



U.S. Department
of Transportation
Federal Highway
Administration

1200 New Jersey Ave., SE
Washington, D.C. 20590

December 18, 2015

In Reply Refer To:
HSST/B-256

Ms. Karla Lechtenberg
Midwest Roadside Safety Facility
130 Whittier Research Center
2200 Vine Street
Lincoln, NE 68583-0853

Dear Ms. Lechtenberg:

This letter is in response to your March 6, 2015 request for the Federal Highway Administration (FHWA) to review a roadside safety device, hardware, or system for eligibility for reimbursement under the Federal-aid highway program. This FHWA letter of eligibility is assigned FHWA control number B-256 and is valid until a subsequent letter is issued by FHWA that expressly references this device.

Decision

The following devices are eligible, with details provided in the form which is attached as an integral part of this letter:

- Trailing-End Anchorage for 31" Tall Guardrail

Scope of this Letter

To be found eligible for Federal-aid funding, new roadside safety devices should meet the crash test and evaluation criteria contained in the American Association of State Highway and Transportation Officials' Manual for Assessing Safety Hardware (MASH). However, the FHWA, the Department of Transportation, and the United States Government do not regulate the manufacture of roadside safety devices. Eligibility for reimbursement under the Federal-aid highway program does not establish approval, certification or endorsement of the device for any particular purpose or use.

This letter is not a determination by the FHWA, the Department of Transportation, or the United States Government that a vehicle crash involving the device will result in any particular outcome, nor is it a guarantee of the in-service performance of this device. Proper manufacturing, installation, and maintenance are required in order for this device to function as tested.

This finding of eligibility is limited to the crashworthiness of the system and does not cover other structural features, nor conformity with the Manual on Uniform Traffic Control Devices.

Eligibility for Reimbursement

Based solely on a review of crash test results and certifications submitted by the manufacturer, and the crash test laboratory, FHWA agrees that the device described herein meets the crash test and evaluation criteria of the American Association of State Highway and Transportation Officials' Manual for Assessing Safety Hardware (MASH). Therefore, the device is eligible for reimbursement under the Federal-aid highway program if installed under the range of tested conditions.

Name of system: Trailing-End Anchorage for 31" Tall Guardrail

Type of system: Longitudinal Barrier

Test Level: MASH Test Level 3

Testing conducted by: Midwest Roadside Safety Facility

Task Force 13 Designator: SEW31

Date of request: May 11, 2015

Date initially acknowledged: March 28, 2015

Date of completed package: August 21, 2015

Full Description of the Eligible Device

The device and supporting documentation, including reports of the crash tests or other testing done, videos of any crash testing, and/or drawings of the device, are described in the attached form.

Notice

If a manufacturer makes any modification to any of their roadside safety hardware that has an existing eligibility letter from FHWA, the manufacturer must notify FHWA of such modification with a request for continued eligibility for reimbursement. The notice of all modifications to a device must be accompanied by:

- Significant modifications – For these modifications, crash test results must be submitted with accompanying documentation and videos.
- Non-signification modifications – For these modifications, a statement from the crash test laboratory on the potential effect of the modification on the ability of the device to meet the relevant crash test criteria.

FHWA's determination of continued eligibility for the modified hardware will be based on whether the modified hardware will continue to meet the relevant crash test criteria.

You are expected to supply potential users with sufficient information on design, installation and maintenance requirements to ensure proper performance.

You are expected to certify to potential users that the hardware furnished has the same chemistry, mechanical properties, and geometry as that submitted for review, and that it will meet the test and evaluation criteria of the MASH.

Issuance of this letter does not convey property rights of any sort or any exclusive privilege. This letter is based on the premise that information and reports submitted by you are accurate and correct. We reserve the right to modify or revoke this letter if: (1) there are any inaccuracies in the information submitted in support of your request for this letter, (2) the qualification testing was flawed, (3) in-service performance or other information reveals safety problems, (4) the system is significantly different from the version that was crash tested, or (5) any other information indicates that the letter was issued in error or otherwise does not reflect full and complete information about the crashworthiness of the system.

Standard Provisions

- This letter provides a AASHTO/ARTBA/AGC Task Force 13 designator that should be used for the purpose of the creation of a new and/or the update of an existing Task Force 13 drawing for posting on the on-line 'Guide to Standardized Highway Barrier Hardware' currently referenced in AASHTO Roadside Design Guide.
- To prevent misunderstanding by others, this letter of eligibility designated as FHWA control number B-256 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 upon request.
- This 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.
- If the subject device is a patented product it may be considered to be proprietary. If proprietary systems are specified by a highway agency for use on Federal-aid projects:
 - (a) they must be supplied through competitive bidding with equally suitable unpatented items;
 - (b) the highway agency must certify that they are essential for synchronization with the existing highway facilities or that no equally suitable alternative exists; or
 - (c) they must be used for research or for a distinctive type of construction on relatively short sections of road for experimental purposes.

Our regulations concerning proprietary products are contained in Title 23, Code of Federal Regulations, Section 635.411.

Sincerely yours,

A handwritten signature in blue ink that reads "Michael S. Griffith". The signature is written in a cursive style with a large, stylized initial "M".

Michael S. Griffith
Director, Office of Safety Technologies
Office of Safety

Enclosures

Request for Federal Aid Reimbursement Eligibility Of Highway Safety Hardware

Submitter	Date of Request:	May 11, 2015	<input checked="" type="radio"/> New <input type="radio"/> Resubmission
	Name:	Karla Lechtenberg	
	Company:	Midwest Roadside Safety Facility	
	Address:	130 Whittier Research Center, 2200 Vine Street, Lincoln, NE 68583-0853	
	Country:	USA	
	To:	Michael S. Griffith, Director FHWA, Office of Safety Technologies	

I request the following devices be considered eligible for reimbursement under the Federal-aid highway program.

[Help](#)

System Type	Submission Type	Device Name / Variant	Testing Criterion	Test Level
'CC': Crash Cushions, Attenuators, & Terminals	<input checked="" type="radio"/> Physical Crash Testing <input type="radio"/> FEA & V&V Analysis <input type="radio"/> Engineering Analysis	Trailing-End Anchorage for 31" Tall Guardrail	AASHTO MASH	TL3

By submitting this request for review and evaluation by the Federal Highway Administration, I certify that the product(s) was (were) tested in conformity with the AASHTO Manual for Assessing Safety Hardware and that the evaluation results meet the appropriate evaluation criteria in the MASH.

Identification of the individual or organization responsible for the product:

Contact Name:	Karla Lechtenberg	Same as Submitter <input checked="" type="checkbox"/>
Company Name:	Midwest Roadside Safety Facility	Same as Submitter <input checked="" type="checkbox"/>
Address:	130 Whittier Research Center, 2200 Vine Street, Lincoln, NE 68583-	Same as Submitter <input checked="" type="checkbox"/>
Country:	USA	Same as Submitter <input checked="" type="checkbox"/>

PRODUCT DESCRIPTION

<input checked="" type="radio"/> New Hardware	<input type="radio"/> Modification to Existing Hardware	
<p>The Trailing-End Anchorage for 31-in. tall Guardrail (SEW31) is comprised of two timber breakaway cable terminal (BCT) posts (PDF01) set into 72-in. long, ASTM A500 Grade B steel foundation tubes (PTE06) such that the top of the BCT timber posts are 32 in. from the ground. The two steel foundation tubes are spaced 75 in. apart and are connected at the ground by a Strut and Yoke Assembly (PFP02) with a 10-in. long, ASTM A307 bolt with nut (FBX16a) and washers (FWC16a) under the head of the bolt and the nut at each foundation tube. One end of a BCT Anchor Cable Assembly (FCA01) was attached to the backside of the Trailing-End Anchorage Rail Section (RWM14a) with an Anchor Bracket Assembly (FPA01). The Anchor Bracket Assembly was attached to the Trailing-End anchorage Rail Section with eight 1 1/2-in. long ASTM A307 hex head bolts and nuts (FBX16a) with washers (FWC16a) under the head of the bolt and the nut. The other end of a BCT Anchor Cable Assembly (FCA01) passed through the hole at the bottom of the end timber BCT post (PDF01) which contained a BCT Post Sleeve (FMM02) and was secured through an ASTM A36 steel BCT Bearing Plate (FPB01). The rail is attached to the timber BCT posts with standard guardrail bolts or ASTM A307 5/8-in. diameter x 10-in. long guardrail bolts and nuts (FBB03). A 12-gauge, Rounded W-Beam End Section (RWE03a) is attached to the end of the Trailing-End Anchorage Rail Section (RWM14a). A 6-ft long, standard W6x8.5 (or W6x9) ASTM A992 or A36 steel post (PWE06), embedded 40 inches in the ground, is placed 150-in. upstream from the last PDF01 post.</p> <p>The Trailing-End Anchorage for 31-in. tall Guardrail should be used where needed to anchor the downstream end of guardrail and (1) end-on impacts will not occur or (2) the end terminal is placed outside of the clear zone for opposite direction traffic.</p> <p>The non-gating, redirective length-of-need of the Trailing-End Anchorage (SEW31) is 375 in. from the centerline of the last PDF01 post and includes four 6-ft long, standard W6x8.5 (or W6x9) ASTM A992 or A36 steel posts (PWE06) or 6-in. x 8-in. Southern Yellow Pine or White Pine posts (PDE02 or PDE20) contained in a standard Midwest Guardrail System (SGR20a-c), which is depicted as the 6th Post in the attached Placement Guidelines for Shielding Hazards Near Trailing-End Anchorage. Farther downstream from this post, the Trailing-End Anchorage becomes a gating terminal, and guidance for using the Trailing-End Anchorage (SEW31) to shield hazards near the Trailing-End Anchorage is provided in the attached Placement Guidelines for Shielding Hazards Near Trailing-End Anchorage and described by a working width envelope as follows. Note, the working width for the gating terminal was determined by the vehicle trajectory.</p> <p>(1) At the last PDF01 post, 125 in. of working width recommended.</p> <p>(2) At 225" upstream from the last PDF01 post, 65 in. of working width recommended.</p> <p>(3) Linearly interpolate between 125 in. and 65 in. such that for every 3 3/4 in. longitudinally upstream from the last PDF01 post, 1 in. less of working width recommended. (e.g., at 75 in. upstream from the last PDF01 post, 105 in. of working width is needed)</p> <p>(4) Linearly interpolate between 65 in. and 60 in. such that for every additional 15 in. longitudinally upstream from 225 in. upstream from the last PDF01 post, 1 in. less of working width recommended. (e.g., at 255 in. upstream from the last PDF01 post, 63 in. of working width is needed)</p> <p>(5) At greater than or equal to 300 in. upstream from the last PDF01 post, 60 in. of working width recommended.</p>		
Required Test Number	Narrative Description	Evaluation Results
3-30 (1100C)	Trailing-end guardrail terminal, thus only reverse-direction impact (test designation no. 3-37) necessary.	WAIVER REQUESTED
3-31 (2270P)	Trailing-end guardrail terminal, thus only reverse-direction impact (test designation no. 3-37) necessary.	WAIVER REQUESTED
3-32 (1100C)	Trailing-end guardrail terminal, thus only reverse-direction impact (test designation no. 3-37) necessary.	WAIVER REQUESTED

Required Test Number	Narrative Description	Evaluation Results
3-33 (2270P)	Trailing-end guardrail terminal, thus only reverse-direction impact (test designation no. 3-37) necessary.	WAIVER REQUESTED
3-34 (1100C)	Trailing-end guardrail terminal, thus only reverse-direction impact (test designation no. 3-37) necessary.	WAIVER REQUESTED
3-35 (2270P)	Trailing-end guardrail terminal, thus only reverse-direction impact (test designation no. 3-37) necessary.	WAIVER REQUESTED
3-36 (2270P)	Trailing-end guardrail terminal, thus only reverse-direction impact (test designation no. 3-37) necessary.	WAIVER REQUESTED

CRASH TESTING

A brief description of each crash test and its result:

<p style="text-align: center;">3-37 (2270P)</p>	<p>Two modified versions of test designation no. 3-37 were conducted: (1) test no. WIDA-1 was a modified test no. 3-37 with the intent of assessing the end of the length-of-need rather than maximizing vehicle snag and instability; and (2) test no. WIDA-2 was a modified test no. 3-37 performed with an 1100C instead of a 2270P to assess vehicle snag and instability. The results from both tests are found in MwRSF report no. TRP-03-279-13.</p> <p>In test no. WIDA-1, conducted on May 18, 2012, a 5,172-lb pickup truck with a simulated occupant seated in the right-front seat, impacted the trailing-end anchorage system, with its rail height set to the nominal height of 31 inches, at a speed of 63.0 mph and at an angle of 26.4 degrees. Impact occurred at the sixth post upstream from the downstream end of the terminal. At 0.330 sec after impact, the vehicle became parallel to the barrier system with a speed of 45.3 mph. At 0.406 sec, the vehicle exited the system at an angle of 4.2 degrees and at a speed of 43.5 mph. Exterior vehicle damage was moderate. Interior occupant compartment deformations were minimal, with a maximum deformation of 3/8 in., consequently not violating the limits established in MASH. Damage to the barrier was extensive, consisting of deformed W-beam rail and guardrail posts, disengaged rail and wood blockouts, contacts marks on guardrail and posts, and fractured timber BCT posts. The maximum lateral dynamic barrier deflection was 32 ft - 6.6 in. The working width of the system was 32 ft - 6.6 in. which included the barrier dynamic deflection. Maximum lateral vehicle intrusion behind the traffic-side face of the barrier was 124 in. All occupant risk measures were well below recommended values, and the test vehicle showed no tendency to roll over.</p> <p>In test no. WIDA-2, conducted on June 5, 2012, a 2,916-lb small passenger car with a simulated occupant seated in the right-front seat, impacted the trailing-end anchorage system, with its rail height set to the maximum tolerance of 32 inches, at a speed of 62.0 mph and at an angle of 25.5 degrees. Impact occurred at the mid-span between the second and third posts upstream from the downstream end of the terminal. After impact, the vehicle's impacting tire slid under the BCT Anchor Cable and BCT Bearing Plate, causing the vehicle to pitch downward and roll toward the barrier. At 0.248 sec, the vehicle exited the system and angle of 15.9 degrees and at a speed of 32.2 mph. After exiting the system, the vehicle yawed 180 degrees. Exterior vehicle damage was extensive. Interior occupant compartment deformations were minimal, with a maximum of 1 in., consequently not violating the limits established in MASH. Damage to the barrier was also extensive, consisting of deformed W-beam rail, guardrail posts bearing plate, and foundation tube, disengaged rail and wood blockouts, contact marks on guardrail and posts, and fractured timber BCT posts. The maximum lateral dynamic barrier deflection was 12 ft - 3.3 in. The working width of the system was not determined since the terminal gated and the vehicle was not redirected. All occupant risk measures were below the maximum values, and the test vehicle showed no tendency to roll over.</p>	<p style="text-align: center;">PASS</p>
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3-38 (1500A)	Trailing-end guardrail terminal, thus only reverse-direction impact (test designation no. 3-37) necessary.	WAIVER REQUESTED
3-40 (1100C)	Not Applicable	WAIVER REQUESTED
3-41 (2270P)	Not Applicable	WAIVER REQUESTED
3-42 (1100C)	Not Applicable	WAIVER REQUESTED
3-43 (2270P)	Not Applicable	WAIVER REQUESTED
3-44 (2270P)	Not Applicable	WAIVER REQUESTED
3-45 (1500A)	Not Applicable	WAIVER REQUESTED

