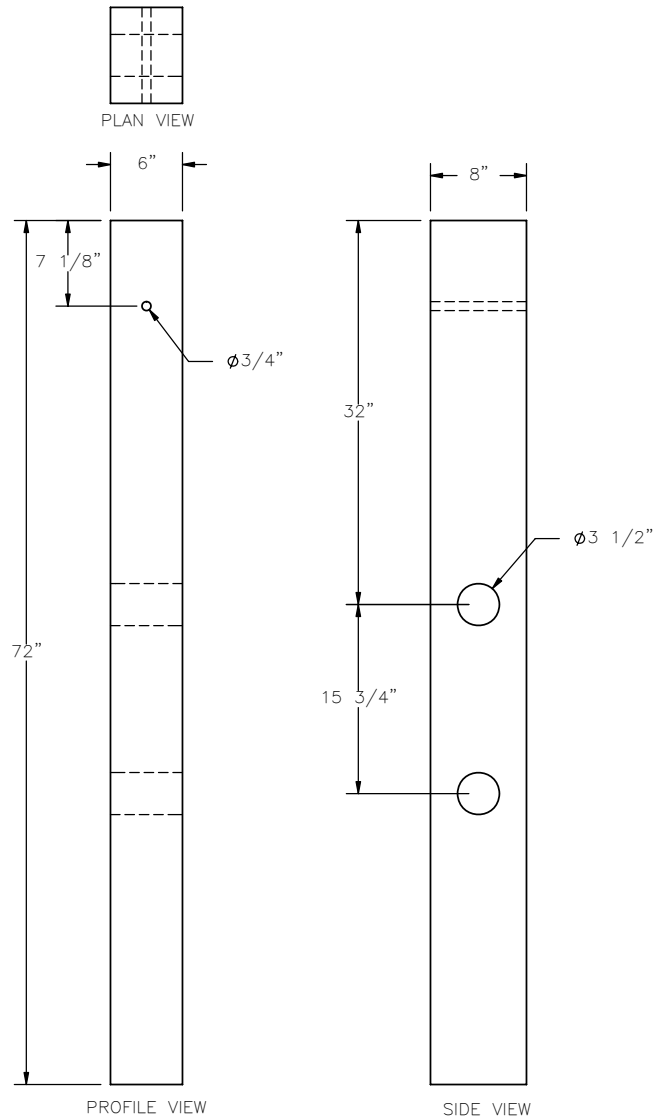
Post 3-10 &
17-24 Detail
W6x9 Posts

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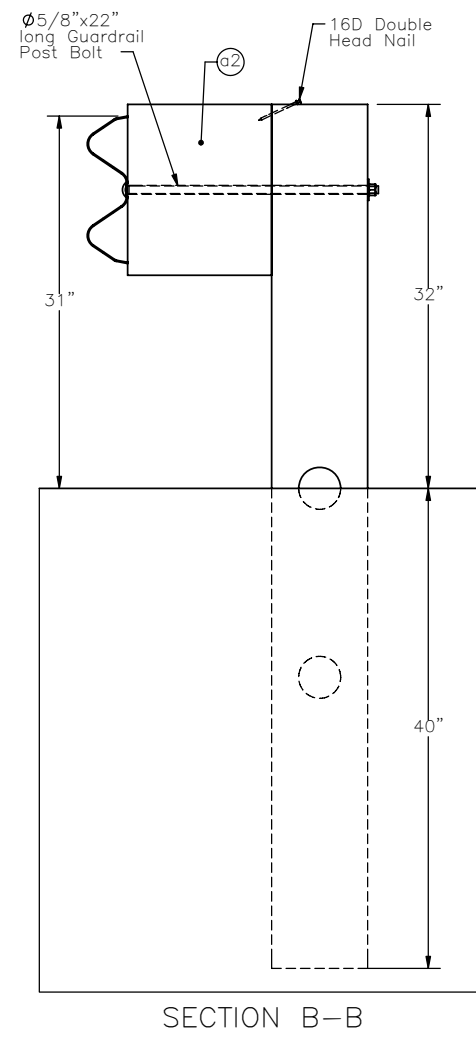
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UNITS: Inches

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DATE:
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CRT Wood Post
Part e1



