U.S. Department
of Transportation
Federal Highway Administration

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

July 7, 2017

In Reply Refer To:
HSST-1/ B-284

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 April 25, 2017 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-284 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:

- RESTORE Longitudinal Barrier

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'(AASHTO) 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: RESTORE Longitudinal Barrier
Type of system: Longitudinal Barrier
Test Level: MASH Test Level 4 (TL4)
Testing conducted by: Midwest Roadside Safety Facility
Date of request: April 25, 2017
Date initially acknowledged: April 28, 2017

FHWA concurs with the recommendation of the accredited crash testing laboratory as stated within the attached form.

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

This eligibility letter is issued for the subject device as tested. Modifications made to the device are not covered by this letter and will need to be tested in accordance with all recommended tests in AASHTO's MASH as part of a new and separate submittal.

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 AASHTO's 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

- To prevent misunderstanding by others, this letter of eligibility designated as FHWA control number B-284 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,

Robert Ritter
Acting Director, Office of Safety
Technologies
Office of Safety

Enclosures

Request for Federal Aid Reimbursement Eligibility of Highway Safety Hardware

Submitter			
	Date of Request:	April 25, 2017	◉ New ○ 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.

Device & Testing Criterion - Enter from right to left starting with Test Level

!-!-!

System Type	Submission Type	Device Name / Variant	Testing Criterion	Test Level
'B': Rigid/Semi-Rigid Barriers (Roadside, Median, Bridge Railings)	◉ Physical Crash Testing ○ Engineering Analysis	RESTORE Longitudinal Barrier	AASHTO MASH	TL4

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.

Individual or Organization responsible for the product:

Contact Name:	Jennifer Schmidt	Same as Submitter ☐
Company Name:	Midwest Roadside Safety Facility	Same as Submitter ☒
Address:	130 Whittier Research Center, 2200 Vine Street, Lincoln, NE, [illegible]	Same as Submitter ☒
Country:	USA	Same as Submitter ☒

Enter below all disclosures of financial interests as required by the FHWA `Federal-Aid Reimbursement Eligibility Process for Safety Hardware Devices' document.

The Midwest Roadside Safety Facility (MwRSF) and its employees are requesting a letter of eligibility on behalf of the Nebraska Department of Roads.

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;
(iii) Research funding or other forms of research support include continuing to fund research projects with MwRSF, the RESTORE Longitudinal Barrier was funded by the Federal Highway Administration and Nebraska Department of Roads;
(iv) Patent application has been filed for this system, patent application number 62/146,677, MwRSF researchers are the sole inventors and the The Board of Regents of the University of Nebraska is the Assignee, No 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.

PRODUCT DESCRIPTION

(•) New Hardware or Significant Modification ( ) Modification to Existing Hardware

The RESTORE Longitudinal Barrier (SGM39) consists of an upper steel tube rail attached to the top of concrete RESTORE Barrier elements (ROM06) connected with Adjustable Continuity Joints (FMM09) and supported by shear fenders (PPF01) and steel skids. The top of the upper steel tube rail is set a nominal height of 38-5/8 inches. Eight high-strength or ASTM A325 1-in. diameter x 11 1/2-in. long hex bolts (FBX24b) are placed at a 45-degree angle though the concrete RESTORE Barrier elements (ROM06) and Adjustable Continuity Joint (FMM09) to connect the concrete RESTORE Barrier elements (ROM06) together.

Each concrete RESTORE Barrier element (ROM06) was supported by four shear fenders (PPF01) and two steel skids. The shear fenders (PPF01) were spaced at 60 in. on-center, while the skids were spaced at 120 in. on-center. Each shear fender (PPF01) was anchored to a concrete foundation with four 10-in. long, ASTM A193 Grade B7 threaded rods (FRR20c) with a hardened washer (FWC20b) and a high-strength hex nut (FNX20b). The threaded rod (FRR20c) was embedded 8 in. and epoxied into concrete. The upper portion of the skid pipe was inserted into the 6 5/8-in. diameter holes in each concrete RESTORE Barrier element (ROM06). A 1/2-in. thick elastomer pad was inserted between the top steel plate on the skid and the bottom of the concrete RESTORE Barrier element (ROM06).

A 239½-in. long, 8-in. x 4-in. x ¼-in. steel rail was mounted on top of the concrete RESTORE Barrier element (ROM06) using 4-in. long x 4-in. square tubes with anchor plates and four 3/4-in. diameter x 21-in. long high-strength or ASTM A325 hex bolts (FBX20b) running through the concrete beam to the shear fenders (PPF01) underneath and a hardened washer (FWC20b) under the bolt head and nut. Adjacent steel tubes were spliced together with a splicing tube insert which consisted of a 3/16-in. bent plate and two 5 1/2-in. long round head bolts (FBB10) with a plain round washer (FWC12a) and high-strength structural hex nut (FNX12b).

The upstream and downstream ends of the RESTORE Longitudinal Barrier (SGM39) should be transitioned and terminated into another barrier system such as a rigid concrete barrier or buttress.

CRASH TESTING

By signature below, the Engineer affiliated with the testing laboratory, agrees in support of this submission that all of the critical and relevant crash tests for this device listed above were conducted to meet the MASH test criteria. The Engineer has determined that no other crash tests are necessary to determine the device meets the MASH criteria.

Engineer Name:	Jennifer Schmidt	
Engineer Signature:	Jennifer Schmidt — Digitally signed by Jennifer Schmidt DN: cn=Jennifer Schmidt, o=MWRSF, ou=UNL-MWRSF, email=jennifer.schmidt@unl.edu, c=US Date: 2017.04.25 10:16:06 -05'00'	
Address:	130 Whittier Research Center, 2200 Vine Street, Lincoln, NE, 68583-0853	Same as Submitter ☒
Country:	USA	Same as Submitter ☒

A brief description of each crash test and its result:

Required Test Number	Narrative Description	Evaluation Results
4-10 (1100C)	The results of test no. SFH-2 conducted on August 11, 2014 are found in MwRSF report no. TRP-03-318-15. A 2,406-lb small car with a simulated occupant seated in the left-front seat, impacted the RESTORE longitudinal barrier at a speed of 64.3 mph and at an angle of 24.8 degrees. After impact, the vehicle began to redirect, including a clockwise yaw rotation. At 0.250 sec after impact, the vehicle became parallel to the system. At 0.330 sec, the vehicle exited the barrier at an angle of 4.6 degrees and at a speed of 44.6 mph. However, the vehicle contacted the system again approximately 3 barrier segments downstream of the barrier where the vehicle exited the system. The vehicle was smoothly redirected. Exterior vehicle damage was moderate, and the interior occupant compartment deformations were moderate with a maximum of 3¼-in., consequently not violating the limits established in MASH. Damage to the barrier was minimal, consisting of gouging and contact marks on the front face of the concrete segments and cuts in the rubber posts. The maximum lateral dynamic barrier deflections at the top downstream end of barrier no. 7 and the top of the upper tube assembly at the same location, including barrier rotation backward, were 7.1 in. and 7.3 in., respectively. The working width of the system was 28.8 in. All occupant risk measures were below preferred values, and the test vehicle showed no tendency to rollover.	PASS

Required Test Number	Narrative Description	Evaluation Results
4-11 (2270P)	The results of test no. SFH-1 conducted on July 2, 2014 are found in MwRSF report no. TRP-03-318-15. A 5,021-lb pickup truck with a simulated occupant seated in the left-front seat, impacted the RESTORE longitudinal barrier at a speed of 63.4 mph and an angle of 24.8 degrees. After impact, the vehicle began to redirect, including a clockwise yaw rotation. At 0.206 sec after impact, the vehicle became parallel to the system. At 0.540 sec, the vehicle exited the barrier at an angle of 8.4 degrees and at a speed of 46.2 mph. The vehicle was smoothly redirected. Exterior vehicle damage was moderate, and the 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 minimal, consisting of contact marks, concrete spalling and gouges, and hairline concrete cracks. The maximum lateral dynamic barrier deflections at the top upstream end of concrete barrier no. 6 and the top of the upper tube assembly at the same location, including barrier rotation backward, were 11.2 in. and 10.9 in, respectively. The working width of the system was 33.5 in. All occupant risk measures were below preferred values, and the test vehicle showed no tendency to rollover.	PASS

4-12 (36000V)	The results of test no. SFH-3 conducted on March 13, 2015 are found in MwRSF report no. TRP-03-318-15. A 21,746-lb single-unit truck with a simulated occupant seated in the left-front seat, impacted the RESTORE longitudinal barrier at a speed of 56.5 mph and an angle of 14.9 degrees. After impact, the vehicle began to redirect, including a clockwise yaw rotation. At 0.326 sec after impact, the vehicle became parallel to the system. At 1.320 sec, the vehicle exited the barrier at an angle of 9 degrees and at a speed of 38.7 mph. The vehicle was smoothly redirected. Exterior vehicle damage was moderate, and the interior occupant compartment deformations were minimal with a maximum of 2⅜-in., consequently not violating the limits established in MASH. Damage to the barrier was minimal, consisting of contact marks and gouging on the front face of the concrete beams, cracking and spalling at the joint connections, contact marks along the top of the concrete beams and along the upper tube assembly, and contact with the rubber posts. The maximum lateral dynamic barrier deflections at the top upstream end of concrete barrier no. 6 and the top of the upper tube assembly at the same location, including barrier rotation backward were 13.9 in. and 15.1 in., respectively. The working width of the system was 60.2 inches. The test vehicle showed no tendency to rollover.	PASS
4-20 (1100C)	Test no. 4-20 is not applicable for this type of system.	Non-Relevant Test, not conducted
4-21 (2270P)	Test no. 4-21 is not applicable for this type of system.	Non-Relevant Test, not conducted
4-22 (10000S)	Test no. 4-22 is not applicable for this type of system.	Non-Relevant Test, not conducted

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 Signature:	Karla Lechtenberg — Digitally signed by Karla Lechtenberg DN: cn=Karla Lechtenberg, o=Midwest Roadside Safety Facility (MwRSF), ou, email=kpolivka2@unl.edu, c=US Date: 2017.04.25 18:35:37 -05'00'	
Address:	130 Whittier Research Center, 2200 Vine Street, Lincoln, NE, 68583-0853	Same as Submitter ☒
Country:	USA	Same as Submitter ☒
Accreditation Certificate Number and Dates of current Accreditation period :	A2LA Certificate Number: 2937.01, Valid to November 30, 2017	