Full Scale Crash Testing was done in compliance with MASH by the following accredited crash test laboratory (cite the laboratory's accreditation status as noted in the crash test reports.):

Laboratory Name:	Midwest Roadside Safety Facility	
Laboratory Contact:	Karla Lechtenberg	Same as Submitter <input checked="" type="checkbox"/>
Address:	130 Whittier Research Center, 2200 Vine Street, Lincoln, NE 68583-0853	Same as Submitter <input checked="" type="checkbox"/>
Country:	USA	Same as Submitter <input checked="" type="checkbox"/>
Accreditation Certificate Number and Date:	A2LA Certificate Number: 2937.01, Valid to November ^{December} 30, 2015	

Submitter Signature*: Karla Lechtenberg

Digitally signed by Karla Lechtenberg
DN: cn=Karla Lechtenberg, o=Midwest
Roadside Safety Facility, email=lechten@msf.com,
c=US
Date: 2015.05.11 16:31:07 -0500

Submit Form

ATTACHMENTS

Attach to this form:

- 1) A copy of the full test report, video, and a Test Data Summary Sheet for each test conducted in support of this request.
- 2) A drawing or drawings of the device(s) that conform to the Task Force-13 Drawing Specifications [[Hardware Guide Drawing Standards](#)]. For proprietary products, a single isometric line drawing is usually acceptable to illustrate the product, with detailed specifications, intended use, and contact information provided on the reverse. Additional drawings (not in TF-13 format) showing details that are key to understanding the performance of the device should also be submitted to facilitate our review.

FHWA Official Business Only:

Eligibility Letter		AASHTO TF13	
Number	Date	Designator	Key Words

December 11, 2015

Subject: Not Applicable Tests

Dear Will:

This letter is intended to further clarify the Not Applicable statement in the Narrative Description for Required Test Number 3-40, 3-41, 3-42, 3-43, 3-44, and 3-45 in the Request for Federal Aid Reimbursement Eligibility of Highway Safety Hardware form submitted for **Trailing-End Anchorage for 31" Tall Guardrail** for which we are requesting a letter of eligibility on behalf of the state departments of transportation participating in the Midwest States Regional Pooled Fund Program, specifically Wisconsin Department of Transportation.

Test numbers 3-40, 3-41, 3-42, 3-43, 3-44, and 3-45 are not applicable for this type of system.

If you need any further information or clarification, please feel free to contact Dr. Ron Faller or myself.

Sincerely,



Karla A. Lechtenberg
Research Associate Engineer

cc: Ronald K. Faller, Ph.D., Director and Research Associate Professor

August 27, 2015

Subject: Financial Interest Statement

Dear Will:

This letter is intended to be a disclosure of any financial interest that the Midwest Roadside Safety Facility (MwRSF) and its employees have in the **Trailing-End Anchorage for 31" Tall Guardrail** for which we are requesting a letter of eligibility on behalf of the state departments of transportation participating in the Midwest States Regional Pooled Fund Program, specifically Wisconsin Department of Transportation.

MwRSF's financial interests are as follows:

- (i) No compensation, including wages, salaries, commissions, professional fees, or fees for business referrals;
- (ii) Consulting relationships consist of answering design and implementation questions from the member states;
- (iii) Research funding or other forms of research support include continuing to fund the Midwest States Regional Pooled Fund Program as well as state departments of transportation funding individual research projects with MwRSF;
- (iv) No patents, copyrights, or other intellectual property interests for this system;
- (v) No licenses or contractual relationships for this system; and
- (vi) No business ownership and investment interests for this system.

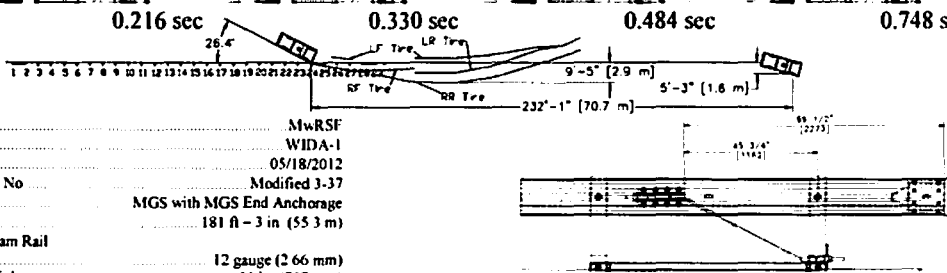
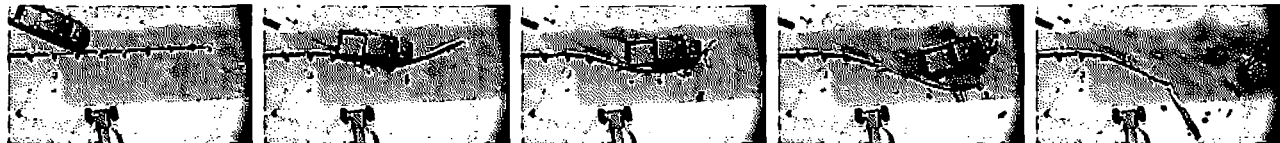
If you need any further information or clarification, please feel free to contact Dr. Ron Faller or myself.

Sincerely,



Karla A. Lechtenberg
Research Associate Engineer

cc: Ronald K. Faller, Ph.D., Director and Research Associate Professor



- Test Agency MWRSF
- Test Number WIDA-1
- Date 05/18/2012
- MASH Test Designation No Modified 3-37
- Test Article MGS with MGS End Anchorage
- Total Length 181 ft - 3 in (55.3 m)
- Key Component - W-Beam Rail
 - Thickness 12 gauge (2.66 mm)
 - Top Mounting Height 31 in (787 mm)
- Key Component - Line Posts (Nos. 3-27)
 - Type W6x8.5 (152x12.6)
 - Length 72 in (1,829 mm)
 - Spacing 75 in (1,905 mm)
 - Material ASTM A992 or A36
- Key Component - Wood Spacer Blocks
 - Dimensions 6 x 12 x 72 in (152 x 305 x 1,829 mm)
- Key Component - MGS End Anchorage
 - BCT Post Dimensions 5 1/2 x 7 1/2 x 46 in (140 x 191 x 1,168 mm)
 - BCT Post Material SYP Grade 1
 - Foundation Tube Dimensions 6 x 8 x 1/16 x 72 in (152 x 203 x 5 x 1,829 mm)
 - Foundation Tube Material ASTM A53 Grade B
 - Strut and Yoke Assembly ASTM A36 Galvanized
- Soil Type Coarse Crushed Limestone
- Vehicle Make /Model 2007 Dodge Ram 1500 Quad Cab
 - Curb 5,016 lb (2,275 kg)
 - Test Inertial 5,002 lb (2,269 kg)
 - Gross Static 5,172 lb (2,346 kg)
- Impact Conditions
 - Speed 63.0 mph (101.4 km/h)
 - Angle (vehicle c.g.) 26.4 deg
 - Angle (vehicle orientation) 25.8 deg
 - Impact Location 1 in (25 mm) upstream from post no. 24
- Exit Conditions
 - Speed 43.5 mph (70.0 km/h)
 - Angle (vehicle c.g.) 4.2 deg
 - Angle (vehicle orientation) -6.5 deg
- Vehicle Stability Satisfactory
- Vehicle Stopping Distance 232 ft - 1 in (70.7 m) downstream
5 ft - 3 in (1.6 m) laterally behind

- Vehicle Damage Moderate
 - VDS⁽¹⁾ 01-RFQ-3
 - CDC^(1c) 01-RFEN-4
 - Maximum Interior Deformation 1/2 in (13 mm)
- Test Article Damage Extensive
- Maximum Test Article Deflections
 - Permanent Set 26 ft - 6 1/2 in (8.1 m)
 - Dynamic 32 ft - 6 6 in (9.9 m)⁽¹⁾
 - Working Width 32 ft - 6 6 in (9.9 m)⁽¹⁾ (barrier)
(10 ft - 4 in (3.2 m)⁽¹⁾) (vehicle)
- Impact Severity (IS) 131.3 kip-ft (178.0 kJ) > 106 kip-ft (144 kJ) MASH limit
- Transducer Data

Evaluation Criteria	Transducer			MASH Limit	
	EDR-3	DTS	DTS-SLICE		
OIV ft/s	Longitudinal	-15.27 (-4.65)	-14.64 (-4.46)	-14.56 (-4.44)	≤ 40 (12.2)
	Lateral	-14.85 (-4.53)	-14.83 (-4.52)	-15.13 (-4.61)	≤ 40 (12.2)
ORA g's	Longitudinal	-8.13	-7.48	-8.01	< 20.49
	Lateral	-6.25	-6.91	-6.31	≤ 20.49
THIV - ft/s (m/s)	N/A	20.07 (6.12)	19.74 (6.02)	Not required	
PHD - g's	N/A	9.36	9.50	Not required	
ASI (MASH)	0.53	0.53	0.54	Not required	
Roll Angle - degree	N/A	5.8	10.2	75	
Pitch Angle - degree	N/A	3.0	4.5	75	
Yaw Angle - degree	N/A	-62.7	-62.5	Not required	

⁽¹⁾ Downstream W-beam rotated backward almost 90 degrees
^(1c) Maximum vehicle penetration behind traffic-side face of rail at end post

Figure 129. Summary of Test Results and Sequential Photographs, Test No. WIDA-1



SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

MIDWEST ROADSIDE SAFETY FACILITY (MwRSF)¹

University of Nebraska-Lincoln
 4800 NW 35th Street
 Lincoln, NE 68524
 Ms. Karla Lechtenberg Phone: 402 472 9070

MECHANICAL

Valid To: December 31, 2015

Certificate Number: 2937.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following tests:

Tests

Test Methods²

Full-Scale Vehicle Crash Tests of Highway Safety Features

NCHRP Report 350; MASH; EN 1317

Full-Scale Vehicle Crash Tests of Perimeter Protection Systems and Access Control Devices

ASTM F2656; SD-STD-02.01 Revision A

Bogie and Pendulum Dynamic Tests of Highway Safety Features

Non-Standard Test Method: Dynamic Testing of Steel Post and Rigid Foundation; Non-Standard Test Method: Dynamic Testing of Post in Soil; Non-Standard Test Method: Dynamic Testing of Spacer Blocks

Crushable Nose Pendulum/Bogie Testing for Breakaway Supports

Non-Standard Test Method: Dynamic Testing of Breakaway Supports; AASHTO Breakaway Poles and Supports; NCHRP Report 350

On the following types of products, materials, and/or structures: Metal, Wood, Concrete and Plastic Structures, Components of Structures, Fasteners, and Roadway Pavements.

¹ Administrative office located at: 2200 Vine Street, 130 Whittier Building, Lincoln, NE 68583-0853.

² This laboratory meets A2LA R104 – *General Requirements: Accreditation of Field Testing and Field Calibration Laboratories* for these tests.



Accredited Laboratory

A2LA has accredited

MIDWEST ROADSIDE SAFETY FACILITY (MWRSF)

Lincoln, NE

for technical competence in the field of

Mechanical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *General requirements for the competence of testing and calibration laboratories*. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009).

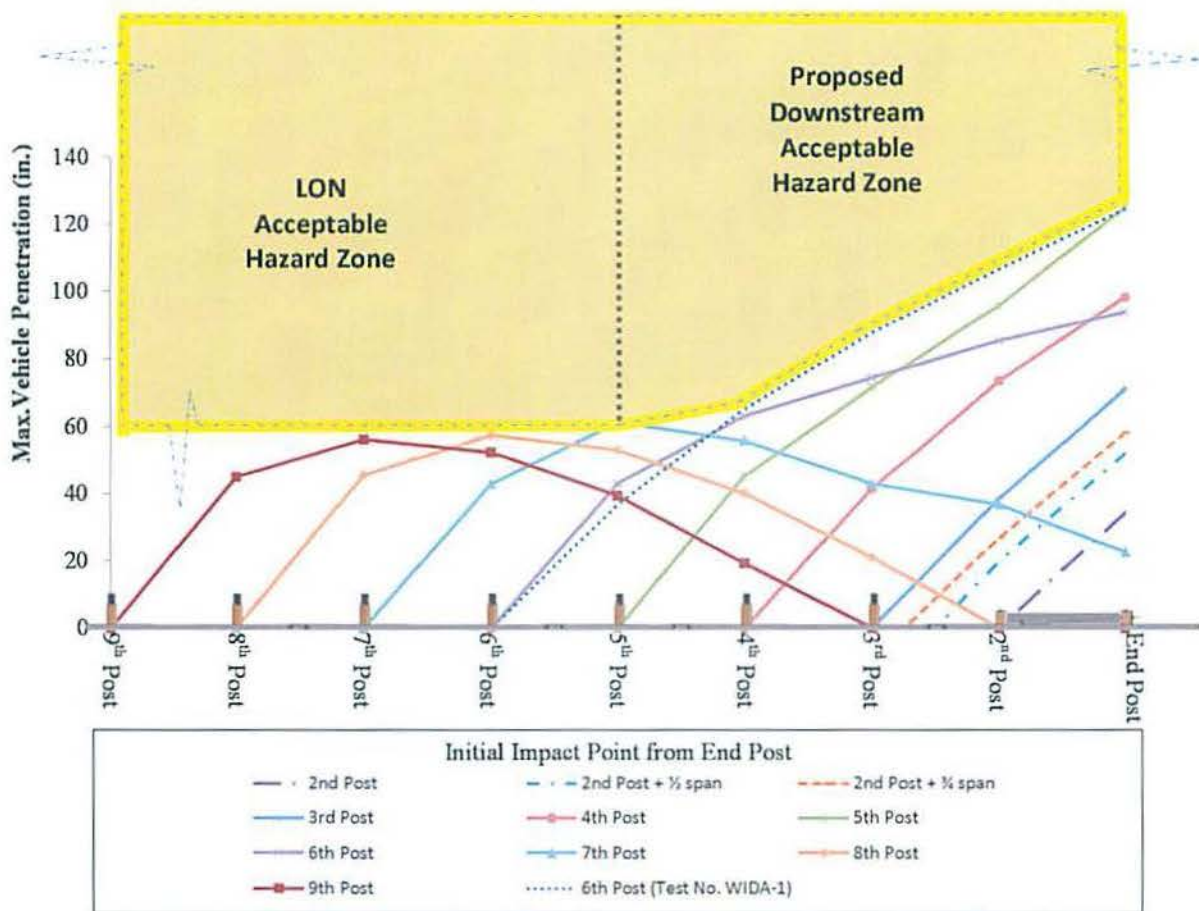


Presented this 31st day of December 2013.