Midwest Roadside
Safety Facility

MGS Long Span LSC-2

Post 11-16 Detail
CRT Wood Posts

DWG. NAME.
MGS_Longspan_LSC-2_R2

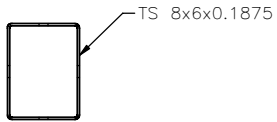
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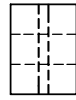
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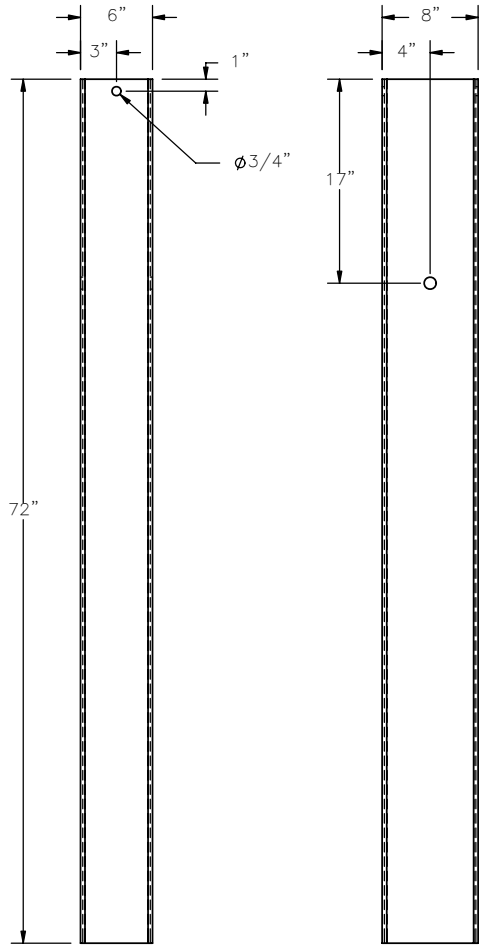
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PLAN VIEW



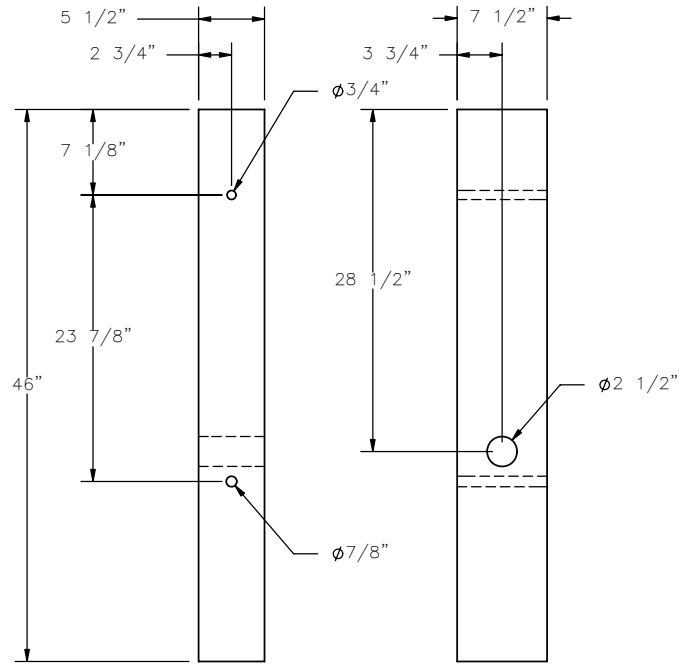
PLAN VIEW



PROFILE VIEW

SIDE VIEW

Foundation Tube
Part b1



PROFILE VIEW

SIDE VIEW

BCT (MGS) Timber Post
Part b2



Midwest Roadside
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MGS Long Span LSC-2