Submitter Signature*: Karla Lechtenberg — Digitally signed by Karla Lechtenberg DN: cn=Karla Lechtenberg, o=Midwest Roadside Safety Facility (MwRSF), ou, email=kpolivka2@unl.edu, c=US Date: 2017.04.25 18:36:12 -05'00'

Submit Form

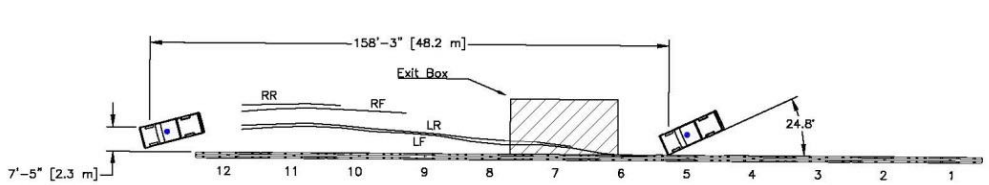
ATTACHMENTS

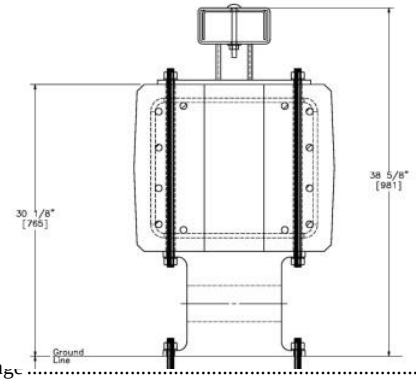
Attach to this form:

1) Additional disclosures of related financial interest as indicated above.
2) A copy of the full test report, video, and a Test Data Summary Sheet for each test conducted in support of this request.
3) 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 relevant to understanding the dimensions and performance of the device should also be submitted to facilitate our review.

FHWA Official Business Only:

Eligibility Letter		
Number	Date	Key Words

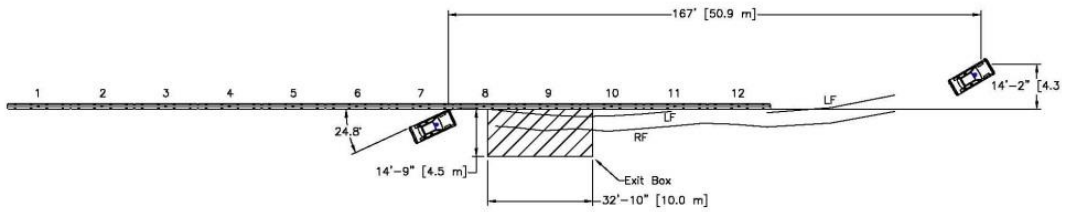


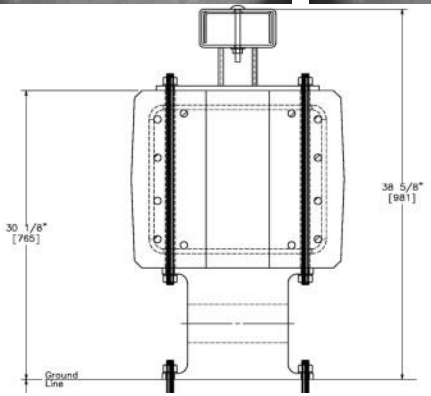


- MASH Test Designation 4-11
- Test Article ..... Low-Maintenance, Energy-Absorbing Concrete Median Barrier
- Total Length ..... 239 ft 11½ in. (73.1 m)
- Key Component – Concrete Barrier Section
  - Length ..... 239½ in. (6,083 mm)
  - Height ..... 18½ in. (470 mm)
  - Depth ..... 21½ in. (546 mm)
- Key Component – Post
  - Nominal Height ..... 11⅝ in. (295 mm)
  - Width ..... 10 in. (254 mm)
  - Depth ..... 15¾ in. (400 mm)
  - Spacing ..... 60 in. (1,524 mm)
- Vehicle Make /Model ..... 2005 Dodge Ram 1500
  - Curb Weight ..... 5,094 lb (2,311 kg)
  - Test Inertial Weight ..... 5,021 lb (2,277 kg)
  - Gross Static Weight ..... 5,186 lb (2,352 kg)
- Impact Conditions
  - Speed ..... 63.4 mph (102.1 km/h)
  - Angle ..... 24.8 deg
  - Impact Location ..... $41\frac{3}{16}$ in. (1,046 mm) upstream from joint between barrier nos. 5 and 6
- Exit Conditions
  - Speed ..... 46.2 mph (74.4 km/h)
  - Angle ..... 8.4 deg
- Exit Box Criterion ..... Pass
- Vehicle Stability ..... Satisfactory
- Vehicle Stopping Distance ..... 158 ft – 3 in. (48.2 m) downstream of impact ..... Laterally 7 ft – 5 in. (2.3 m) in front of the system
- Vehicle Damage ..... Moderate
  - VDS [11] 11-LFQ-3
  - CDC [12] 11-LFMW-6
  - Maximum Interior Deformation ..... 1 in. (25 mm)
- Test Article Damage ..... Minimal
- Maximum Test Article Deflections
  - Permanent Set ..... ⅞ in. (22 mm)
  - Dynamic of Concrete Beam ..... 11.2 in. (284 mm)
  - Dynamic of Upper Tube Assembly ..... 10.9 in. (277mm)
  - Working Width ..... 33.5 in. (851 mm)
- Impact Severity (IS) ..... 118.6 kip-ft (160.8 kJ) > 105.6 kip-ft (143.2 kJ) limit from MASH
- Transducer Data

Evaluation Criteria		Transducer		MASH Limit
		SLICE-1 (Primary)	SLICE-2	
OIV ft/s (m/s)	Longitudinal	-17.62 (-5.37)	-16.04 (-4.89)	≤ 40 (12.2)
	Lateral	21.29 (6.49)	21.16 (6.45)	≤ 40 (12.2)
ORA g's	Longitudinal	-4.81	-9.62	≤ 20.49
	Lateral	8.40	10.10	≤ 20.49
MAX ANGULAR DISP. deg.	Roll	-27.3	-24.2	≤75
	Pitch	-8.0	-9.0	≤75
	Yaw	36.4	35.7	not required
THIV – ft/s (m/s)		25.89 (7.89)	25.72 (7.84)	not required
PHD – g's		9.39	13.86	not required
ASI		1.24	1.31	not required

Figure 43. Summary of Test Results and Sequential Photographs, Test No. SFH-1





- Test Number SFH-2
- Date 8/11/2014
- MASH Test Designation 4-10
- Test Article ..... Low-Maintenance, Energy-Absorbing Concrete Median Barrier
- Total Length ..... 239 ft 11½ in. (73.1 m)
- Key Component – Concrete Barrier Section
  - Length ..... 239½ in. (6,083 mm)
  - Height ..... 18½ in. (470 mm)
  - Depth ..... 21½ in. (546 mm)
- Key Component – Post
  - Height ..... 11⅝ in. (295 mm)
  - Width ..... 10 in. (254 mm)
  - Depth ..... 15¾ in. (400 mm)
  - Spacing ..... 60 in. (1,524 mm)
- Vehicle Make /Model ..... 2005 Kia Rio
  - Curb ..... 2,406 lb (1,091 kg)
  - Test Inertial ..... 2,406 lb (1,091 kg)
  - Gross Static ..... 2,572 lb (1,167 kg)
- Impact Conditions
  - Speed ..... 64.3 mph (103.5 km/h)
  - Angle ..... 24.8 deg
  - Impact Location ..... $8^{5}/_{16}$ in. (211 mm) upstream of the joint Between barrier nos. 7 and 8
- Exit Conditions
  - Speed ..... 44.6 mph (71.8 km/h)
  - Angle ..... 4.6 deg
- Exit Box Criterion ..... Pass
- Vehicle Stability ..... Satisfactory
- Vehicle Stopping Distance ..... 167 ft (50.9 m) downstream of impact ..... Laterally 14 ft – 2 in. (4.3 m) behind the system
- Vehicle Damage ..... Moderate
  - VDS [11] 11-LFQ-5
  - CDC [12] 11-LFAW-6
  - Maximum Interior Deformation ..... 3¼ in. (83 mm)
- Impact Severity (IS) ..... 58.3 kip-ft (79.1 kJ) > 51.0 kip-ft (69.1 kJ) limit from MASH
- Test Article Damage ..... Minimal
- Maximum Test Article Deflections
  - Permanent Set ..... 1¾ in. (44 mm)
  - Dynamic of Concrete Beam ..... 7.1 in. (180 mm)
  - Dynamic of Upper Tube Assembly ..... 7.3 in. (185 mm)
  - Working Width ..... 28.8 in. (732 mm)
- Transducer Data

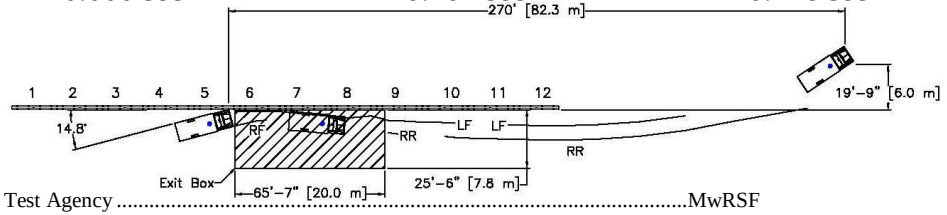
Evaluation Criteria		Transducer		MASH Limit
		SLICE-1 (Primary)	SLICE-2	
OIV ft/s (m/s)	Longitudinal	-26.51 (-8.08)	-26.31 (-8.02)	≤ 40 (12.2)
	Lateral	25.59 (7.80)	24.38 (7.43)	≤ 40 (12.2)
ORA g's	Longitudinal	-5.06	-4.86	≤ 20.49
	Lateral	8.19	7.35	≤ 20.49
MAX ANGULAR DISP. deg.	Roll	-4.4	3.7	≤75
	Pitch	-4.6	-6.4	≤75
	Yaw	30.6	29.8	not required
THIV – ft/s (m/s)		35.20 (10.73)	33.66 (10.26)	not required
PHD – g's		8.69	7.99	not required
ASI		2.01	1.92	not required