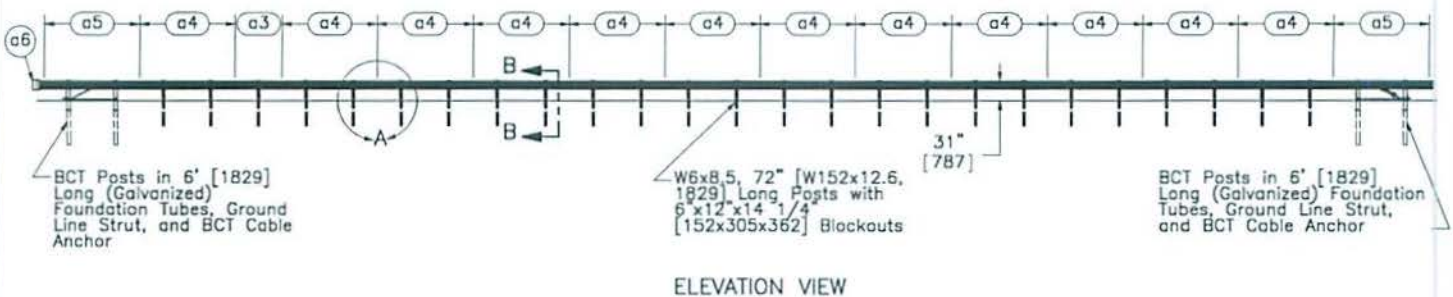
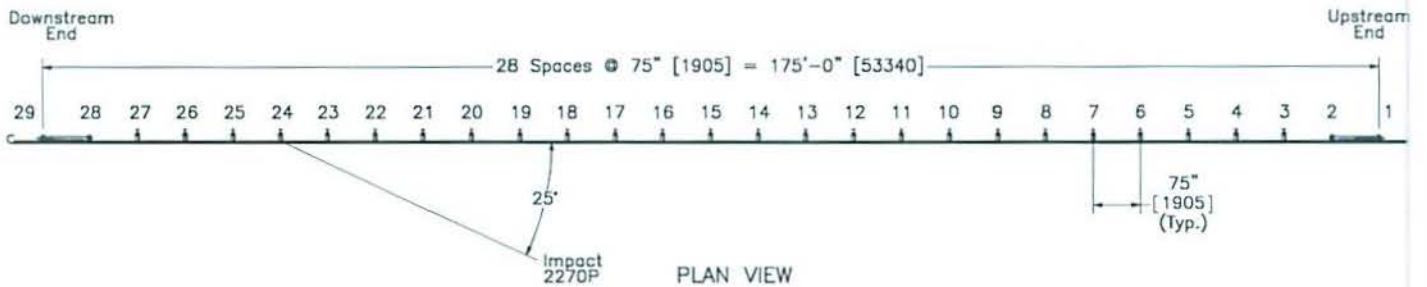
A handwritten signature in black ink that reads 'Peter Abney'.

President & CEO
For the Accreditation Council
Certificate Number 2937.01
Valid to December 31, 2015


For the tests to which this accreditation applies, please refer to the laboratory's Mechanical Scope of Accreditation.

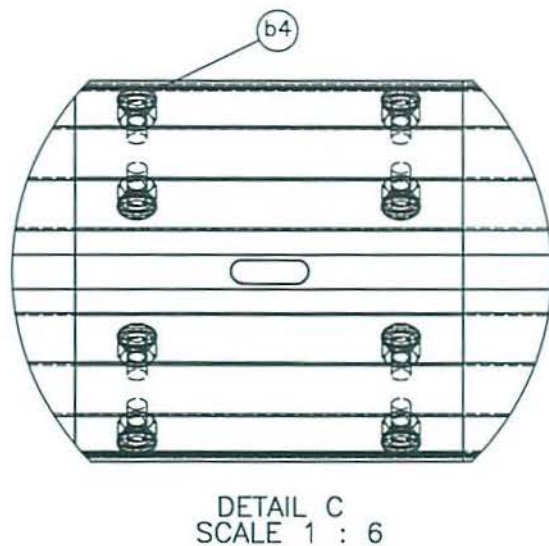
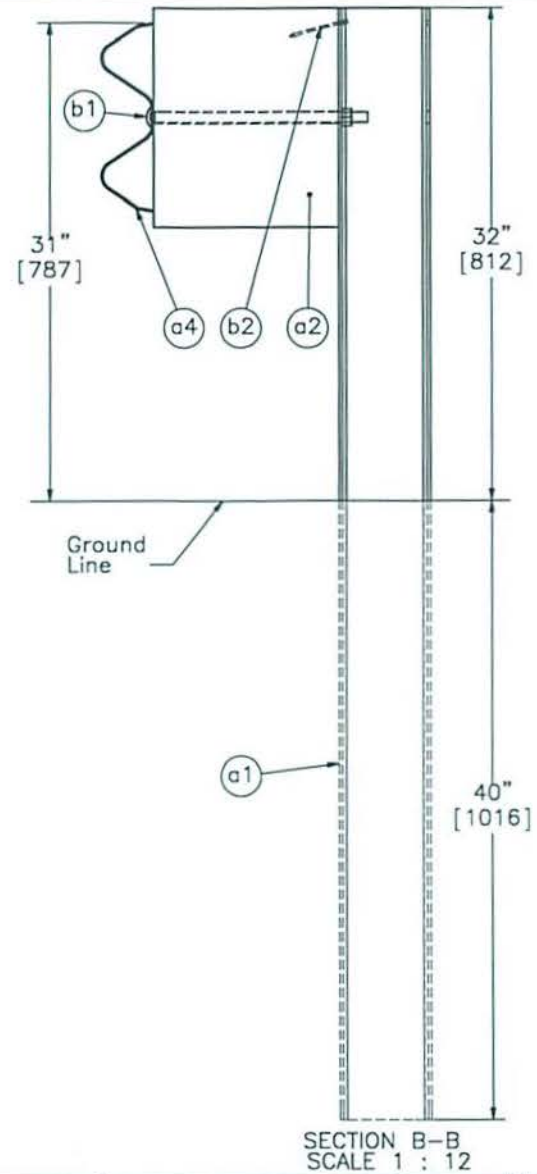
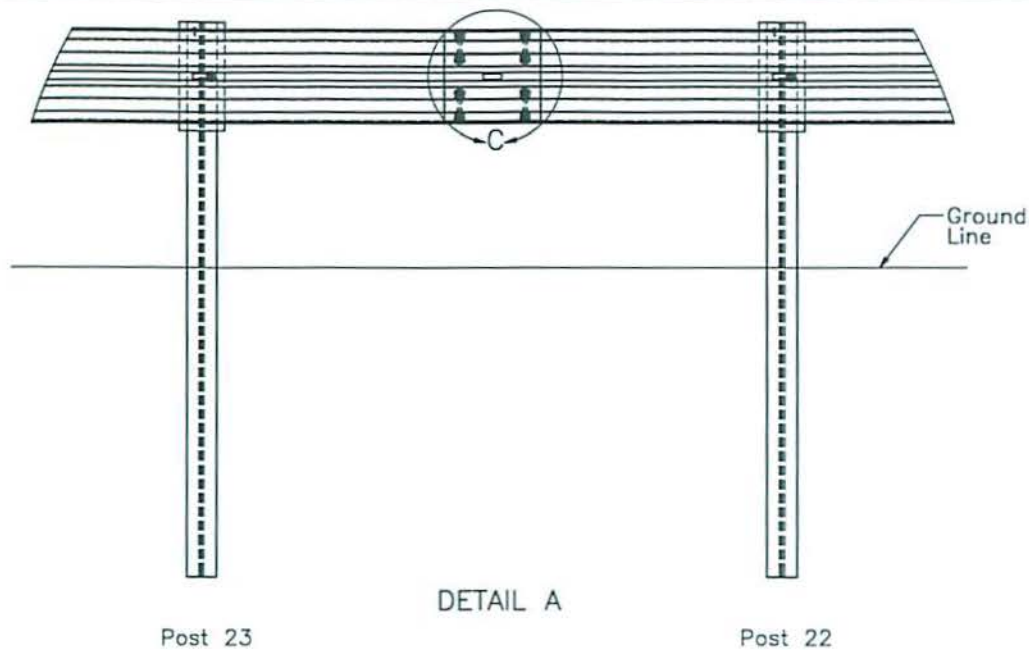


Placement Guidelines for Shielding Hazards Near Trailing-End Terminal



- Notes: (1) Impact location for the 2270P is at the centerline of post no. 24.
- (2) The BCT anchor posts are placed in $\phi 3'$ [914] holes.
- (3) Critical region located between post nos. 21 and 29.
- (4) A string potentiometer and tension load cell shall be placed within the upstream anchorage system.
- (5) A high-speed digital video camera is to be placed perpendicular to downstream anchor.
- (6) Avoid activating vehicle brakes in the first 100' [30480] downstream of post no. 29.
- (7) Allow for a minimum lateral clearance of 30' [9144] behind the system in the first 75' [22860] downstream of post no. 29.
- (8) Paint the downstream bearing plate and BCT cable two different colors.

	Wisconsin DOT Project	SHEET:
	MGs with Standard	1 of 15
Midwest Roadside Safety Facility	Downstream Anchorage System	DATE:
		5/25/2012
	System Layout	DRAWN BY:
DWG. NAME:		JGP
DS-Anchorage-31in_RS	SCALE: 1:225	REV. BY:
	UNITS: in [mm]	KAL/RIJ