BCT Timber Posts &
Foundation Tube Detail

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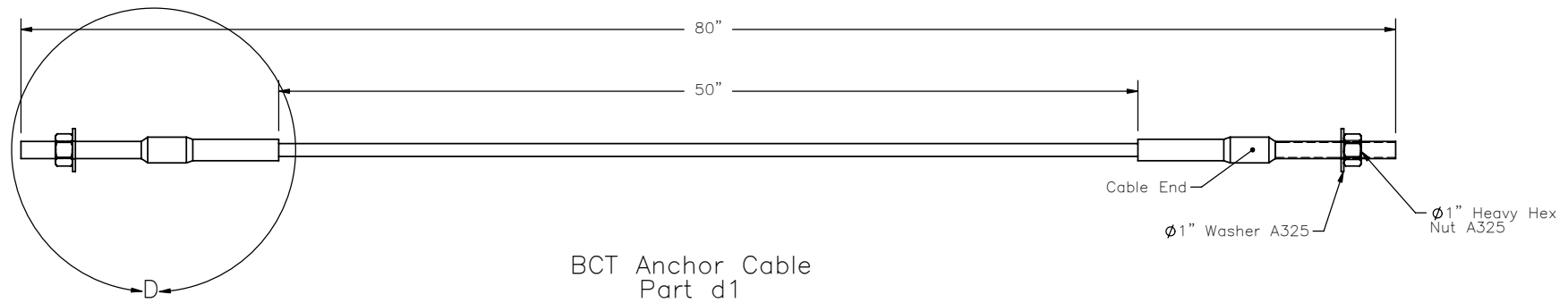
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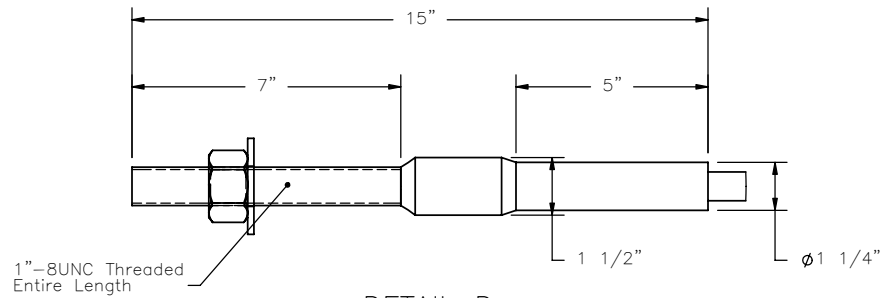
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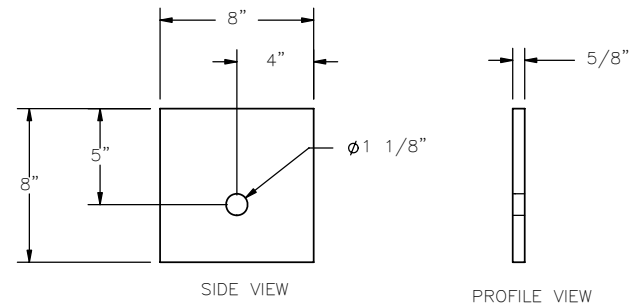
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UNITS: Inches



BCT Anchor Cable
Part d1



DETAIL D
SCALE 1 : 5



Anchor Cable
Bearing Plate
Part d2



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MGS Long Span LSC-2

BCT Anchor Cable Detail

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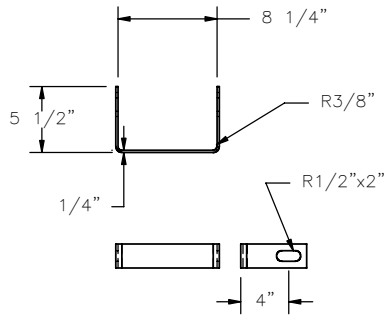
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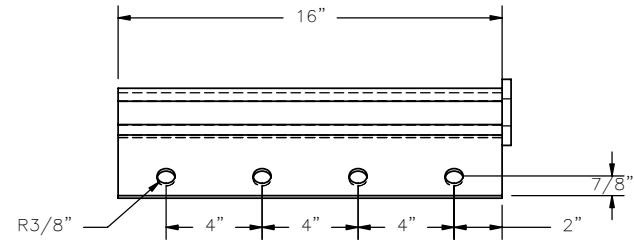
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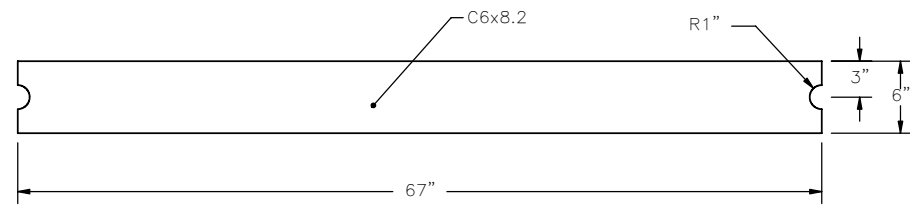
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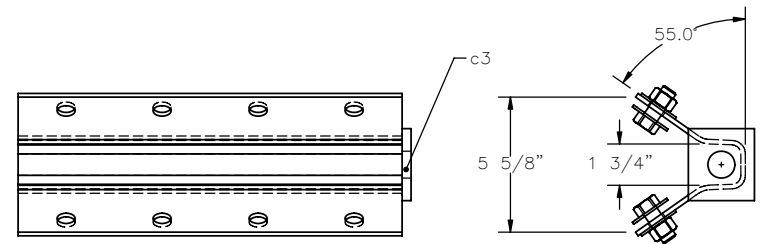
Yoke Detail