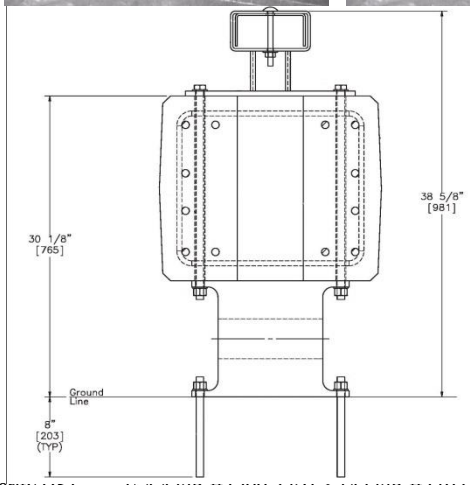
Figure 60. Summary of Test Results and Sequential Photographs, Test No. SFH-2





0.000 sec 0.104 sec 0.216 sec 752 sec

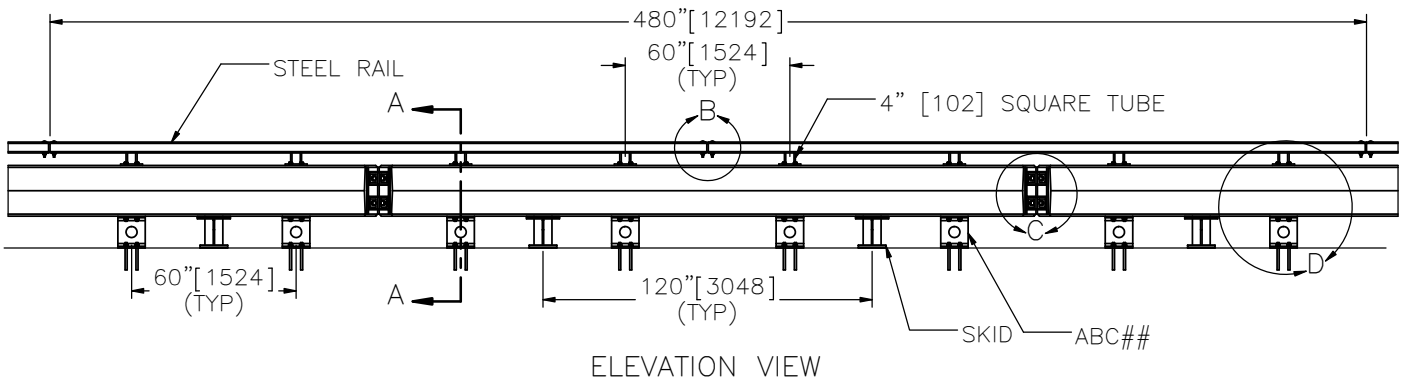




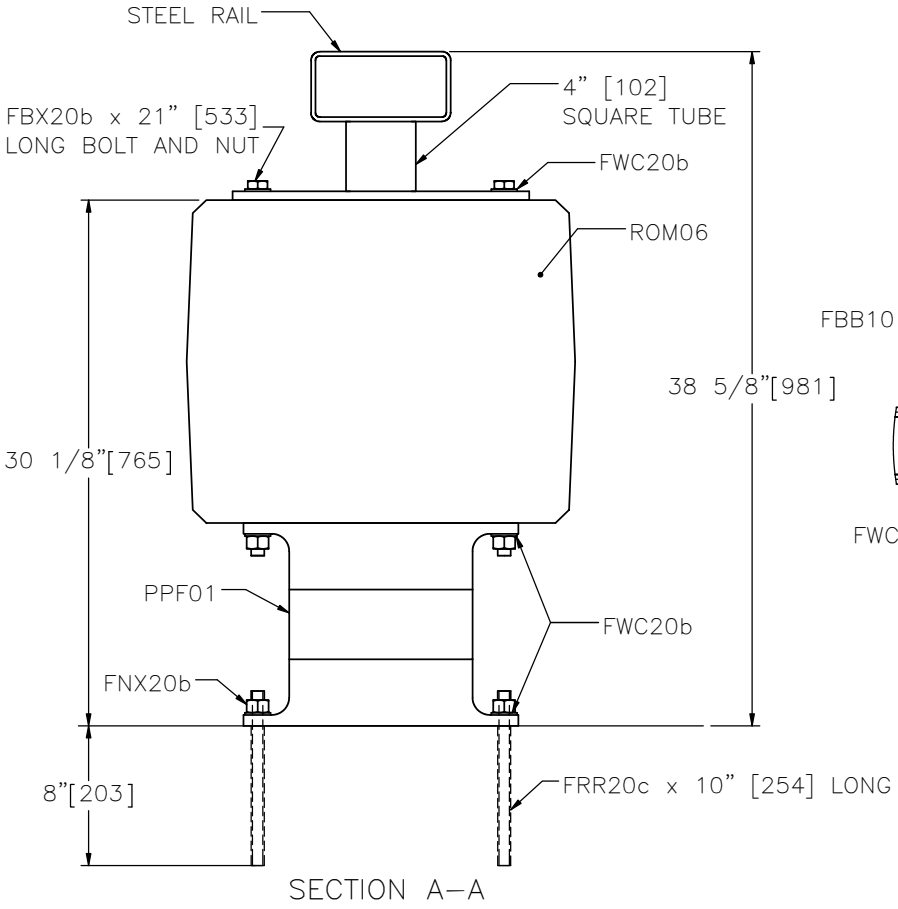
- Test Agency ..... MwRSF
- Test Number SFH-3
- Date 3/13/2015
- MASH Test Designation 4-12
- Test Article ..... Low-Maintenance, Energy-Absorbing Concrete Median Barrier
- Total Length ..... 239 ft 11½ in. (73.1 m)
- Key Component – Concrete Barrier Section
  - Length ..... 239½ in. (6,083 mm)
  - Height ..... 18½ in. (470 mm)
  - Depth ..... 21½ in. (546 mm)
- Key Component – Post
  - Height ..... 11⅝ in. (295 mm)
  - Width ..... 10 in. (254 mm)
  - Depth ..... 15¾ in. (400 mm)
  - Spacing ..... 60 in. (1,524 mm)
- Vehicle Make /Model ..... 1998 Ford F-800
  - Curb ..... 11,180 lb (5,071 kg)
  - Test Inertial ..... 21,746 lb (9,864 kg)
  - Gross Static ..... 21,912 lb (9,939 kg)
- Impact Conditions
  - Speed ..... 56.5 mph (90.9 km/h)
  - Angle ..... 14.9 deg
  - Impact Location ..... 55.75 in. (1,416 mm) upstream of the joint between barrier nos. 5 and 6
- Exit Conditions
  - Speed ..... 38.7 mph (62.3 km/h)
  - Angle ..... 9 deg
- Exit Box Criterion ..... Pass
- Vehicle Stability ..... Satisfactory
- Vehicle Stopping Distance ..... 270 ft (82.3 m) downstream of impact ..... 19 ft – 9 in. (6.0 m) laterally behind the system
- Vehicle Damage ..... Moderate
  - VDS [11] 11-LFQ-4
  - CDC [12] 11-LPEW-9
  - Maximum Interior Deformation ..... 2⅜ in. (60 mm)
- Impact Severity (IS) ..... 154.4 kip-ft (209.3 kJ) > 142 kip-ft (193 kJ) limit from MASH
- Test Article Damage ..... Moderate
- Maximum Test Article Deflections
  - Permanent Set ..... 1½ in. (38 mm)
  - Dynamic of Concrete Beam ..... 13.9 in. (353 mm)
  - Dynamic of Upper Tube Assembly ..... 15.1 in. (384 mm
  - Working Width ..... 60.2 in. (1,529 mm)
- Transducer Data

Evaluation Criteria		Transducer and Location			MASH Limit
		SLICE-1 (Under cargo box)	SLICE-2 (Under cargo box)	DTS (Inside cab)	
OIV ft/s (m/s)	Longitudinal	-8.20 (-2.50)	-8.30 (-2.53)	-5.25 (-1.60)	not required
	Lateral	12.63 (3.85)	13.25 (4.04)	11.68 (3.56)	not required
ORA g's	Longitudinal	-6.65	-6.70	-4.70	not required
	Lateral	9.29	7.82	6.83	not required
MAX ANGULAR DISP. deg.	Roll	-39.1	-33.8	-33.0	not required
	Pitch	-11.9	-10.7	5.6	not required
	Yaw	30.6	25.7	23.9	not required
ASI		0.48	0.53	0.56	not required

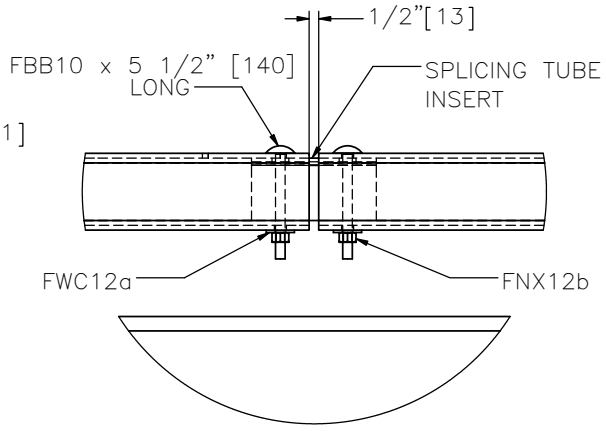
Figure 104. Summary of Test Results and Sequential Photographs, Test No. SFH-3



ELEVATION VIEW



SECTION A–A



DETAIL B

RESTORE LONGITUDINAL BARRIER

MwRSF

SGM39

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INTENDED USE

The RESTORE longitudinal barrier is a non-proprietary system. It is a restorable and reusable energy-absorbing roadside and median barrier which fits current roadside and median footprints and lowers lateral accelerations to passenger vehicle occupants during impact events as compared to impacts with rigid concrete barriers. The RESTORE longitudinal barrier is intended to be used in locations where a maximum dynamic deflection of 13.9" [353] or less is acceptable and where a working width of 60.2" [1529] is provided. The upstream and downstream ends of the RESTORE longitudinal barrier should be transitioned into another barrier, such as a rigid concrete barrier or buttress, or terminated with an acceptable termination for the RESTORE longitudinal barrier. The RESTORE longitudinal barrier has been crash tested under Test Level 4 (TL-4) conditions and deemed acceptable according to the Manual for Assessing Safety Hardware (MASH) performance criteria.