Midwest Roadside Safety Facility

Wisconsin DOT Project
MGS with Standard
Downstream Anchorage
System

Post and Splice Details

DWG. NAME:
DS-Anchorage-31in_R5

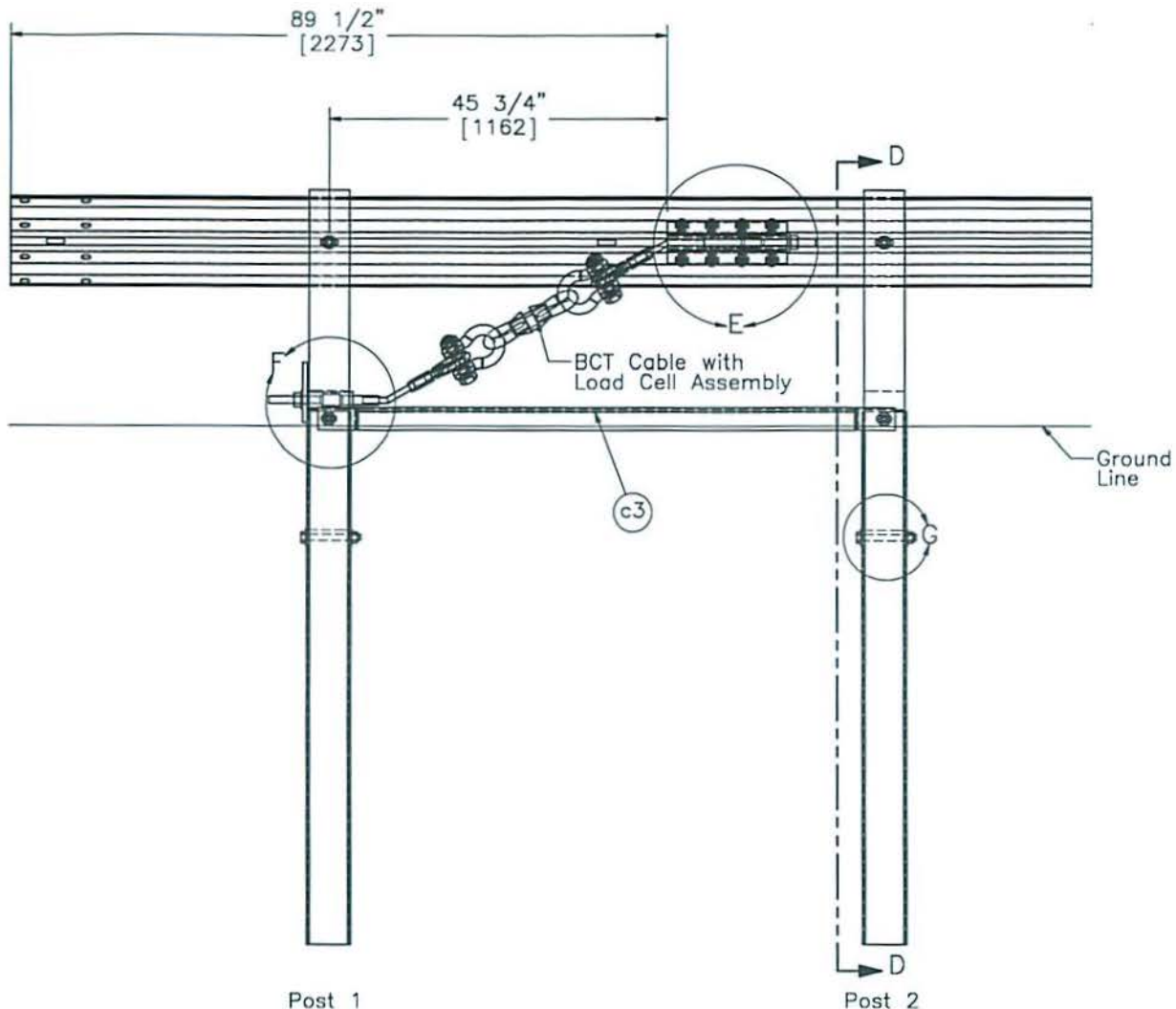
SCALE: 1:24
UNITS: in./mm

SHEET:
2 of 15

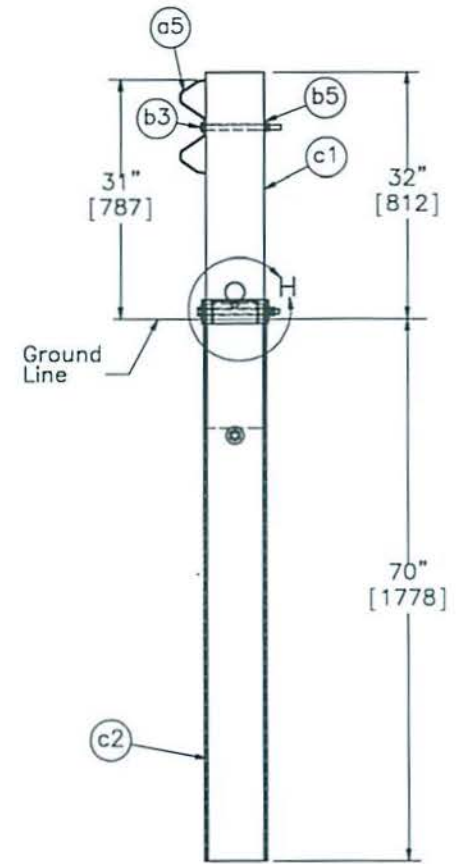
DATE:
5/25/2012

DRAWN BY:
JGP

REV. BY:
KAL/RKF



Upstream End Section Detail



SECTION D-D

Midwest Roadside Safety Facility

Wisconsin DOT Project
MGS with Standard
Downstream Anchorage
System

Upstream End Rail Details

DWG. NAME:
DS-Anchorage-31in_R5

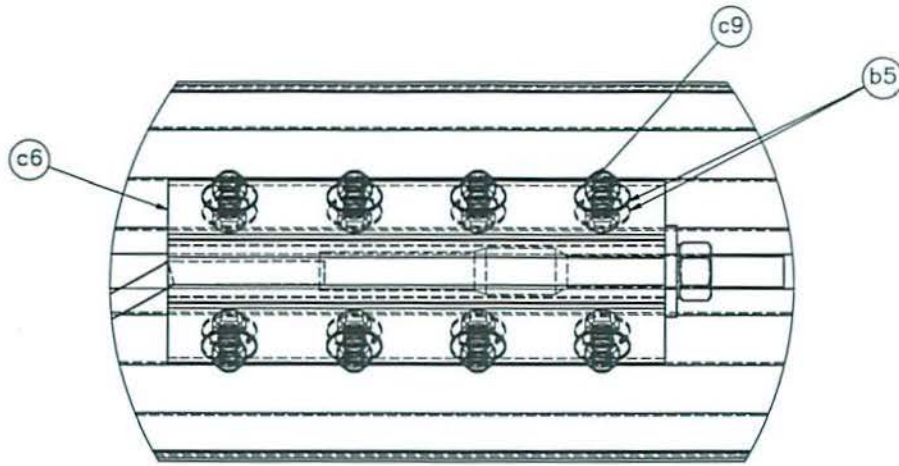
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UNITS: in./mm

SHEET:
3 of 15

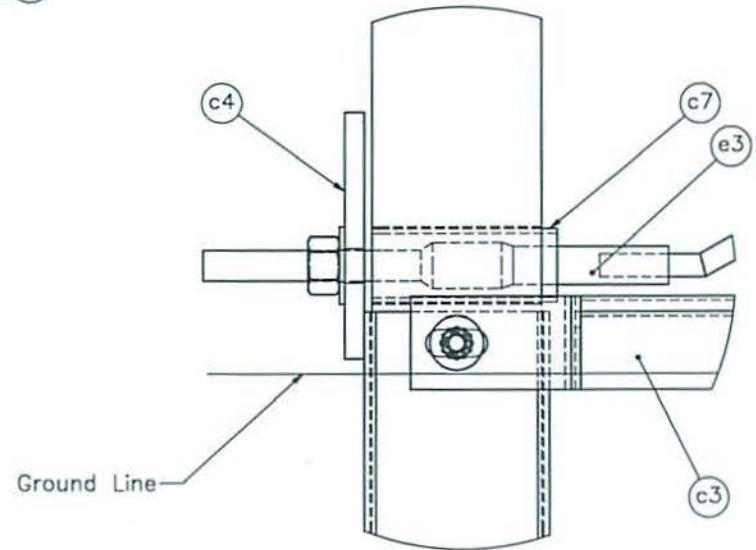
DATE:
5/25/2012

DRAWN BY:
JGP

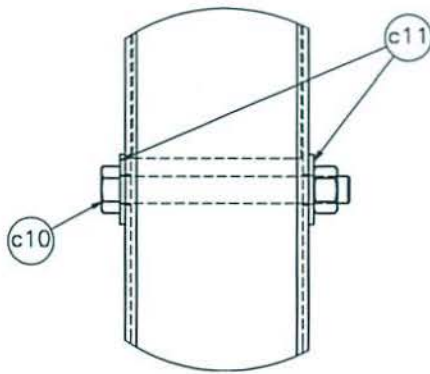
REV. BY:
KAL/RKF



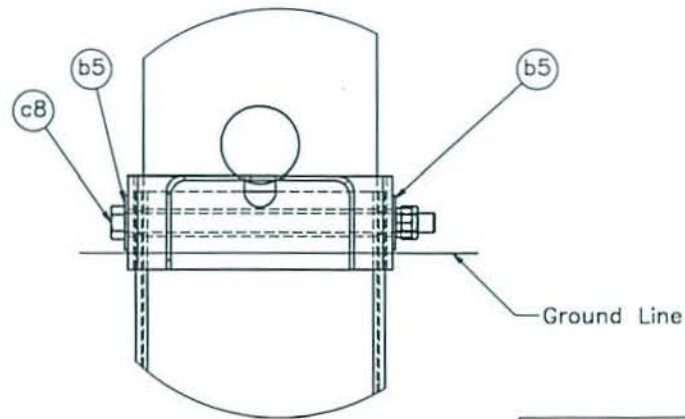
DETAIL E




DETAIL F

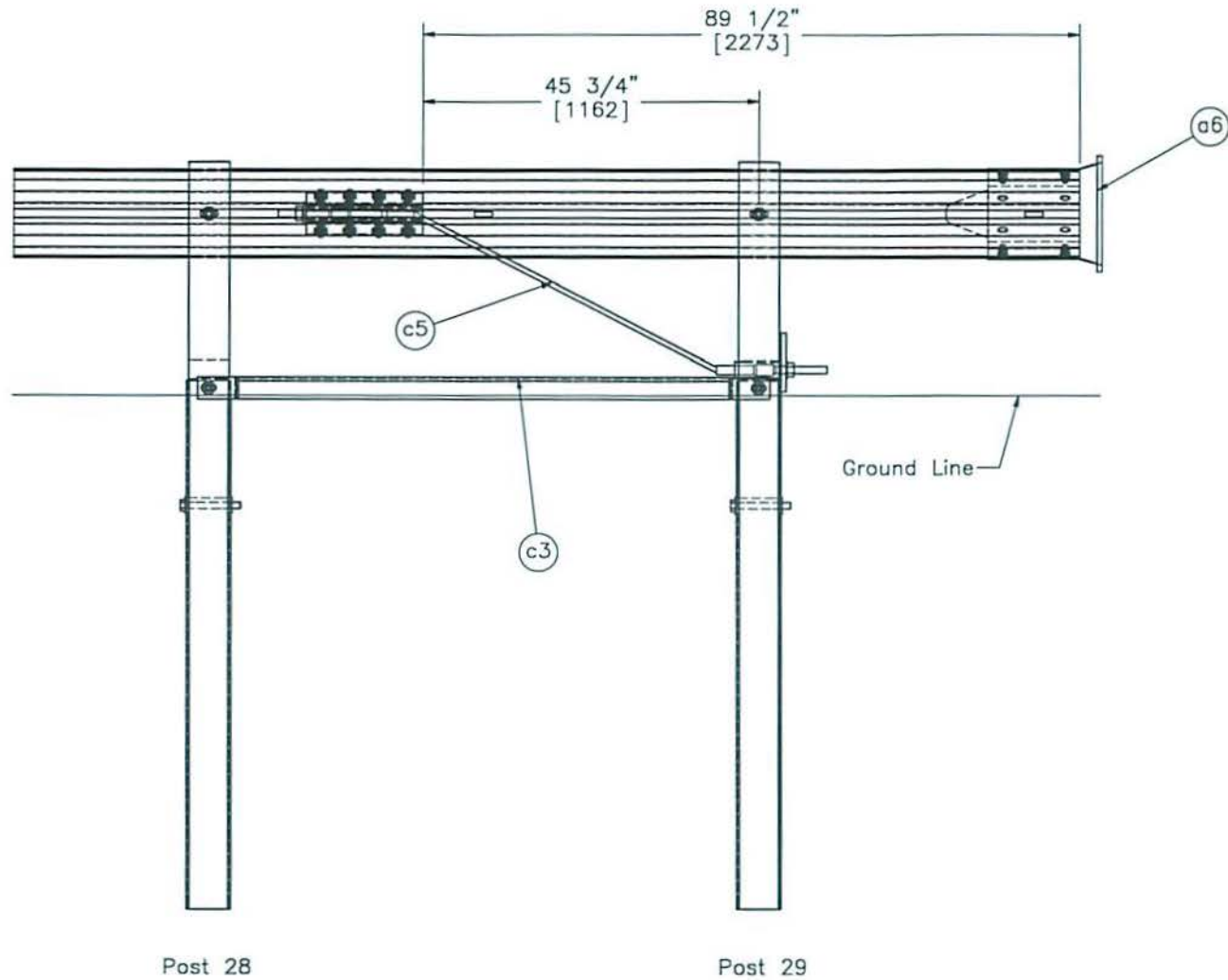


DETAIL G



DETAIL H

	Wisconsin DOT Project MGS with Standard Downstream Anchorage System		SHEET: 4 of 15
	Anchor Details		DATE: 5/25/2012
Midwest Roadside Safety Facility	DWG. NAME: DS-Anchorage-31in_R5	SCALE: 1:6 UNITS: in./mm	DRAWN BY: JGP REV. BY: KAL/RKF



Downstream End Section Detail



Wisconsin DOT Project
 MGS with Standard
 Downstream Anchorage
 System

Downstream End Rail Details

DWG. NAME:
 DS-Anchorage-31in_R5

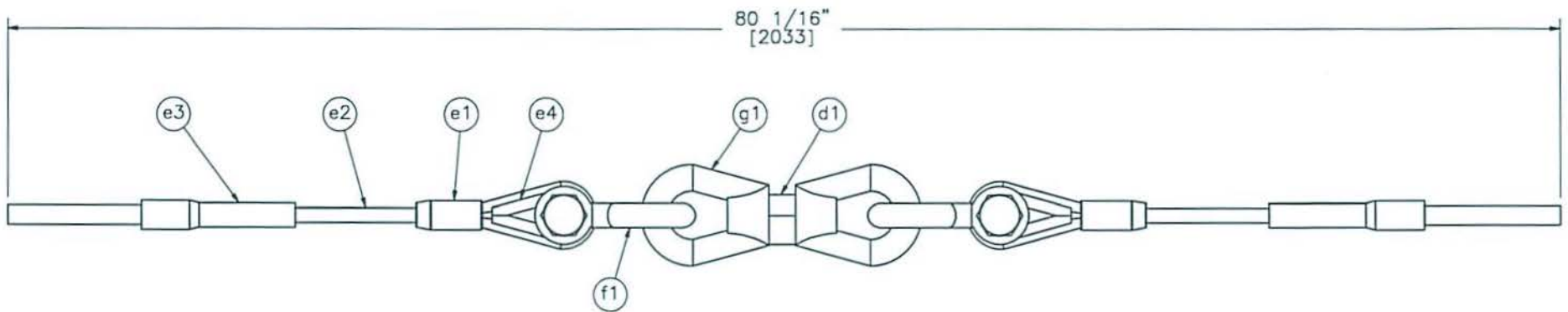
SCALE: 1:24
 UNITS: in./mm

SHEET:
 5 of 15

DATE:
 5/25/2012

DRAWN BY:
 JGP

REV. BY:
 KAL/RKF



Note: (1) 6x25 IWRC IPS cables meet the minimum breaking strength of 42.7 kips [190 kN] and may be substituted for the 6x19 IWRC IPS cables.



Midwest Roadside Safety Facility

Wisconsin DOT Project
MGS with Standard
Downstream Anchorage
System

Modified BCT Cable with Load
Cell Assembly

DWG. NAME:
DS-Anchorage-31in_R5

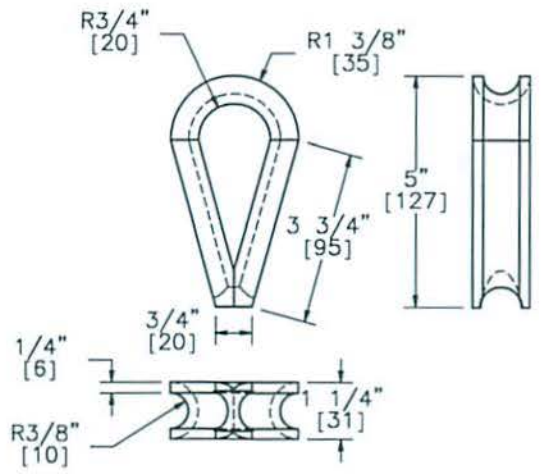
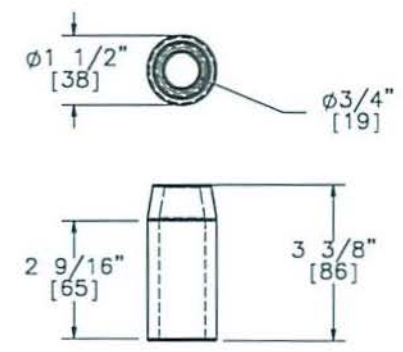
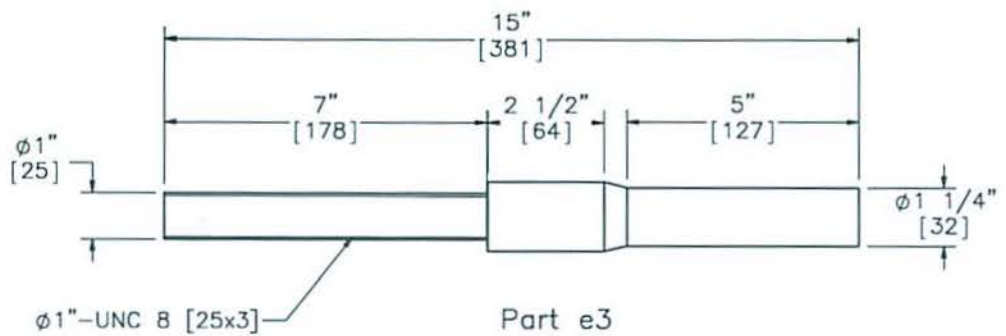
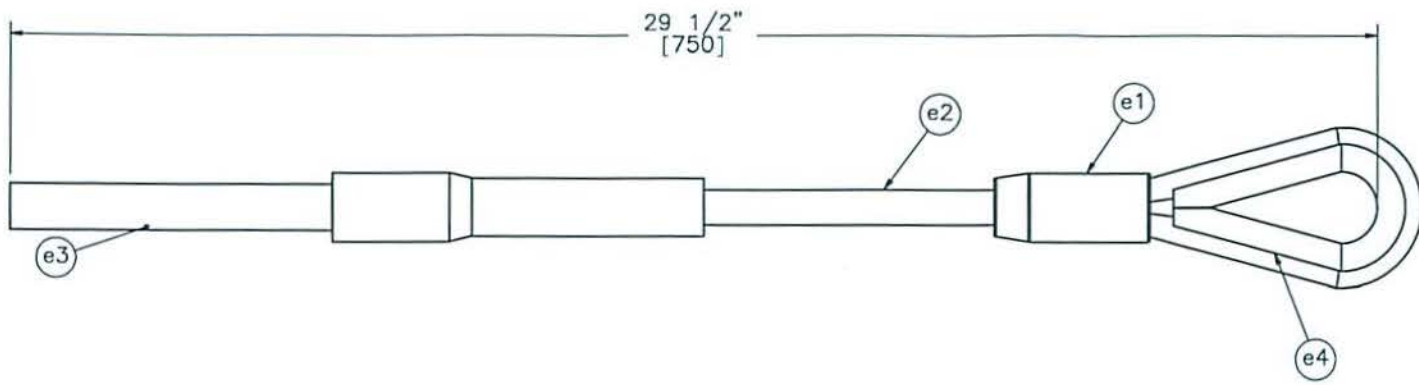
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SHEET:
6 of 15