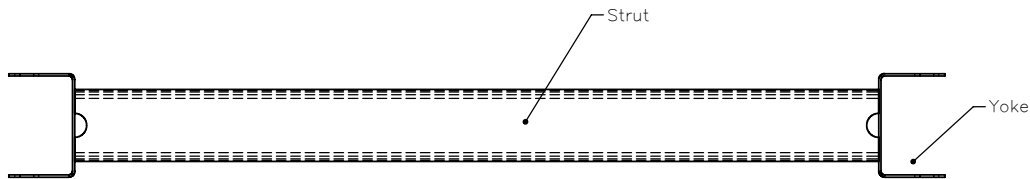
Anchor Bracket Part c2



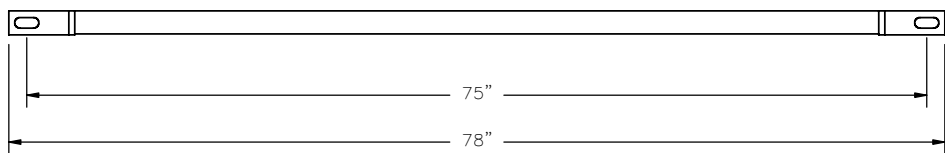
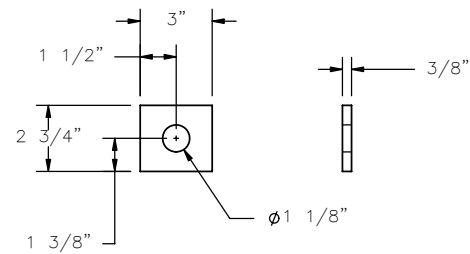
Strut Detail



Anchor Bracket Bearing Plate Part c3



PLAN VIEW



PROFILE VIEW

Ground Strut Part c1



Midwest Roadside Safety Facility

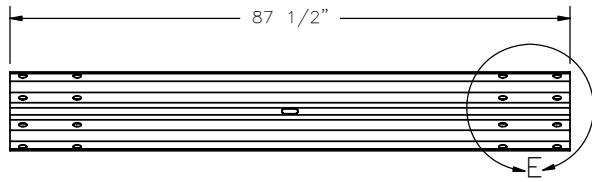
MGS Long Span LSC-2

Ground Strut & Anchor Bracket Details

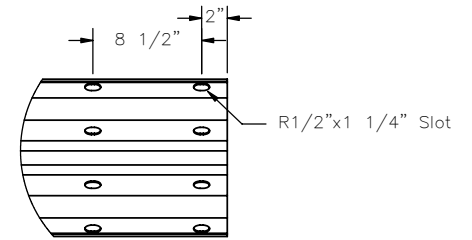
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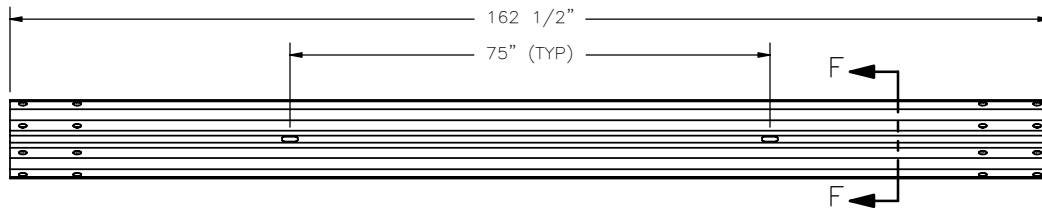
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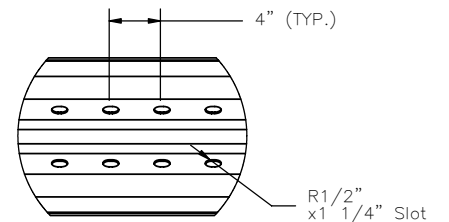
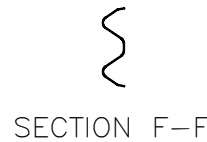
6'-3" W-Beam Section, 12 gauge



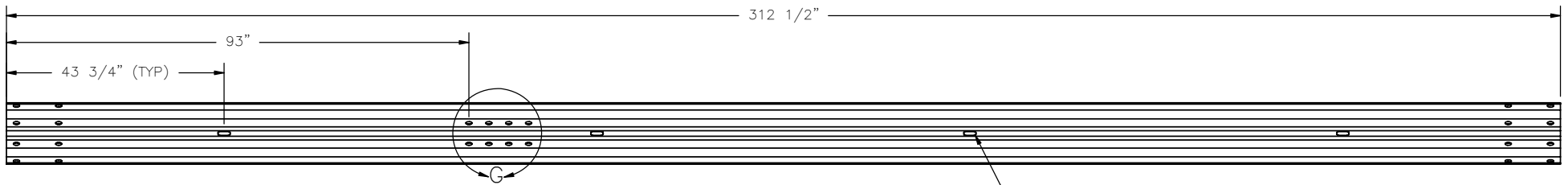
DETAIL E
SCALE 1 : 15



12'-6" W-Beam Section, 12 gauge



DETAIL G
SCALE 1 : 15



25' W-Beam Section, 12 gauge, End Section



Midwest Roadside
Safety Facility

MGS Long Span LSC-2
Rail Section Details

DWG. NAME:
MGS_Longspan_LSC-2_R2

SCALE: None
UNITS: Inches

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DATE:
05/23/2006
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GEP
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