COMPONENTS

Unit Length = 480" [12192]

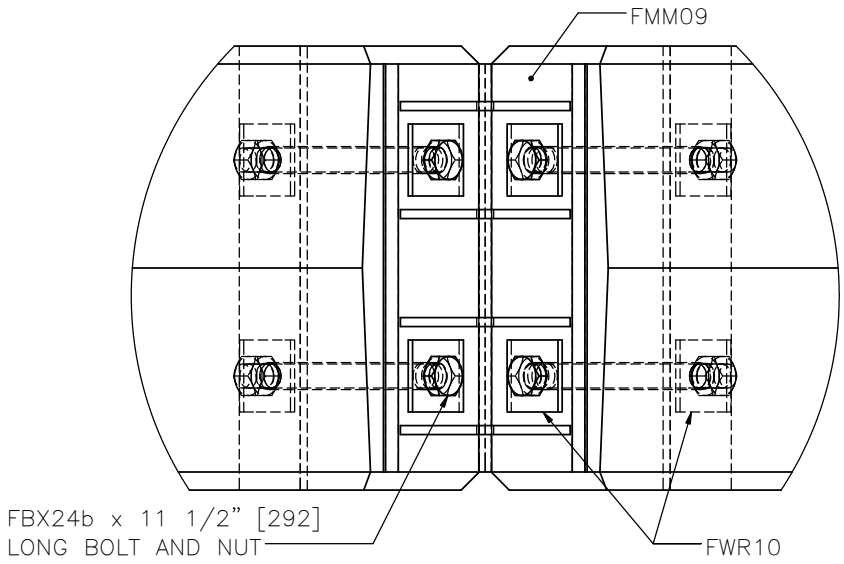
DESIGNATOR	COMPONENTS	NUMBER
PPF01	Shear fender	8
FMM09	Adjustable continuity joint	4
FBB10	Round head bolt, 5½" [140] long	4
FBX20b	High-strength hex bolt, 21" [533] long, and nut	32
FBX24b	High-strength hex bolt, 11½" [292] long, and nut	16
FNX12b	High-strength hex nut	4
FNX20b	High-strength hex nut	32
FRR20c	Threaded rod, 10" [254] long	32
FWC12a	Plain round washer	4
FWC20b	Hardened round washer	96
FWR10	Square plate washer	32
ROM06	Concrete RESTORE barrier element	2
-----	4" [102] square tube	8
-----	Anchor plate	8
-----	Skid	4
-----	Splicing tube insert	2
-----	Steel rail	2

ELIGIBILITY

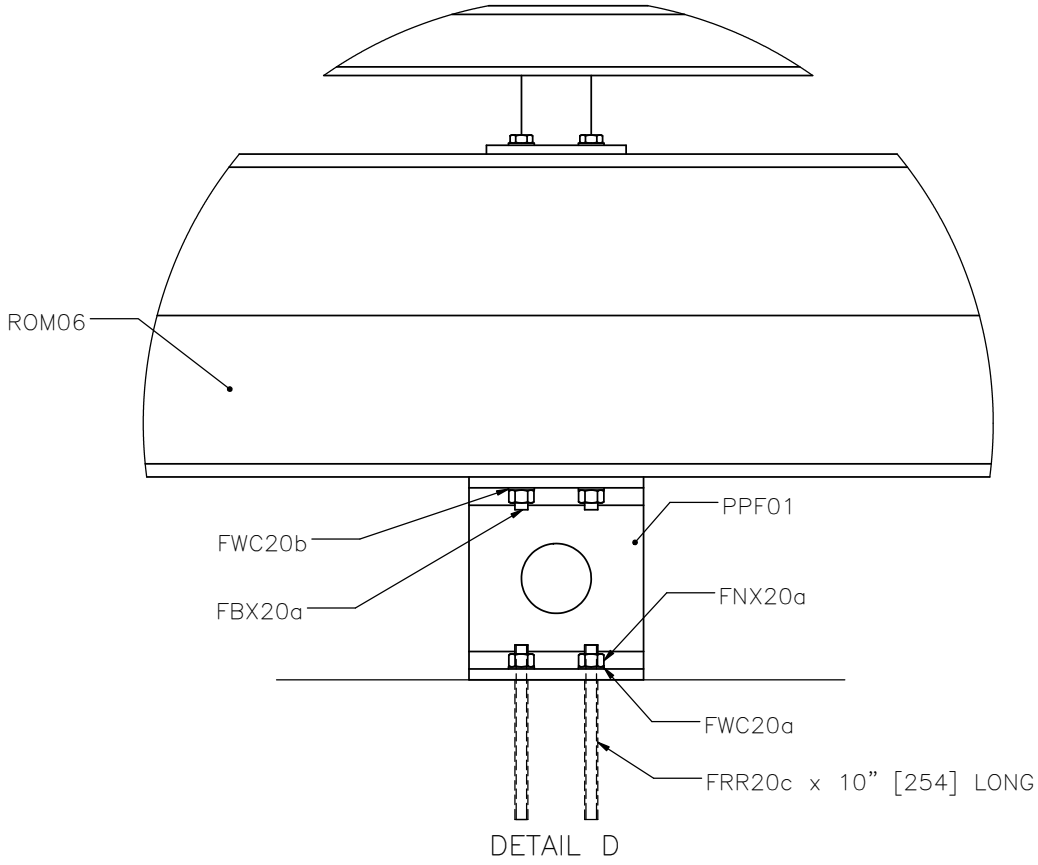
FHWA eligibility will be pursued.

REFERENCES

Schmidt, J.D., Schmidt, T.L., Rosenbaugh, S.K., Faller, R.K., Bielenberg, RW., Reid, J.D., Holloway, J.C., and Lechtenberg, K.A., *MASH TL-4 Crash Testing and Evaluation of the Restore Barrier,* Final Report to Nebraska Department of Roads and Federal Highway Administration, Transportation Research Report No. TRP-03-318-15, Project No. NDOR DPU-STWD (94), Midwest Roadside Safety Facility, University of Nebraska-Lincoln, November 3, 2015.



DETAIL C



DETAIL D

RESTORE LONGITUDINAL BARRIER

SGM39	
SHEET NO.	DATE:
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REFERENCES

Schmidt, J.D., Schmidt, T.L., Faller, R.K., Sicking, D.L., Reid, J.D., Lechtenberg, K.A., Bielenberg, R.W., Rosenbaugh, S.K., and Holloway, J.C., *Evaluation of Energy Absorbers for Use in a Roadside/Median Barrier*, Final Report to the Nebraska Department of Roads and the Federal Highway Administration – Nebraska Division, MwRSF Research Report No. TRP-03-280-14, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, February 6, 2014.

Schmidt, J.D., Rosenbaugh, S.K., Faller, R.K., Bielenberg, R.W., Reid, J.D., Holloway, J.C., Lechtenberg, K.A., and Kohtz, J.E., *Design and Evaluation of an Energy-Absorbing, Reusable, Roadside/Median Barrier, Phase 3,* Draft Report to the Nebraska Department of Roads and the Federal Highway Administration, MwRSF Research Report No. TRP-03-317-15, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, February 10, 2015.

Schmidt, J.D., Rosenbaugh, S.K., Bielenberg, R.W., Faller, R.K., Reid, J.D., Schmidt, T.L., *MASH TL-4 Design and Evaluation of A Restorable Energy-Absorbing Concrete Barrier,* Paper No. 16-0650, Transportation Research Record No. 2588, Journal of the Transportation Research Board, Washington, D.C., January 2016.

CONTACT INFORMATION

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Lincoln, NE 68583-0853
(402) 472-0965
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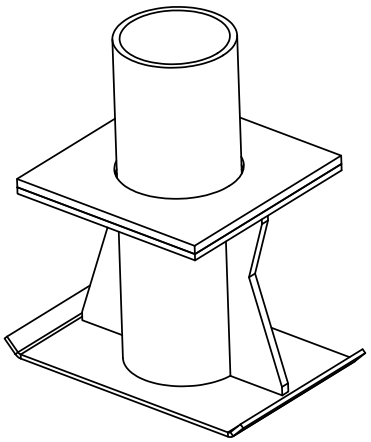
Website: https://mwrsf.unl.edu/



ISOMETRIC VIEW

NOTE: SKID RUBBER ADDED AFTER ALL WELDING AND GALVANIZATION HAS BEEN COMPLETED.

RESTORE LONGITUDINAL BARRIER

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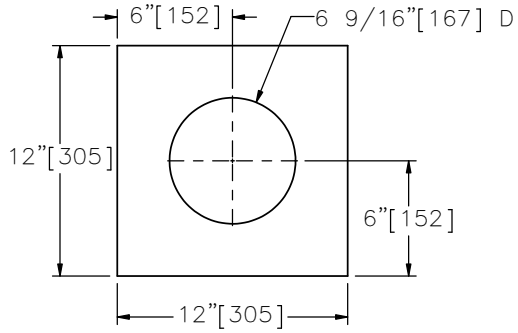
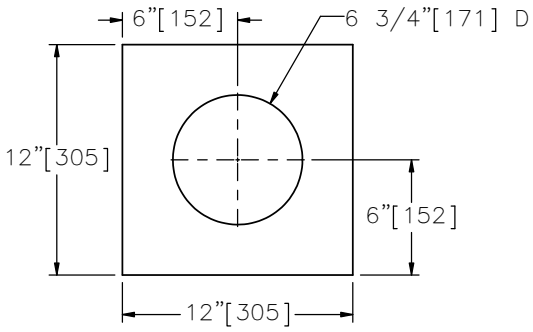
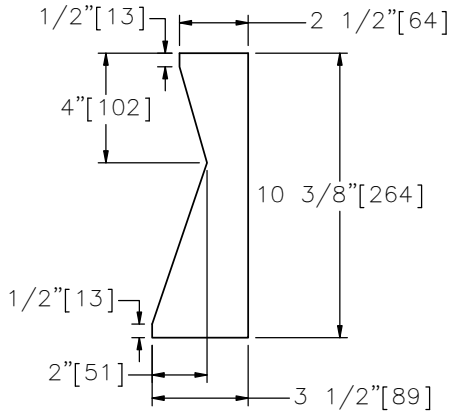