DATE:
5/25/2012

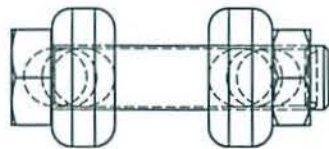
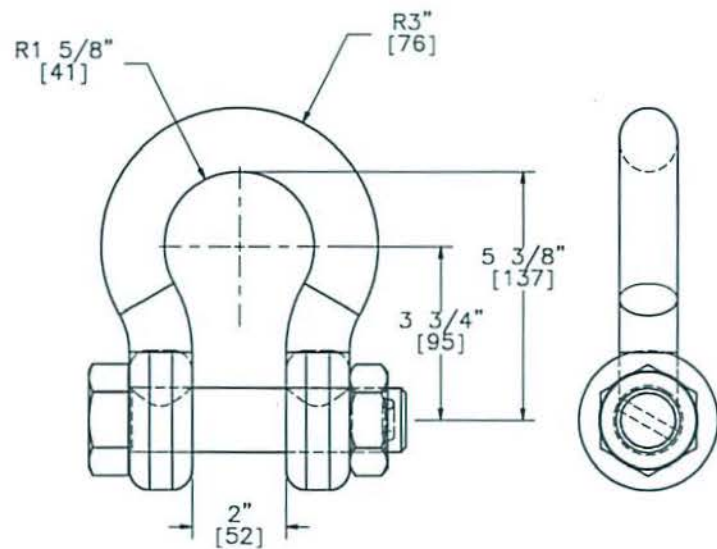
DRAWN BY:
JGP

REV. BY:
KAL/RKF

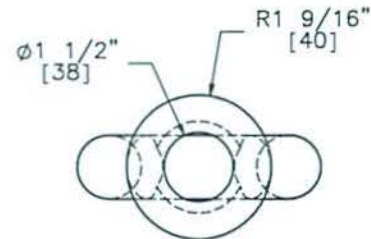
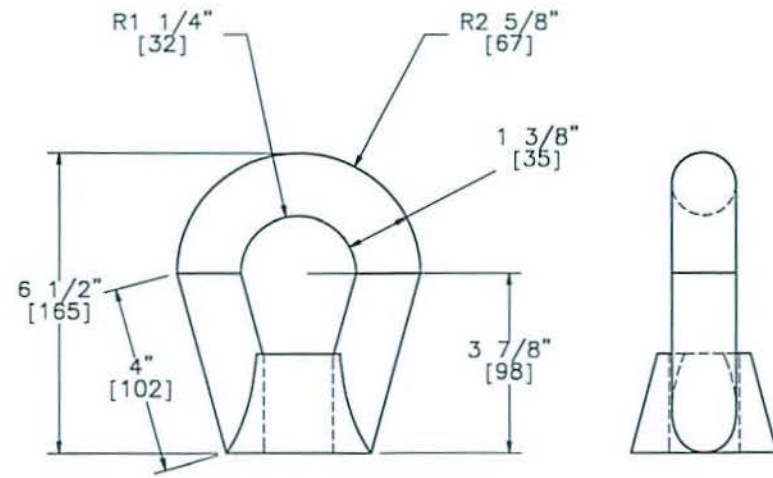


Note: (1) Dimensions are not necessarily representative of the part; see final part for actual dimensions

	Wisconsin DOT Project MGS with Standard Downstream Anchorage System		SHEET: 7 of 15
	Midwest Roadside Safety Facility		DATE: 5/25/2012
Modified BCT Cable		DRAWN BY: JGP	REV. BY: KAL/RKF
DWG. NAME: DS-Anchorage-31in_R5		SCALE: 1:4 UNITS: in./mm	



Part f1



Part g1



Midwest Roadside Safety Facility

Wisconsin DOT Project
MGS with Standard
Downstream Anchorage
System

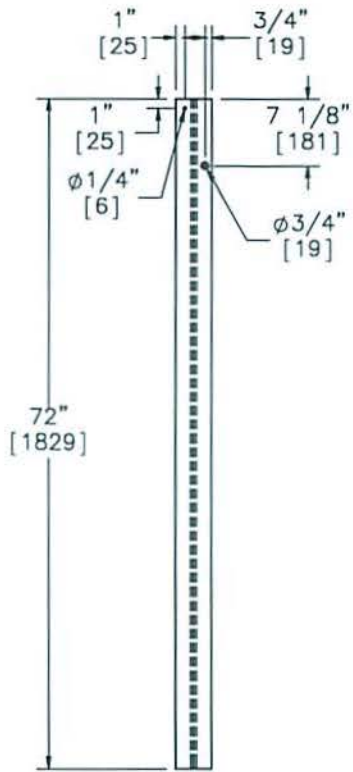
Shackle and Eye Nut

DWG. NAME:
DS-Anchorage-31in_R5

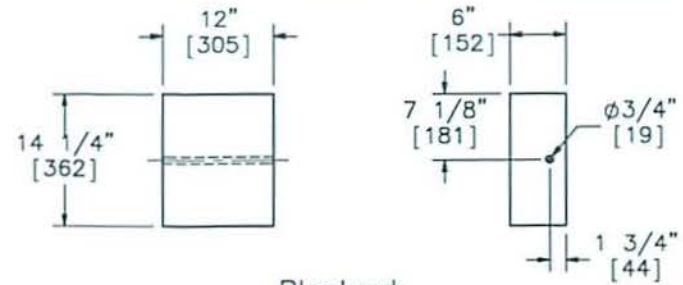
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UNITS: in./mm

SHEET:
8 of 15
DATE:
5/25/2012
DRAWN BY:
JGP
REV. BY:
KAL/RKF

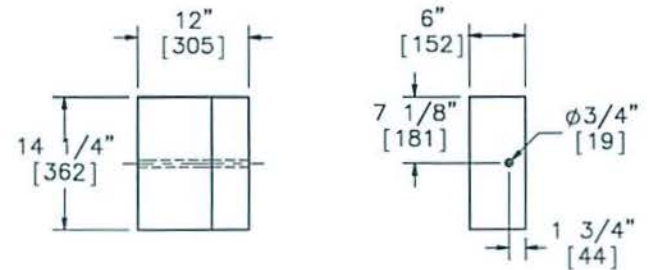
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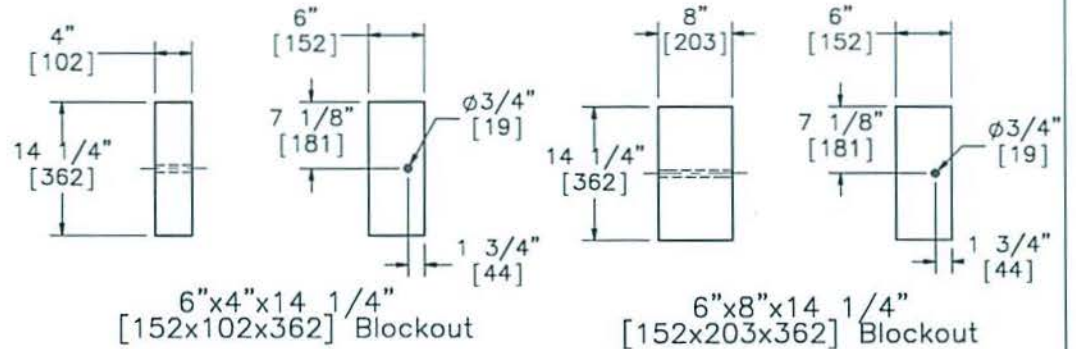
Line Post
Part a1



Blockout
Part a2



Alternate Blockout Option -
6"x4"x14 1/4" [152x102x362] Blockout
with 6"x8"x14 1/4" [152x203x362] Blockout



6"x4"x14 1/4" [152x102x362] Blockout

6"x8"x14 1/4" [152x203x362] Blockout



Midwest Roadside
Safety Facility

Wisconsin DOT Project
MGS with Standard
Downstream Anchorage
System

Post Nos. 3-27 Details

DWG. NAME:
DS-Anchorage-31in_R5

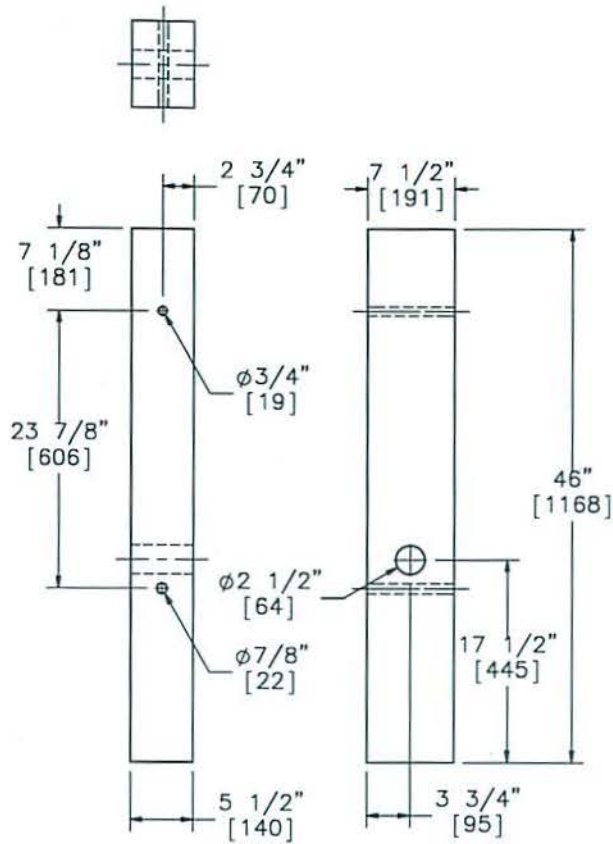
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SHEET:
9 of 15

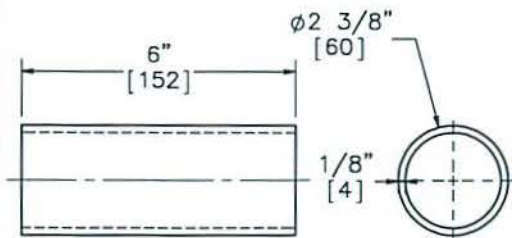
DATE:
5/25/2012

DRAWN BY:
JGP

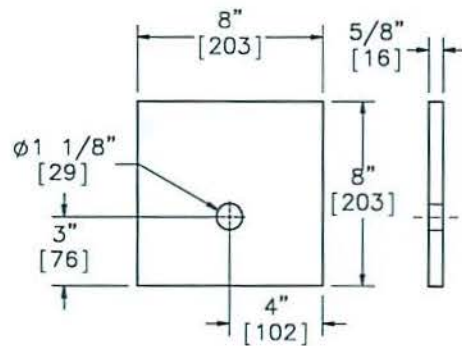
REV. BY:
KAL/RKF



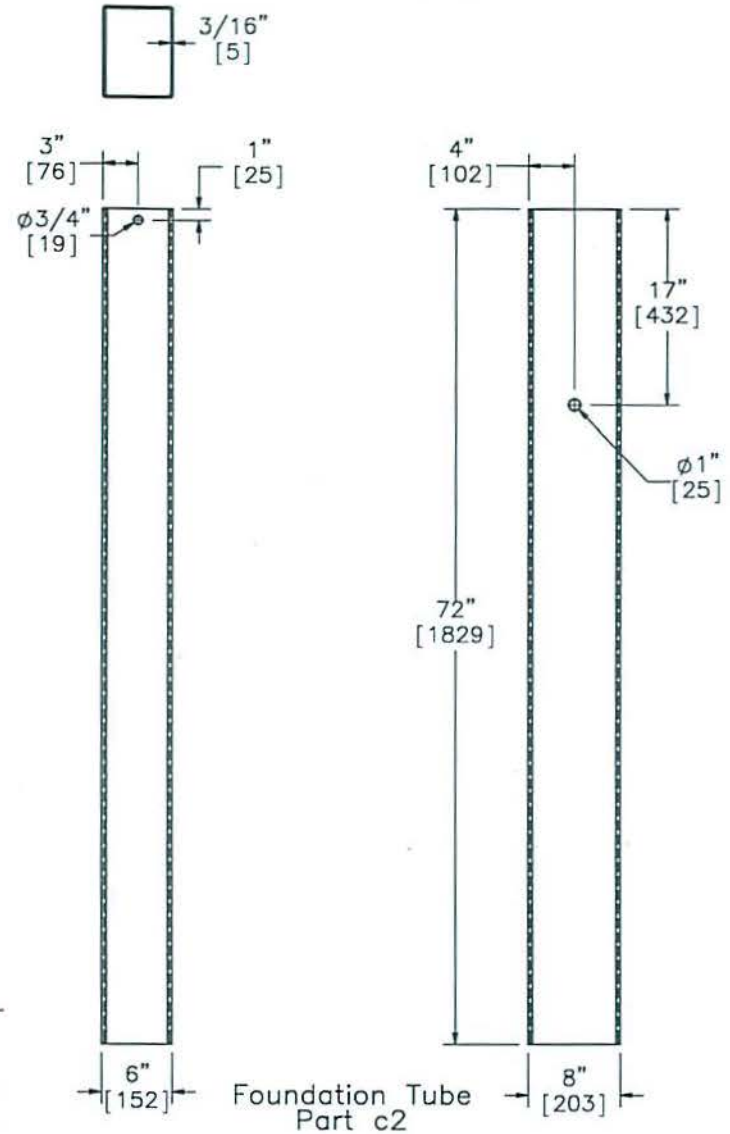
BCT MGS Timber Post
Part c1



BCT Post Sleeve
Part c7
SCALE 1:4



Anchor Bracket Bearing Plate
Part c4
SCALE 1:8



Foundation Tube
Part c2



Midwest Roadside
Safety Facility

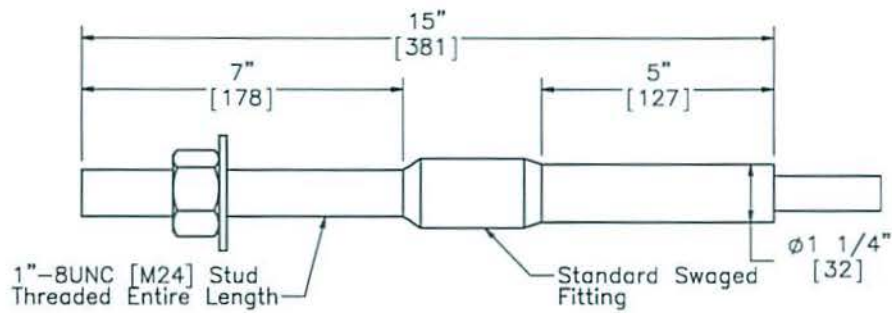
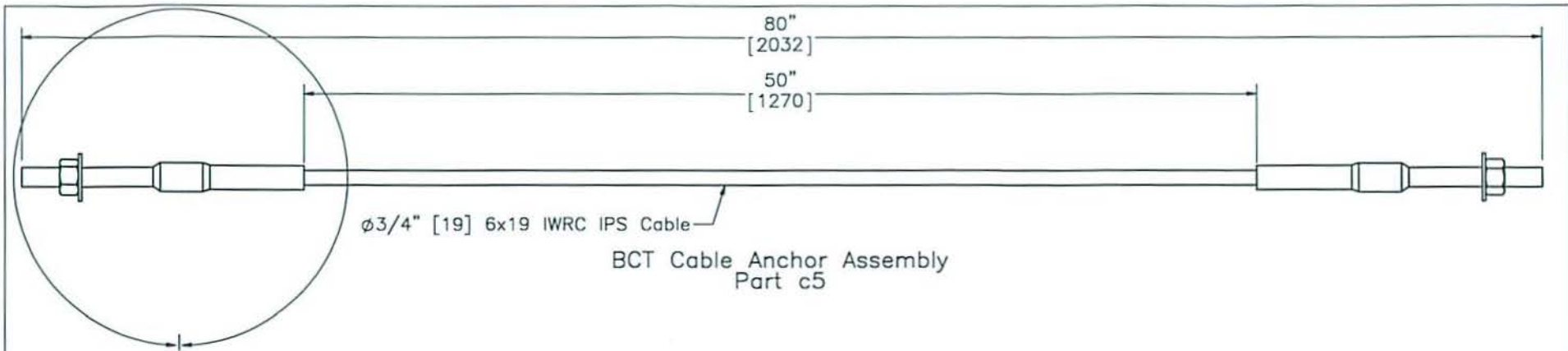
Wisconsin DOT Project
MGS with Standard
Downstream Anchorage
System

BCT Timber Post &
Foundation Tube Details

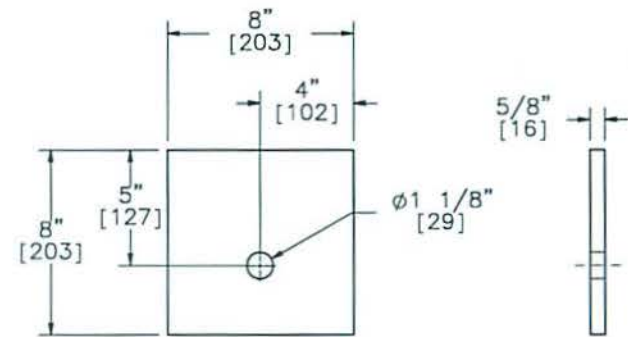
DWG. NAME:
DS-Anchorage-31in_R5

SCALE: 1:16
UNITS: in./mm

SHEET:
10 of 15
DATE:
5/25/2012
DRAWN BY:
JCP
REV. BY:
KAL/RKF



DETAIL I
SCALE 1:4



Anchor Bracket Bearing Plate
Part c4

Notes: (1) 6x25 IWRC IPS meet the minimum breaking strength of 42.7 kips [190 kN] and may be substituted for the 6x19 IWRC IPS cables.



Midwest Roadside
Safety Facility

Wisconsin DOT Project
MGS with Standard
Downstream Anchorage
System

BCT Anchor Cable

DWG. NAME:
DS-Anchorage-31in_R5

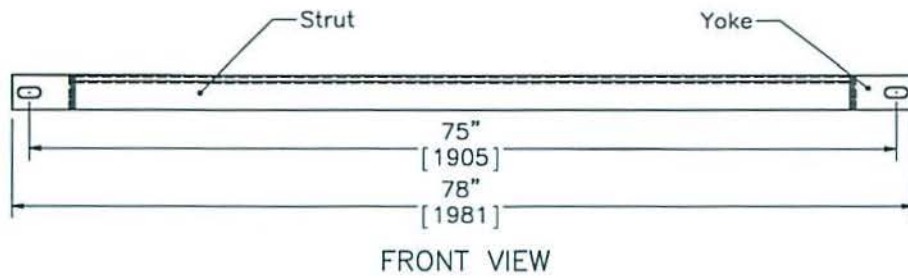
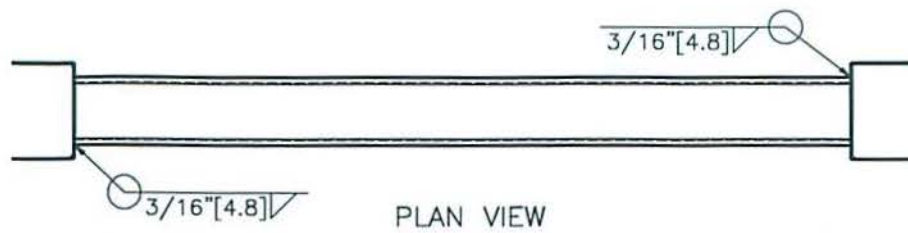
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SHEET:
11 of 15

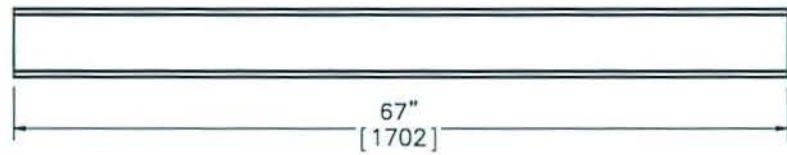
DATE:
5/25/2012

DRAWN BY:
JGP

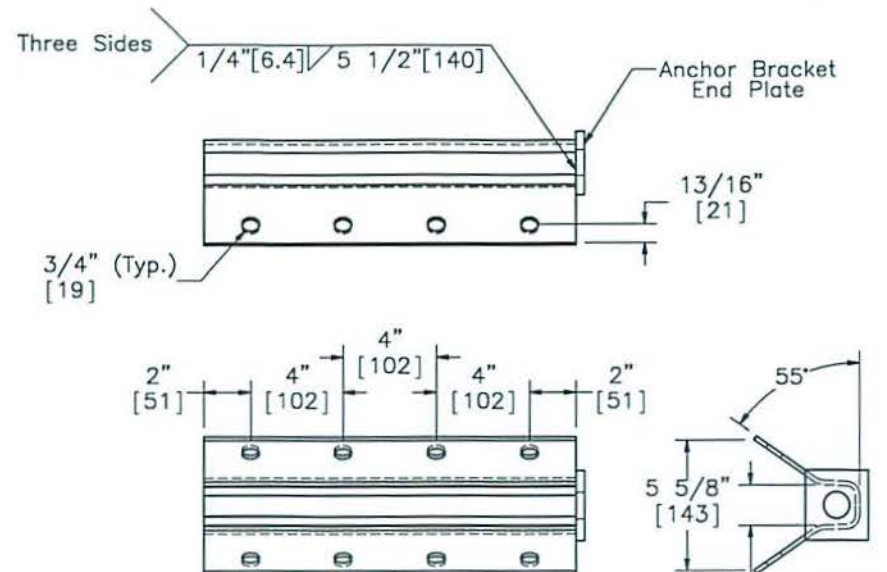
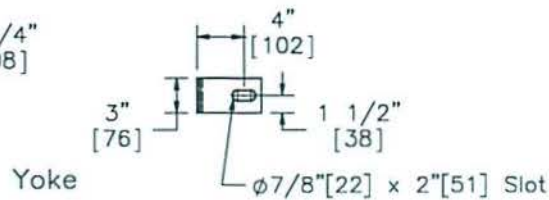
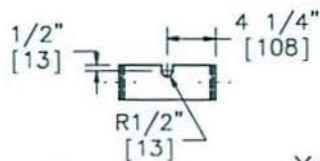
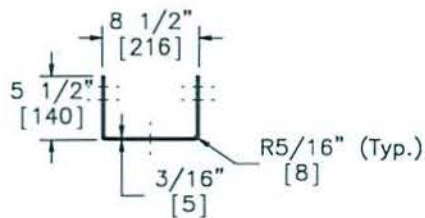
REV. BY:
KAL/RKF



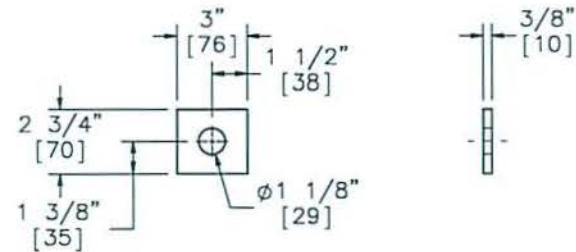
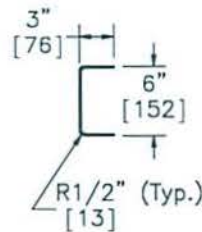
Strut and Yoke Assembly
Part c3



Strut
6"x3" [152x76] 10 Gauge [3.4]



Anchor Bracket
(FPA01)
Part c6
SCALE 1:8



Anchor Bracket End Plate
SCALE 1:8



Midwest Roadside
Safety Facility

Wisconsin DOT Project
MGS with Standard
Downstream Anchorage
System

Ground Strut &
Anchor Bracket Details

DWG. NAME:
DS-Anchorage-31in_R5

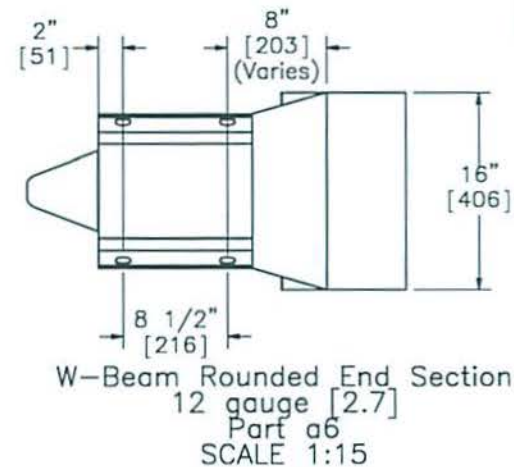
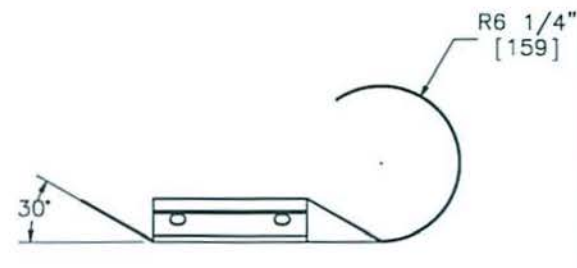
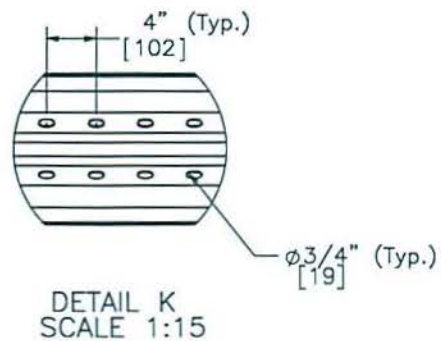
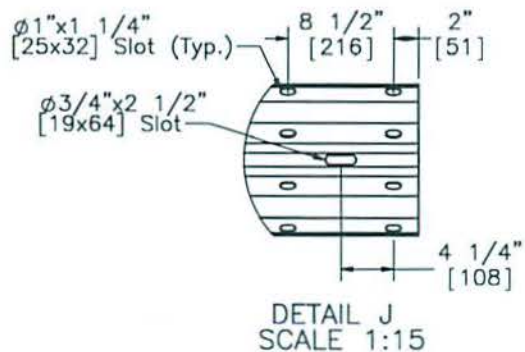
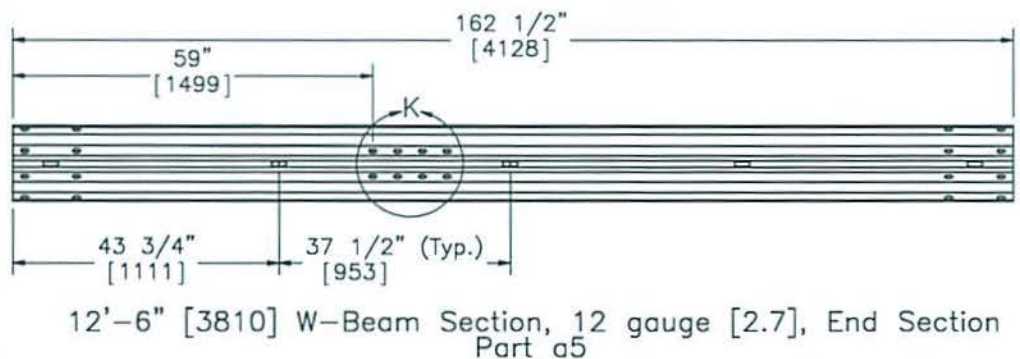
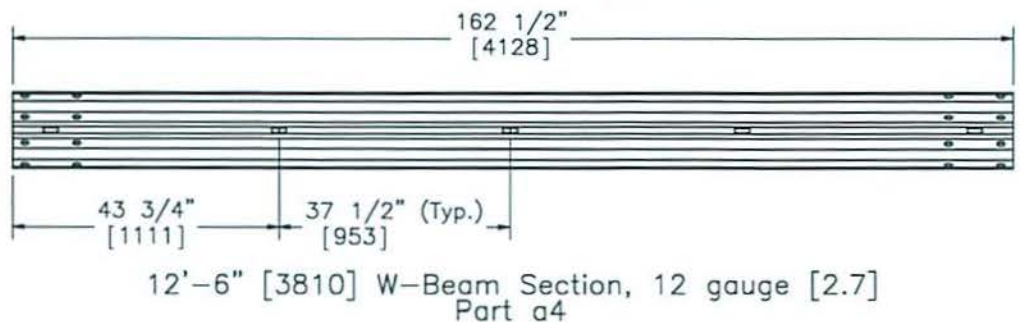
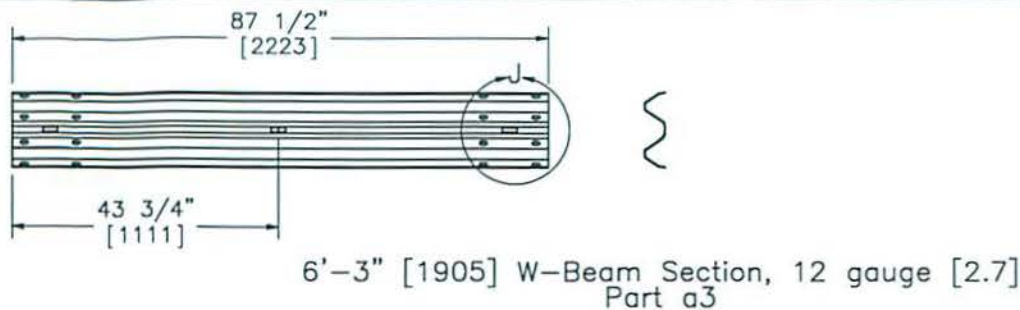
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UNITS: in./mm

SHEET:
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DATE:
5/25/2012

DRAWN BY:
JGP

REV. BY:
KAL/RKF



Notes: (1) If rounded W-beam end section cannot be found locally use a spoon end section.