3/8" [10] THICK SKID TOP PLATE

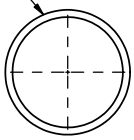


1/2" [13] THICK SKID RUBBER

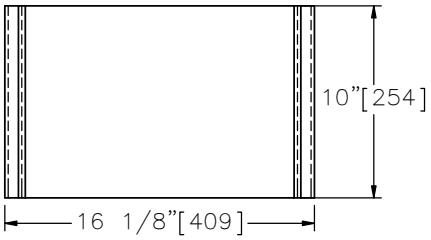


1/2" [13] THICK SKID GUSSET

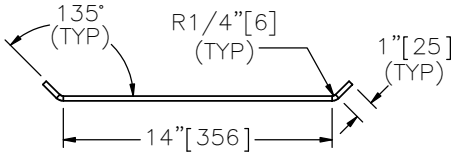
DOM 6 1/2"[165] D x 3/8"[10] THICK
OR
DOM 6 1/2"[165] D x 1/2"[13] THICK
OR
HFS 6 1/2"[165] D x 1/2"[13] THICK
OR EQUIVALENT



PLAN VIEW

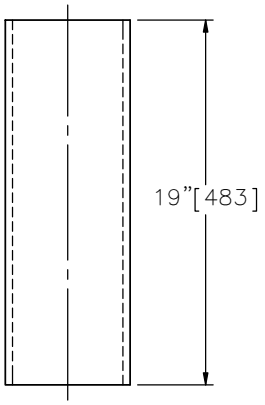


PLAN VIEW



ELEVATION VIEW

1/4" [6] THICK SKID BASEPLATE



ELEVATION VIEW

SKID TUBE

RESTORE LONGITUDINAL BARRIER

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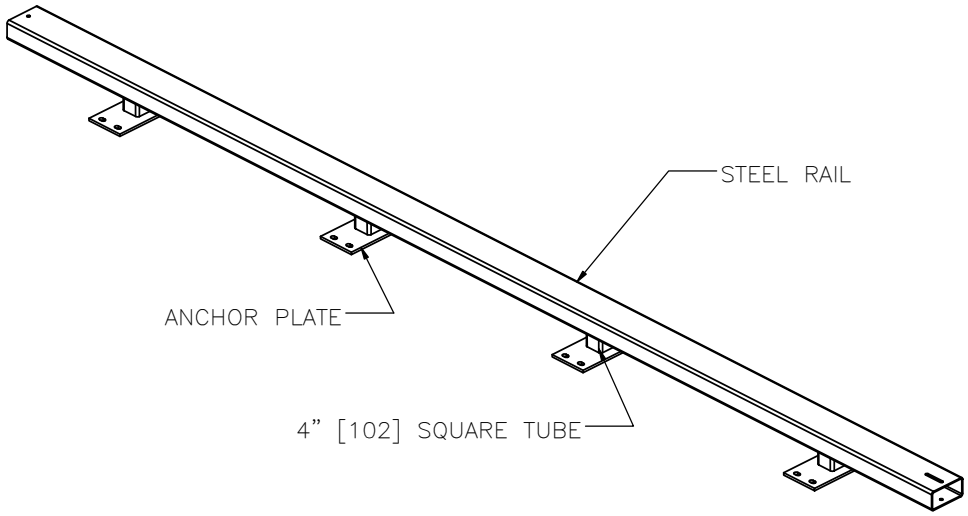
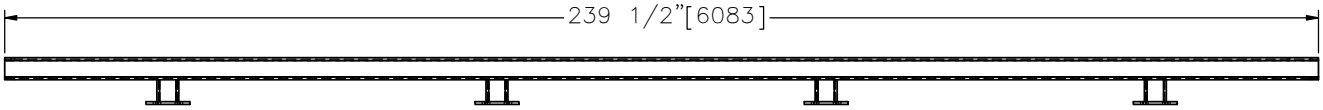
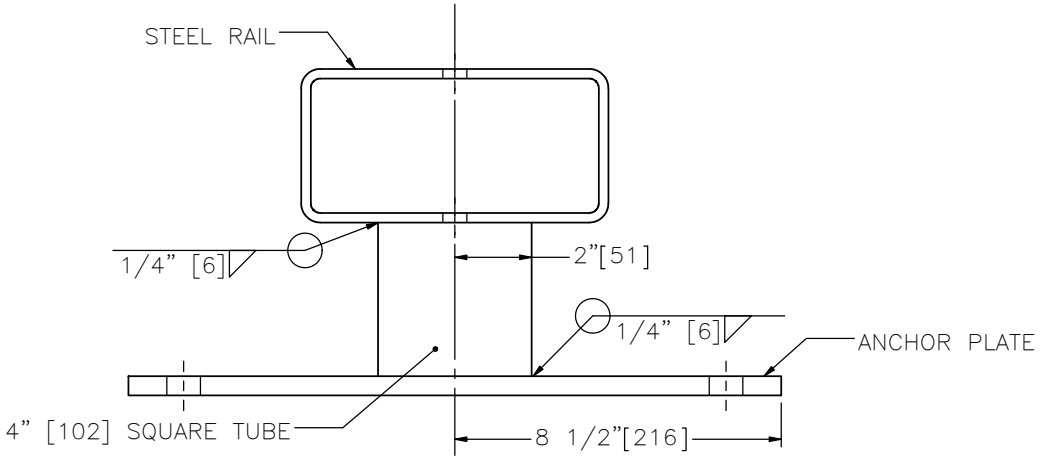


PLAN VIEW



ELEVATION VIEW



PROFILE VIEW

RESTORE LONGITUDINAL BARRIER

MwRSF

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SHEET NO.	DATE:
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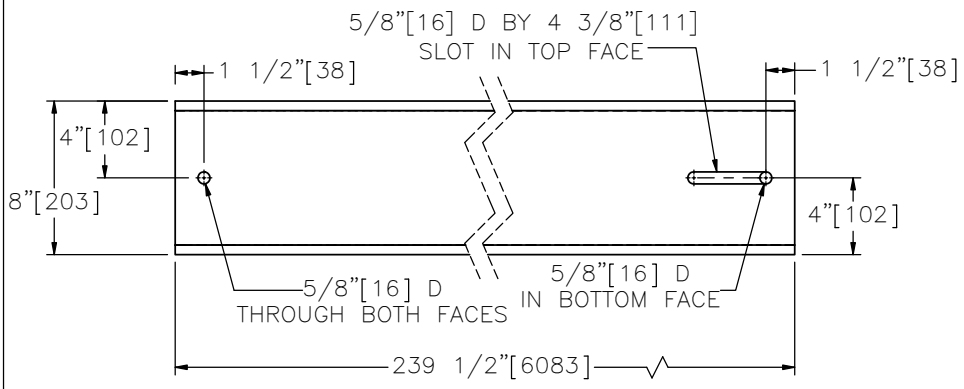
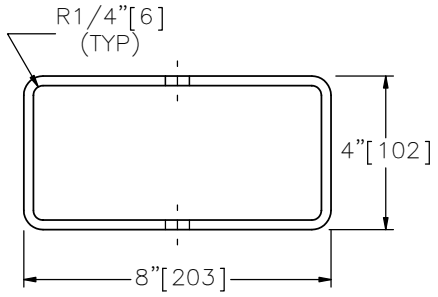
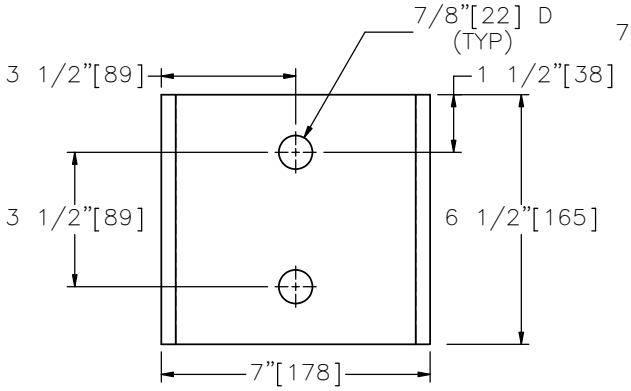


PLAN VIEW

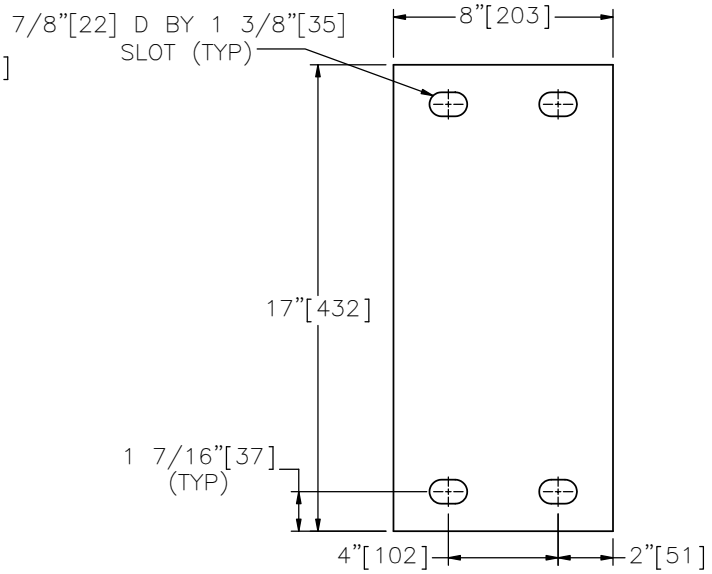


PROFILE VIEW

STEEL RAIL

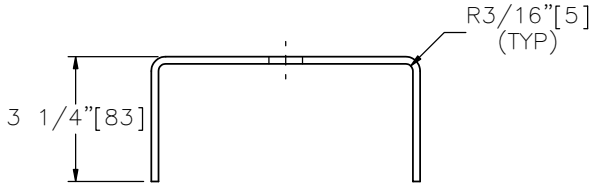


PLAN VIEW



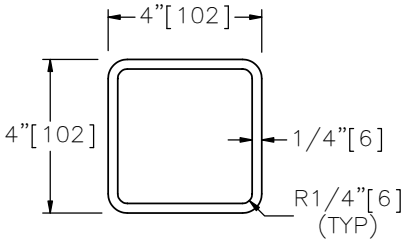
PLAN VIEW

1/2" [13] THICK ANCHOR PLATE



ELEVATION VIEW

3/16" [10] THICK SPLICING TUBE INSERT



PLAN VIEW

4" [102] SQUARE TUBE x 4" [102] LONG

RESTORE LONGITUDINAL BARRIER

MwRSF

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SHEET NO.	DATE:
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SPECIFICATIONS

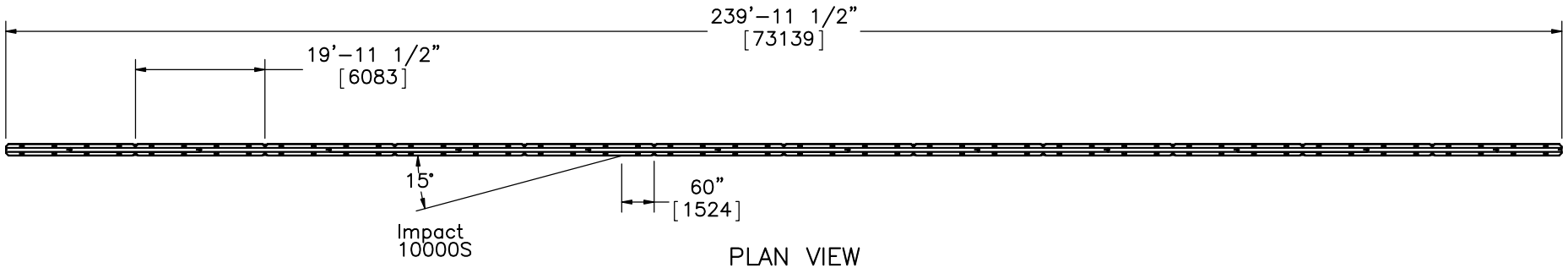
The skid tube shall be manufactured using AISI 1026 or AISI 1020 steel. The skid gusset, skid baseplate, and skid top plate shall be manufactured using ASTM A572 Grade 50 steel. The skid rubber shall be made using minimum 50 durometer rubber.