 Midwest Roadside Safety Facility	Wisconsin DOT Project MGS with Standard Downstream Anchorage System	SHEET: 13 of 15
	Rail Section Details	DATE: 5/25/2012
DWG. NAME: DS-Anchorage-31in_R5	SCALE: 1:30 UNITS: in./mm	DRAWN BY: JGP
		REV. BY: KAL/RKF

ItemNo.	QTY.	Description	Material Specification	Hardware Guide
a1	25	W6x8.5 6' Long [W152x12.6 1829] Steel Post	ASTM A992 Min. 50 ksi [345 MPa] (W6x9 ASTM A36 Min. 36 ksi [248 MPa])	PWE06
a2	25	6x12x14 1/4" [152x305x362] Blockout	SYP Grade No. 1 or better	PDB10a-b
a3	1	6'-3" [1905] W-Beam MGS Section	12 gauge [2.7] AASHTO M180	RWM01a
a4	12	12'-6" [3810] W-Beam MGS Section	12 gauge [2.7] AASHTO M180	RWM04a
a5	2	12'-6" [3810] W-Beam MGS End Section	12 gauge [2.7] AASHTO M180	RWM14a
a6	1	W-Beam Rounded End Section	12 gauge [2.7] AASHTO M180	RWE03a
b1	25	5/8" Dia. x 14" Long [M16x356] Guardrail Bolt and Nut	Bolt ASTM A307, Nut ASTM A563 A	FBB06
b2	25	16D Double Head Nail	-	-
b3	4	5/8" Dia. x 10" [M16x254] Long Guardrail Bolt and Nut	Bolt ASTM A307, Nut ASTM A563 A	FBB03
b4	116	5/8" Dia. x 1 1/2" Long [M16x38] Guardrail Bolt and Nut	Bolt ASTM A307, Nut ASTM A563 A	FBB01
b5	46	5/8" [16] Dia. Flat Washer	ASTM F844 or SAE Grade 2 Steel	FWC16a
c1	4	BCT Timber Post - MGS Height	SYP Grade No. 1 or better	PDF01
c2	4	72" [1829] Long Foundation Tube	ASTM A53 Grade B	PTE06
c3	2	Strut and Yoke Assembly	ASTM A36 Steel Galvanized	-
c4	2	8x8x5/8" [203x203x16] Anchor Bearing Plate	ASTM A36 Steel	FPB01
c5	1	BCT Anchor Cable Assembly	φ3/4" [19] 6x19 IWRC IPS Galvanized Wire Rope	FCA01
c6	2	Anchor Bracket Assembly	ASTM A36 Steel	FPA01
c7	2	2 3/8" [60] O.D. x 6" [152] Long BCT Post Sleeve	ASTM A53 Grade B Schedule 40	FMM02
c8	4	5/8" Dia. x 10" [M16x254] Long Hex Head Bolt and Nut	Bolt ASTM A307, Nut ASTM A563 A	FBX16a
c9	16	5/8" Dia. x 1 1/2" Long [M16x38] Hex Head Bolt and Nut	Bolt ASTM A307, Nut ASTM A563 A	FBX16a
c10	4	7/8" Dia. x 7 1/2" [M22x191] Long Hex Head Bolt and Nut	Bolt ASTM A307, Nut ASTM A563 A	FBX22a
c11	8	7/8" [22] Dia. Flat Washer	ASTM F844 or SAE Grade 2 Steel	FWC22a



Midwest Roadside
Safety Facility

Wisconsin DOT Project
MGS with Standard
Downstream Anchorage
System


Bill of Materials

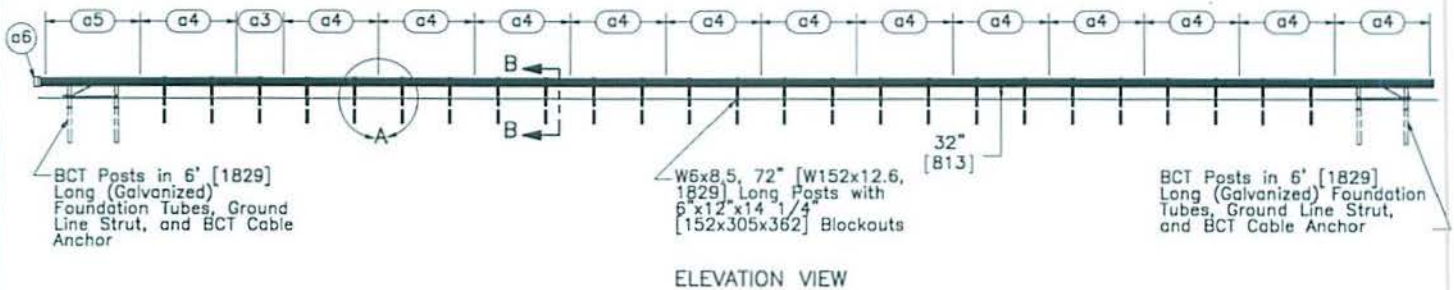
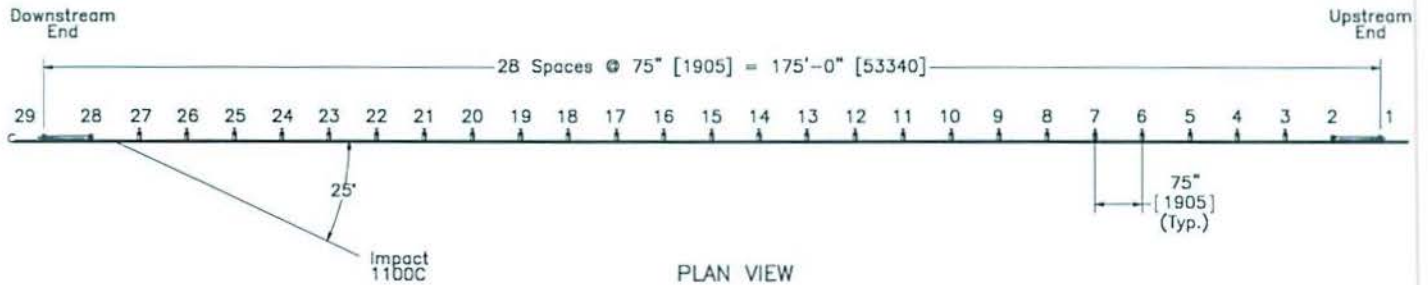
DWG. NAME:
DS-Anchorage-31in_R5

SCALE: NONE
UNITS: in./mm


SHEET:
14 of 15
DATE:
5/25/2012
DRAWN BY:
JGP
REV. BY:
KAL/RKF

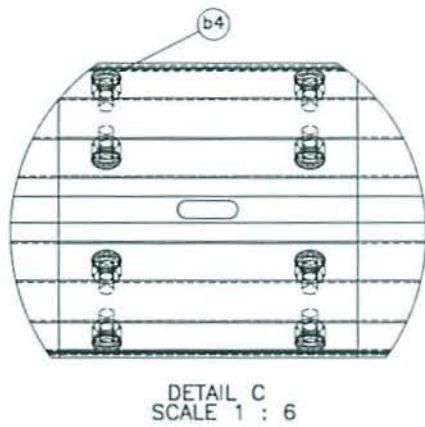
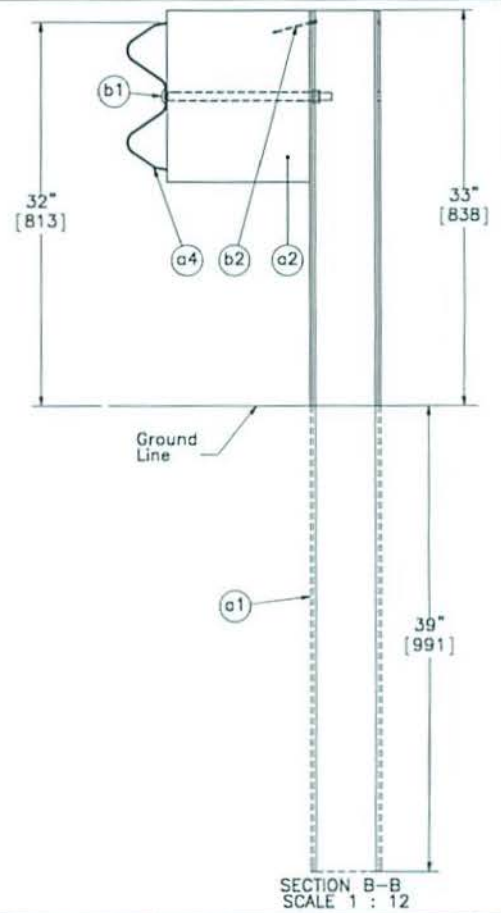
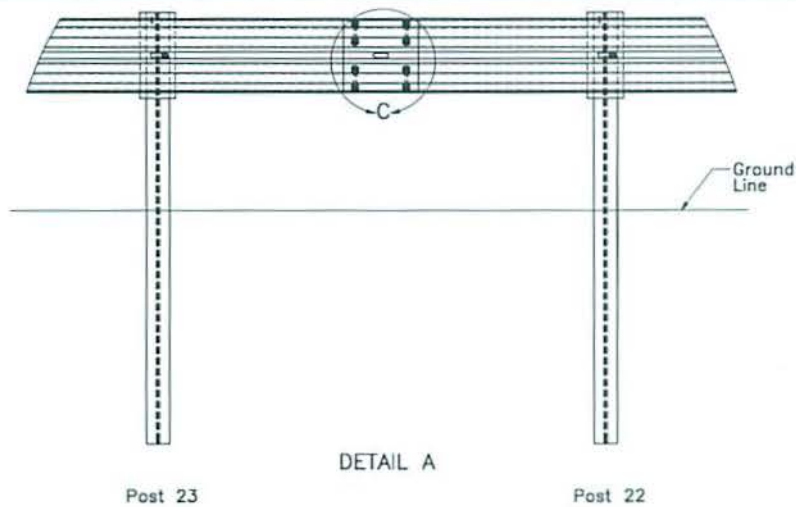
Item No.	QTY.	Description	Material Specification
d1	1	TLL-50K-PTB Load Cell	NA
e1	2	115-HT Mechanical Splice - 3/4" [19] Dia.	As Supplied
e2	2	3/4" [190] 6x19 IWRC IPS Wire Rope	IPS Galvanized
e3	4	BCT Anchor Cable End Swage Fitting	SAE Grade 5 - Galvanized
e4	2	Crosby Heavy Duty HT-3/4" [19] Dia. Cable Thimble	As Manufactured
f1	2	Crosby G2130 or S2130 Bolt Type Shackle - 1 1/4" [32] Dia. with thin head bolt, nut, and cotter pin, Grade A, Class 3	Stock Nos. 1019597 and 1019604 - As Supplied
g1	2	Chicago Hardware Drop-Forged Heavy Duty Eye Nut - Drilled and Tapped 1 1/2" [38] Dia. - UNF 12 [M36]	As Supplied, Stock No. 107


	Wisconsin DOT Project MGS with Standard Downstream Anchorage System		SHEET: 15 of 15
	Bill of Materials Continued		DATE: 5/25/2012
Midwest Roadside Safety Facility	DWG. NAME: DS-Anchorage-31in_R5	SCALE: NONE UNITS: in.[mm]	DRAWN BY: JGP REV. BY: KAL/RKF

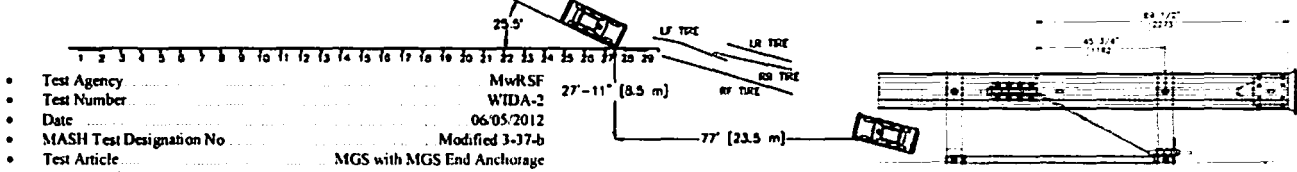
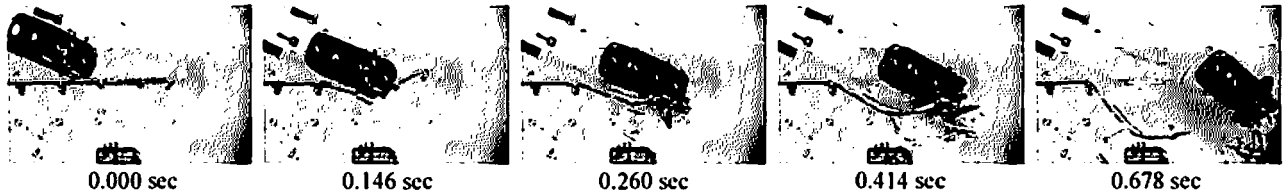


- Notes: (1) Impact location for the 1100C is the midspan of post nos. 27 and 28.
 (2) The BCT anchor posts are placed in $\phi 3'$ [914] holes.
 (3) Critical region located between post nos. 21 and 29.
 (4) A high-speed digital video camera shall be placed perpendicular to downstream anchor.
 (5) Vehicle is expected to gate through.
 (6) Avoid activating vehicle brakes in the first 100' [30480] downstream of post no. 29.
 (7) Allow for a minimum lateral clearance of 30' [9144] behind the system in the first 75' [22860] downstream of post no. 29.
 (8) Paint the downstream bearing plate and BCT cable two different colors.
 (9) Put marks on foundation tube bolts.

	Wisconsin DOT Project MGS with Standard Downstream Anchorage System	SHEET: 1 of 11
	System Layout	DATE: 5/25/2012
Midwest Roadside Safety Facility	DWG. NAME: DS-Anchorage-32in_R3	DRAWN BY: CWP
	SCALE: 1:225 UNITS: in [mm]	REV. BY: KAL/RKF



	Wisconsin DOT Project MGS with Standard Downstream Anchorage System		SHEET: 2 of 11
	Midwest Roadside Safety Facility		DATE: 5/25/2012
Post and Splice Details			DRAWN BY: CWP
DRG. NAME: DS-Anchorage-32in_R3		SCALE: 1:24 UNITS: in./mm	REV. BY: KAL/RKF



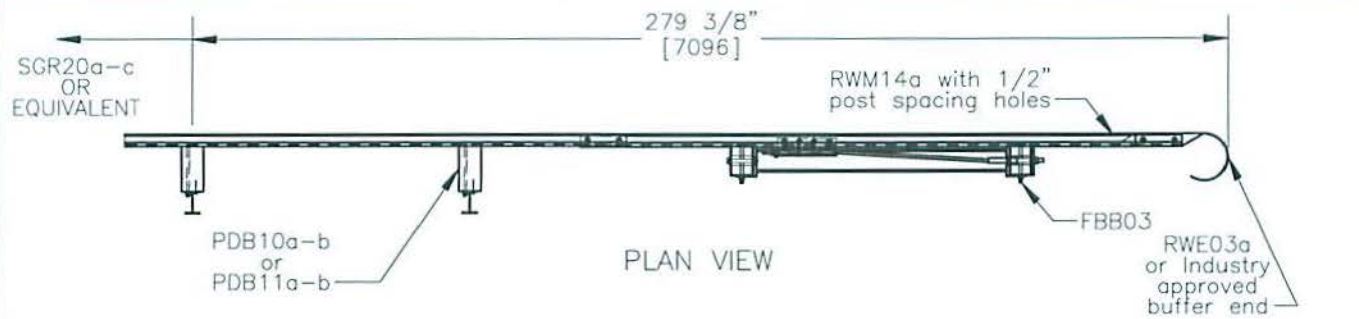
- Test Agency MwRSF
- Test Number WIDA-2
- Date 06/05/2012
- MASH Test Designation No Modified 3-17-b
- Test Article MGS with MGS End Anchorage
- Total Length 181 ft - 3 in (55.3 m)
- Key Component - W-Beam Rail
 - Thickness 12 gauge (2.66 mm)
 - Top Mounting Height 32 in (813 mm)
- Key Component - Line Posts (Nos. 3-27)
 - Type W6x8.5 (152x126)
 - Length 72 in (1,829 mm)
 - Spacing 75 in (1,905 mm)
 - Material ASTM A992 or A36
- Key Component - Wood Spacer Blocks
 - Dimensions 6 x 12 x 72 in (152 x 305 x 1,829 mm)
- Key Component - MGS End Anchorage
 - BCT Post Dimensions 5 1/2 x 7 1/2 x 46 in (140 x 191 x 1,168 mm)
 - BCT Post Material SYP Grade I
 - Foundation Tube Dimensions 6 x 8 x 7/16 x 72 in (152 x 203 x 5 x 1,829 mm)
 - Foundation Tube Material ASTM A53 Grade B
 - Strut and Yoke Assembly ASTM A36 Galvanized
- Soil Type Coarse Crushed Limestone
- Vehicle Make / Model 2006 Kia Rio
 - Curb 2,491 lb (1,130 kg)
 - Test Inertial 2,449 lb (1,111 kg)
 - Gross Static 2,619 lb (1,188 kg)
- Impact Conditions
 - Speed 62.0 mph (99.8 km/h)
 - Angle (vehicle c.g.) 25.5 deg
 - Angle (vehicle orientation) 21.2 deg
 - Impact Location 4 in. (102 mm) US of midspan btwn post nos 27 & 28
- Exit Conditions
 - Speed 32.2 mph (51.8 km/h)
 - Angle (vehicle c.g.) 15.9 deg
 - Angle (vehicle orientation) 28.0 deg

- Vehicle Stability Satisfactory
- Vehicle Stopping Distance 77 ft (23.5 m) downstream
- Vehicle Damage Extensive
 - VDSTM 1-RFQ-6
 - CDCTM 01-FDAW-5
 - Maximum Interior Deformation 1 in (25 mm)
- Test Article Damage Extensive
- Maximum Test Article Deflections
 - Permanent Set 9 ft - 6 1/4 in (2.9 m)
 - Dynamic 12 ft - 3.3 in (3.7 m)¹⁷
 - Working Width 12 ft - 3.3 in (3.7 m)¹⁷
- Impact Severity (IS) 58.3 kip-ft (79.0 kJ) > 51 kip-ft (69.7 kJ) MASH limit
- Transducer Data

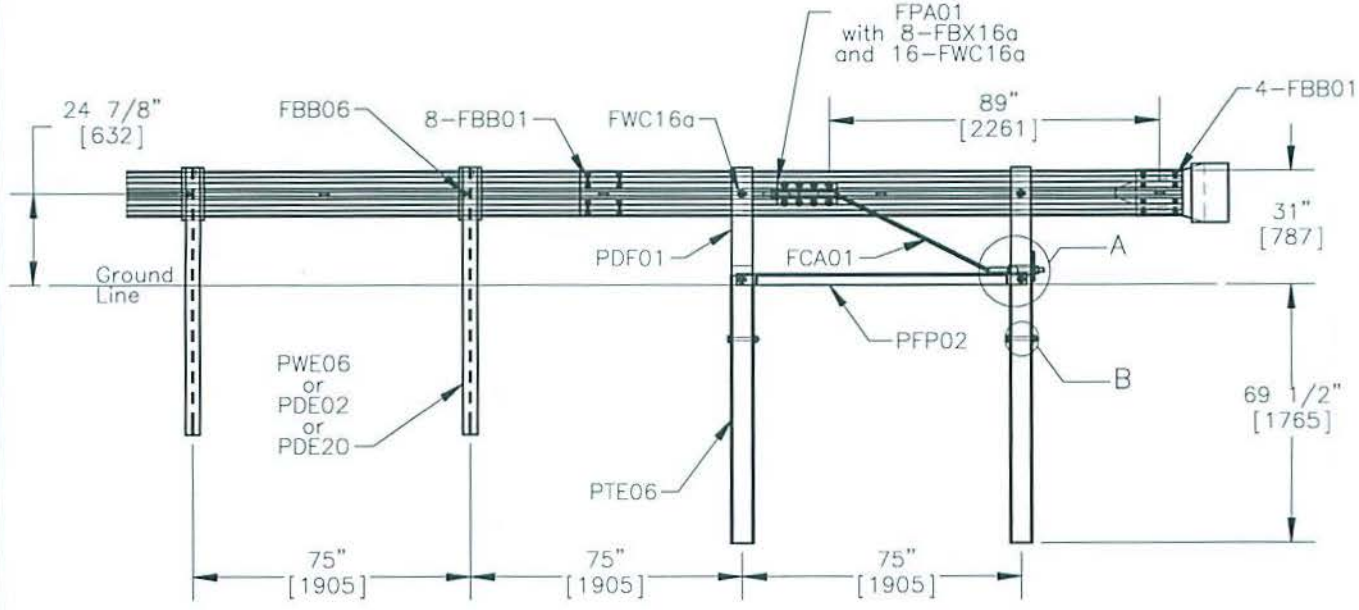
Evaluation Criteria	Transducer			MASH Limit	
	EDR-3	DTS	DTS-SLICE		
OIV ft/s (m/s)	Longitudinal	-37.06 (-11.30)	-34.89 (-10.63)	-36.56 (-11.14)	≤ 40 (12.2)
	Lateral	-15.22 (-4.64)	-15.64 (-4.77)	-14.46 (-4.41)	≤ 40 (12.2)
ORA g's	Longitudinal	-14.87	-14.89	-14.77	≤ 20.49
	Lateral	4.13	-4.53	5.32	≤ 20.49
THIV - ft/s (m/s)	N/A	N/A	42.24 (12.87)		Not required
PHD - g's	N/A	N/A	11.48		Not required
ASI	1.34	1.29	1.31		Not required
Roll Angle - degree	N/A	N/A	10.5		75
Pitch Angle - degree	N/A	N/A	-7.4		75
Yaw Angle - degree	N/A	N/A	33.1		N/A

¹⁷W-beam rotated backward almost 90 degrees. Vehicle was not redirected.

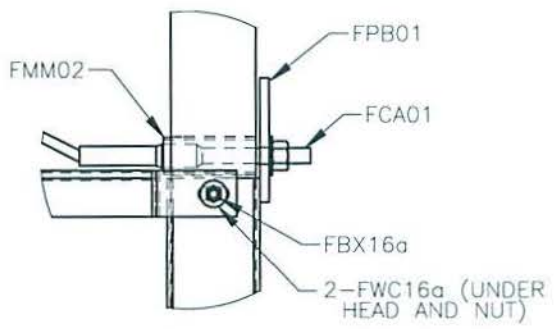
Figure I45. Summary of Test Results and Sequential Photographs, Test No. WIDA-2



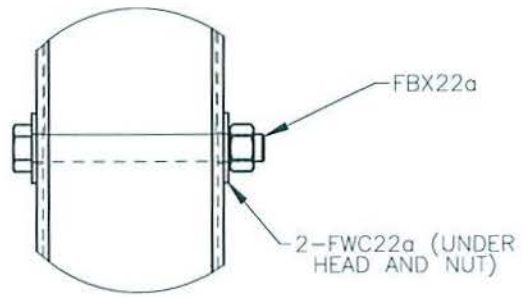
PLAN VIEW



ELEVATION VIEW
NON-TRAFFIC SIDE



DETAIL A



DETAIL B

TRAILING-END ANCHORAGE SYSTEM



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INTENDED USE

The trailing-end anchorage system is intended for use with any Midwest Guardrail System (SGR20a-c, SGR21a-b, SGR22a-b, SGR23a-b, SGR28a-f, SGR38a-b, SGR39) or equivalent 31" [787] tall W-beam guardrail system. The trailing-end anchorage system has been crash tested under Test Level 3 (TL-3) conditions and deemed acceptable according to the *Manual for Assessing Safety Hardware* (MASH) performance. The trailing-end anchorage system should be used where needed to anchor downstream end of guardrail and (1) end-on impacts will not occur or (2) end terminal is placed outside of clear zone for opposite direction traffic. A length of 150" [3810] upstream from the first PDF01 post must consist of standard (75" [1905]) post spacing guardrail before reduced post spacing may start.

The non-gating, redirective length-of-need of the trailing-end anchorage system is 31'-3" [9525] from the centerline of the last PDF01 post and includes four PWE06 or PDE02 or PDE20 posts contained in a standard Midwest Guardrail System (SGR20a-c). The trailing-end anchorage system should be used in locations where a working width envelope is described as follows:

1. at the last PDF01 post, 125" [3175] of working width recommended;
2. at 225" [5715] upstream from the last PDF01 post, 65" [1651] of working width recommended;
3. linearly interpolate between 125" [3175] and 65" [1651] such that for every 3/4" [95] longitudinally upstream from the last PDF01 post, 1" [25] less of working width recommended (e.g., at 75" [1905] upstream from the last PDF01 post, 105" [2667] of working width is recommended);
4. linearly interpolate between 65" [1651] and 60" [1524] such that for every additional 15" [381] longitudinally upstream from 225" [5715] upstream from the last PDF01 post, 1" [25] less of working width recommended (e.g., at 255" [6477] upstream from the last PDF01 post, 63" [1600] of working width is recommended); and
5. at greater than or equal to 300" [7620] upstream from the last PDF01 post, 60" [1524] of working width recommended.

COMPONENTS

Unit Length = 279 3/8" [7096]

DESIGNATOR	COMPONENT	NUMBER
FBB01	Guardrail Bolt and Nut	12
FBB03	Guardrail Bolt and Nut	2
FBB06	Guardrail Bolt and Nut	1
FBX16a	Hex Head Bolt (10" [254]) and Nut	2
FBX16a	Hex Head Bolt (1 1/2" [38]) and Nut	8
FBX22a	Hex Head Bolt (7 1/2" [191]) and Nut	2
FCA01	BCT Anchor Cable Assembly	1
PDB10	MGS Timber Blockout	1
or PDB11	MGS Timber Blockout	1
PWE06	Wide-Flange Guardrail Post	1
or PDE02	Timber Guardrail Post	1
or PDE20	White Pine Guardrail Post	1
FMM02	BCT Post Sleeve	1
FPA01	Anchor Bracket Assembly	1
FPB01	BCT Bearing Plate	1

TRAILING-END ANCHORAGE SYSTEM



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COMPONENTS

Unit Length = 279 3/8" [7096]

DESIGNATOR	COMPONENT	NUMBER
FWC16a	Circular Washer	22
FWC22a	Circular Washer	4
PDF01	BCT Timber Post	2
PTE06	Foundation Tube	2
RWE03a	W-Beam Rounded End Section	1
RWM14a	W-Beam MGS End Section	1
PFP02	Strut and Yoke Assembly	1

ELIGIBILITY

Eligibility will be pursued.

REFERENCES

Mongiardini, M., Faller, R.K., Reid, J.D., Sicking, D.L., Stolle, C.S., and Lechtenberg, K.A., *Downstream Anchoring Requirements for the Midwest Guardrail System*, Final Report to Wisconsin Department of Transportation, Transportation Research Report No. TRP-03-279-13, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, October 28, 2013.

Mongiardini, M., Faller, R.K., Reid, J.D., and Sicking, D.L., *Dynamic Evaluation and Implementation Guidelines for a Non-Proprietary W-Beam Guardrail Trailing End Terminal*, Transportation Research Record No. 2377, Transportation Research Board, National Research Council, Washington, D.C., November 2013, pp. 61-73.

Stolle, C.S., Reid, J.D., Faller, R.K., and Mongiardini, M., *Dynamic Strength of a Modified W-beam BCT Trailing-End Termination System*, International Journal of Crashworthiness, DOI: 10.1080/13588265.2015.1009308, February 2015.

CONTACT INFORMATION

Midwest Roadside Safety Facility
Nebraska Transportation Center
University of Nebraska-Lincoln
130 Whittier Research Center
2200 Vine Street
Lincoln, NE 68583-0853
(402) 472-0965
Email: mwrfsf@unl.edu
Website: <http://mwrfsf.unl.edu>



TRAILING-END ANCHORAGE SYSTEM



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