After the skid assembly is welded, the skid assembly shall be zinc-coated according to AASHTO M111 (ASTM A123) except when corrosion resistant steel is required. The skid rubber is added after all welding and galvanization has been completed.

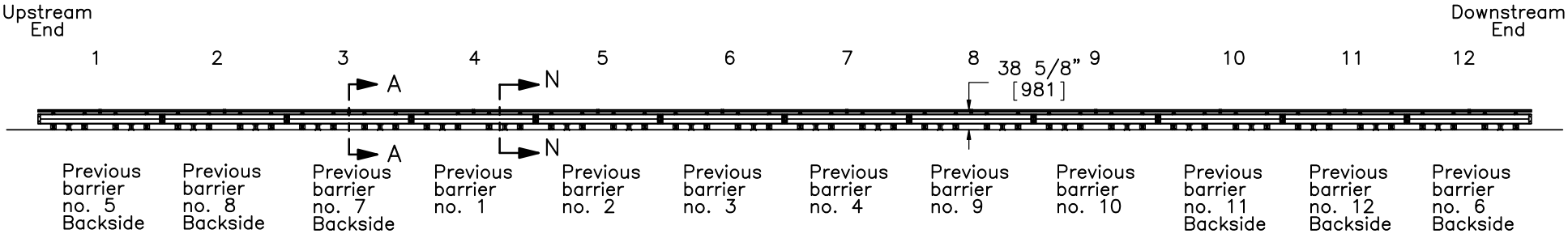
The steel rail, and 4" [102] square tube shall be manufactured using ASTM A500 Grade B steel. The splicing tube insert and anchor plate shall be manufactured using ASTM A572 Grade 50 steel or equivalent.

After welding the steel rail, anchor plate, and 4” [102] square tube, the assembly shall be zinc-coated according to AASHTO M111 (ASTM A123) except when corrosion resistant steel is required. The splicing tube insert shall be zinc-coated according to AASHTO M111 (ASTM A123) except when corrosion resistant steel is required.

Dimensional tolerances not shown or implied are intended to be those consistent with the proper functioning of the part, including its appearance and accepted manufacturing practices.



PLAN VIEW



ELEVATION VIEW

Notes: (1) Impact location is 60" [1524] upstream of joint between barrier nos. 5 and 6.

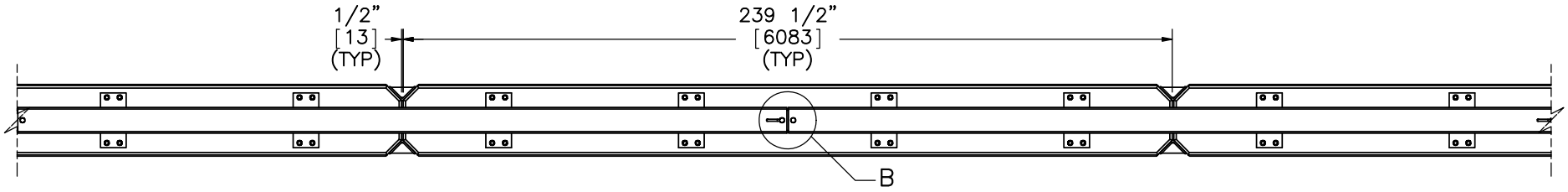
(2) Overall nominal height of barrier may decrease once assembled due to the weight of the rail on rubber.

(3) Mark existing damage from test nos. SFH–1 and SFH–2.

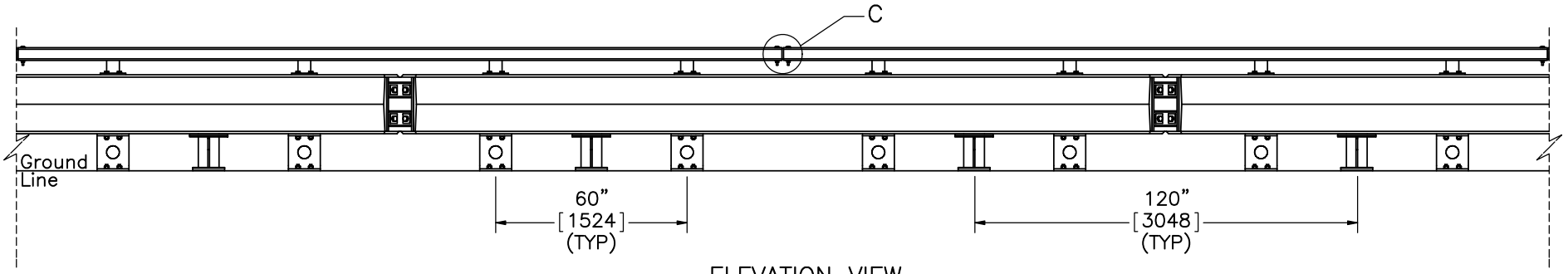
(4) Move damaged posts to the US end of the system.

(5) The barriers with contact marks (5, 6, 7, 8, 11, 12) should be rotated so that the previous backside of the barrier will be impacted.

MwRSF Midwest Roadside Safety Facility	SAFER For Highway – Angle Joint (SFH–3) System Layout	SHEET: 1 of 23 DATE: 10/16/2014 DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3 SCALE: 1:300 UNITS: in.[mm]	REV. BY: JDS/SKR/KAL

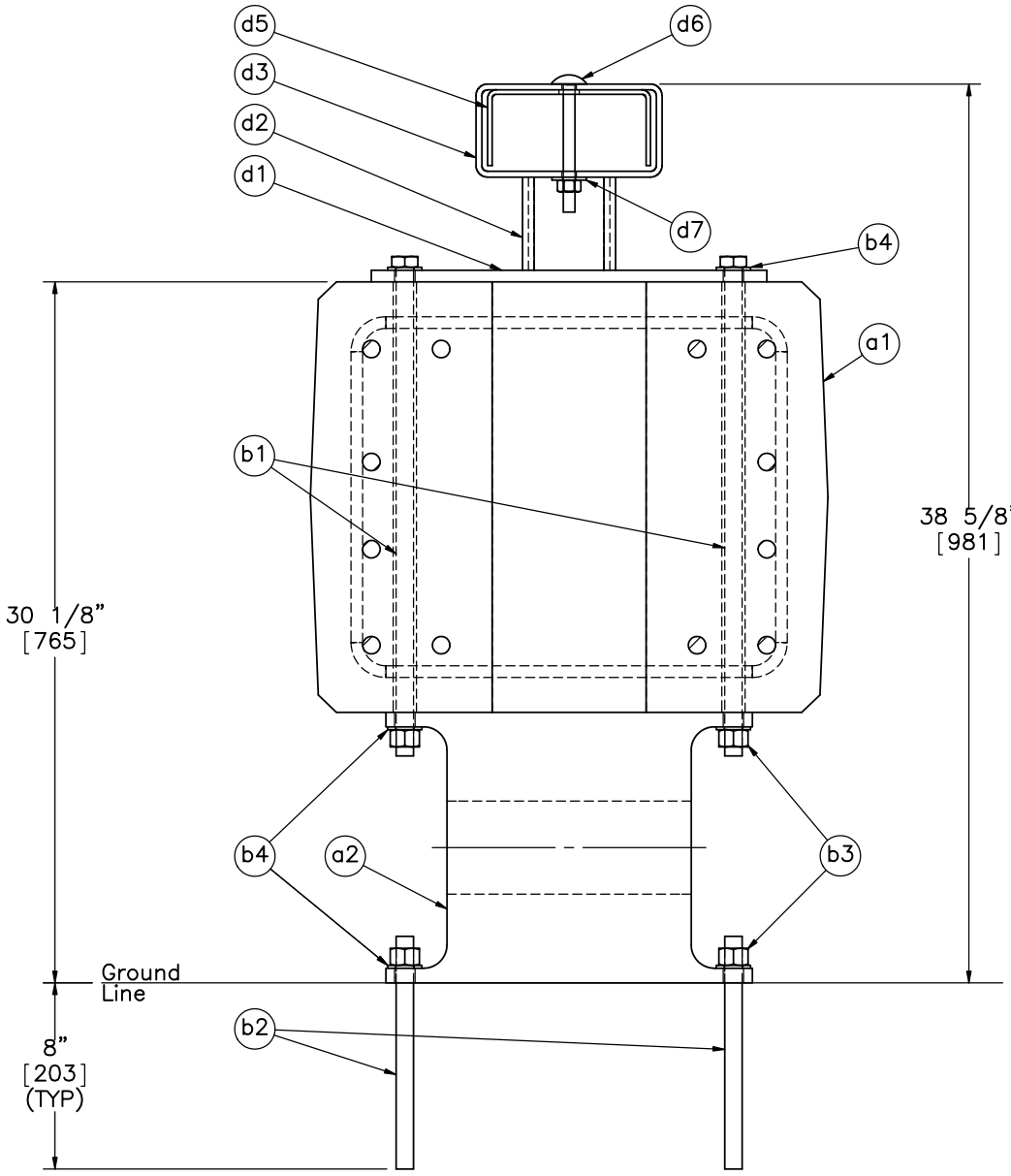


PLAN VIEW

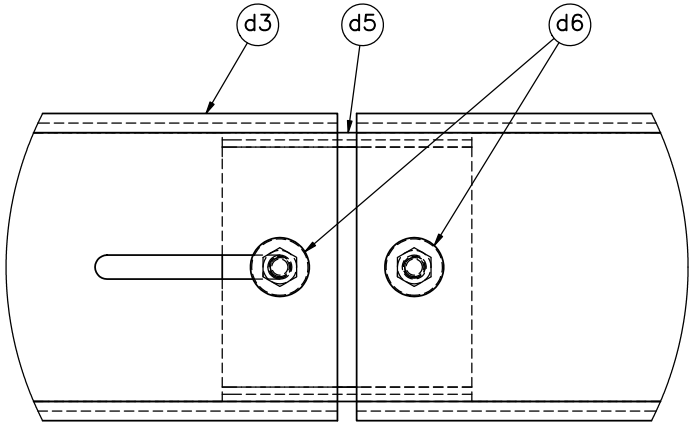


ELEVATION VIEW

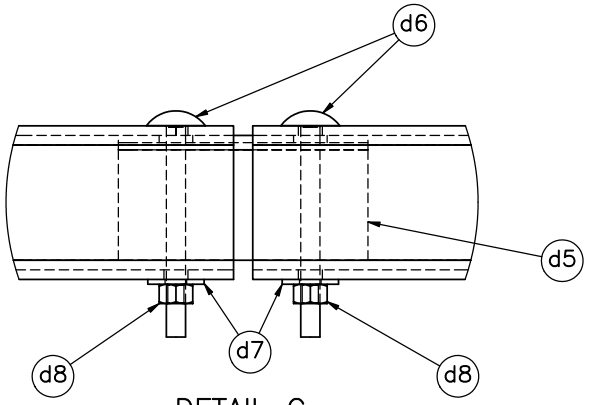
Midwest Roadside Safety Facility	SAFER For Highway – Angle Joint (SFH–3) Barrier Assembly	SHEET: 2 of 23 DATE: 10/16/2014 DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3 / SCALE: 1:50 UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



SECTION A–A



DETAIL B
SCALE 1 : 5



DETAIL C
SCALE 1 : 5

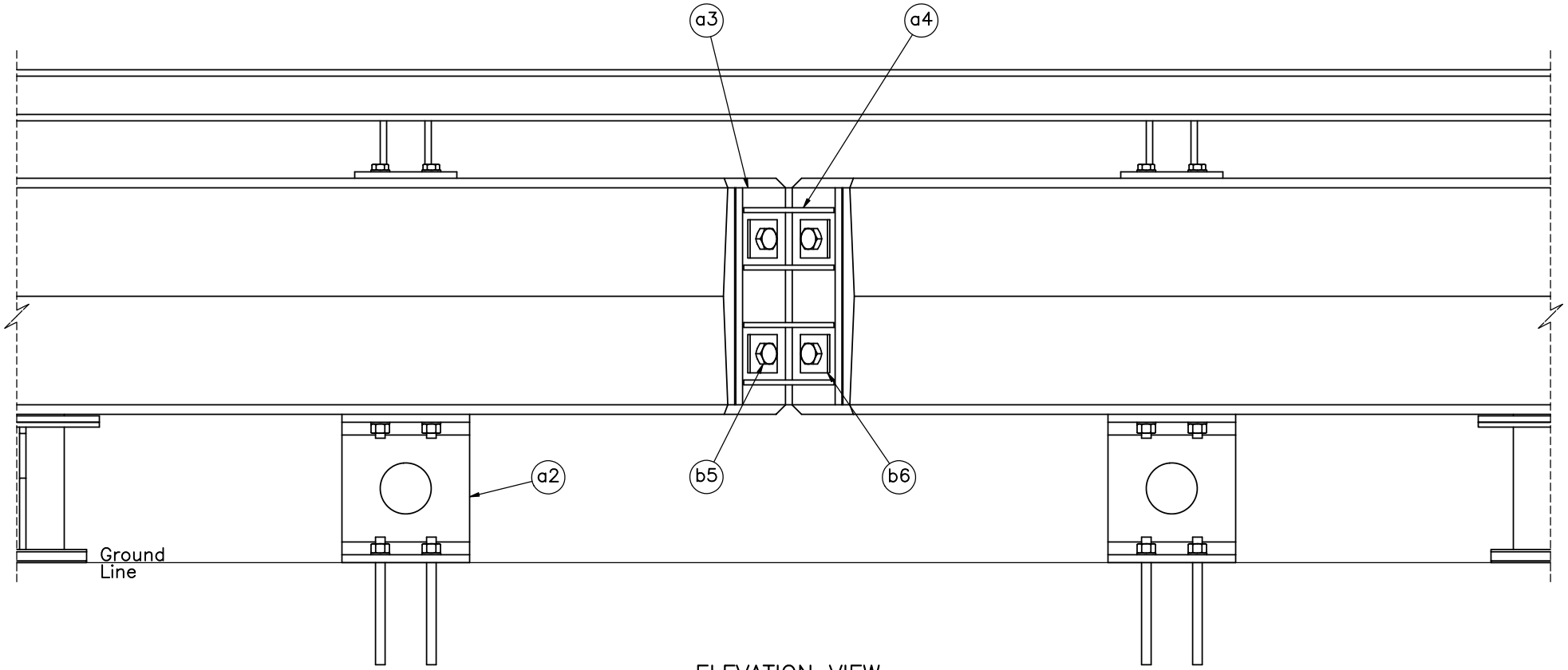
Notes: (1) Anchor part b2 into tarmac with HILTI HIT–RE500 epoxy.

Midwest Roadside Safety Facility

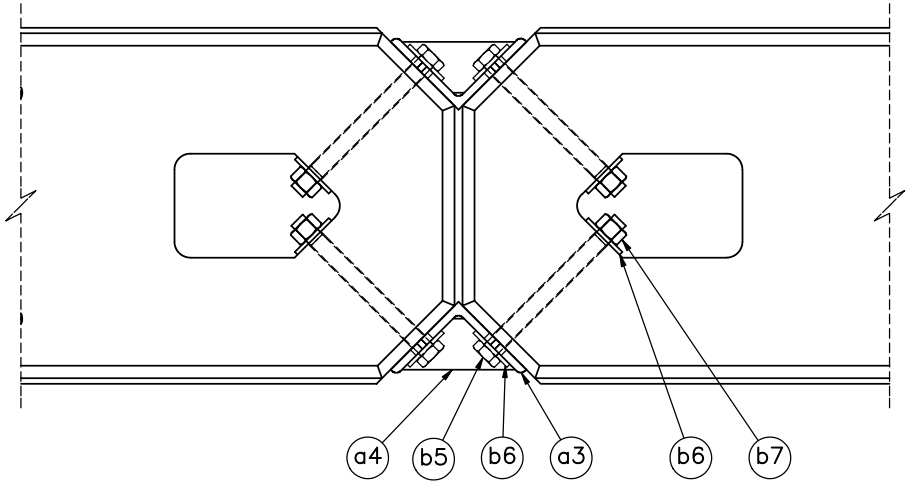
SAFER For Highway – Angle Joint (SFH–3)

Post and Tubing Details

SHEET: 3 of 23		
DATE: 10/16/2014		
DRAWN BY: JEK/SDB		
DWG. NAME. SFH–3_AJ_R3	SCALE: 1:8 UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



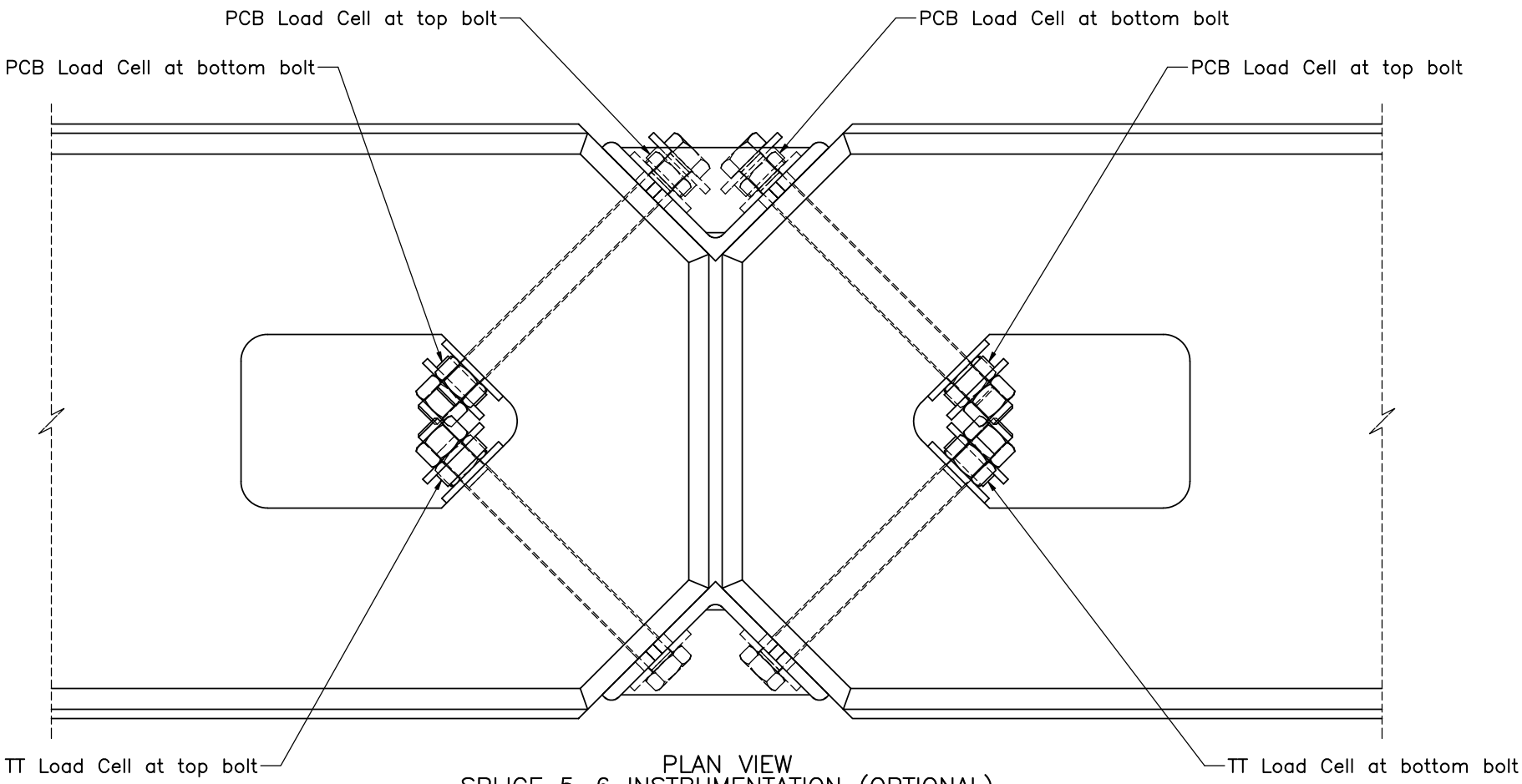
ELEVATION VIEW
SPLICE DETAIL



PLAN VIEW
SPLICE DETAIL

Notes: (1) Rebar, top steel tube assembly, and shear fenders removed from Plan View.

MwRSF	SAFER For Highway – Angle Joint (SFH–3)	SHEET: 4 of 23
		DATE: 10/16/2014
Midwest Roadside Safety Facility	Splice Details	DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3 / SCALE: 1:12 / UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



PLAN VIEW
SPLICE 5–6 INSTRUMENTATION (OPTIONAL)

Notes: (1) Rebar, top steel tube assembly, and shear fenders removed from Plan View.

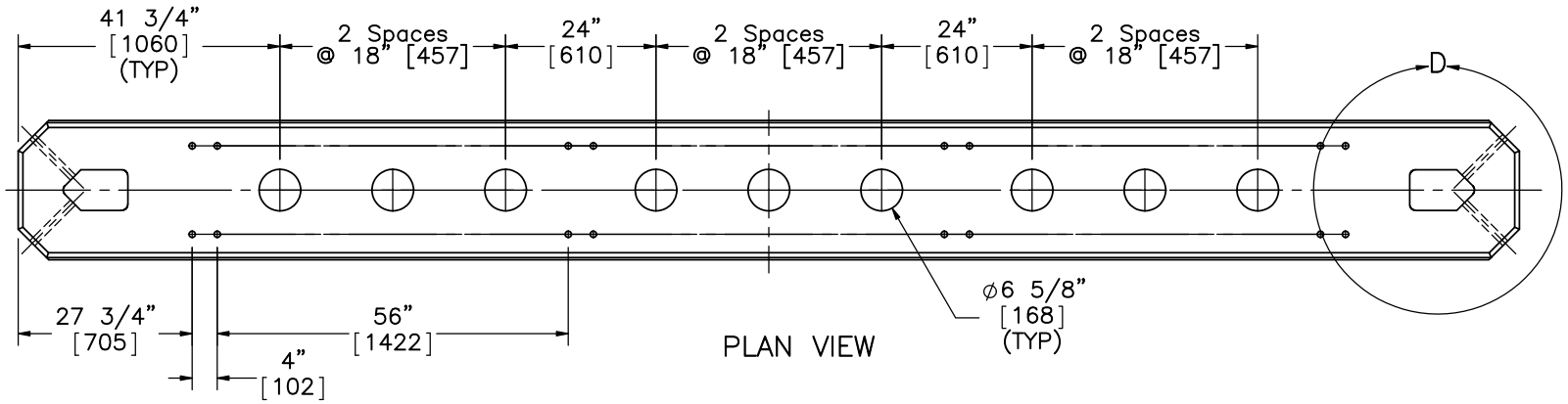
(2) PCB Piezotronics 206C (PCB)
2.00" O.D.
1.024" I.D.
0.500" thickness

(3) Transducer Technique LW0–80 (TT)
2.05" O.D.
1.025" I.D.
0.610" thickness

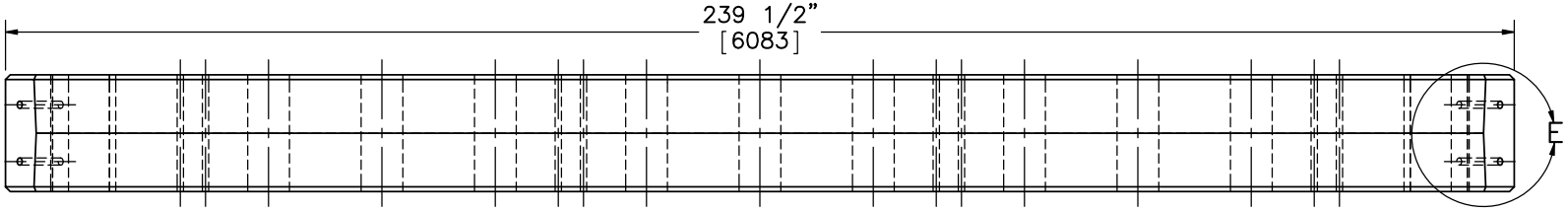
(4) Use additional 3"x3"x1/4" [76x76x6] plate washer if available to sandwich load cell.

(5) Anti–friction washer provided by PCB is optional.

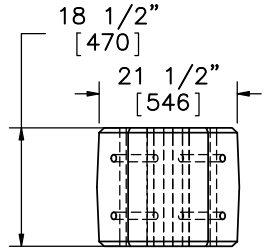
MwRSF	SAFER For Highway – Angle Joint (SFH–3)	SHEET: 5 of 23
		DATE: 10/16/2014
Midwest Roadside Safety Facility	Splice 5–6 Instrumentation Details	DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3 / SCALE: 1:6 / UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



PLAN VIEW



ELEVATION VIEW
Part a1



PROFILE VIEW

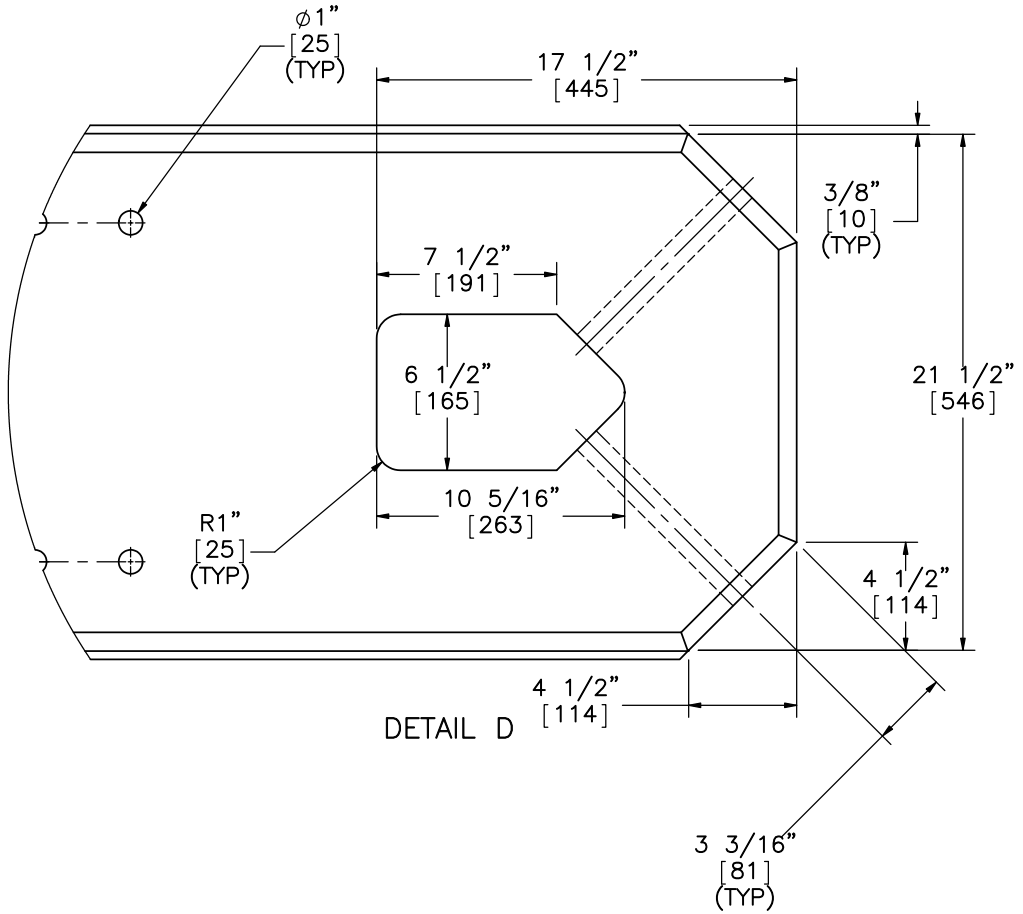
Notes: (1) The ϕ6 5/8" [168] through hole can be cast around a ϕ6" [152] PVC pipe and then the pipe can later be removed.

(2) The 3 surfaces at each end of the barrier must be vertical – front and back of rail drafted for casting purposes.

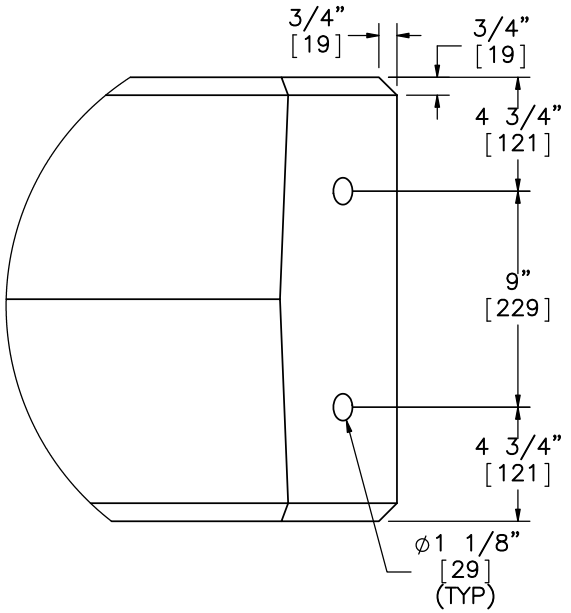
(3) Internal Reinforcement not shown.

(4) See as–built drawings from concrete industries for accurate rebar placement and more details.

MwRSF	SAFER For Highway – Angle Joint (SFH–3)	SHEET: 6 of 23
		DATE: 10/16/2014
Midwest Roadside Safety Facility	Concrete Rail Geometry	DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3 / SCALE: 1:30 / UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



DETAIL D



DETAIL E

Notes:

(1) ø1" [25] and ø1 1/8" [29] through holes can be cast with or without an insert left in the beam.

(2) The "house–shaped" through hole can be case around an insert and then the insert can be removed; the radii can be varied if needed.

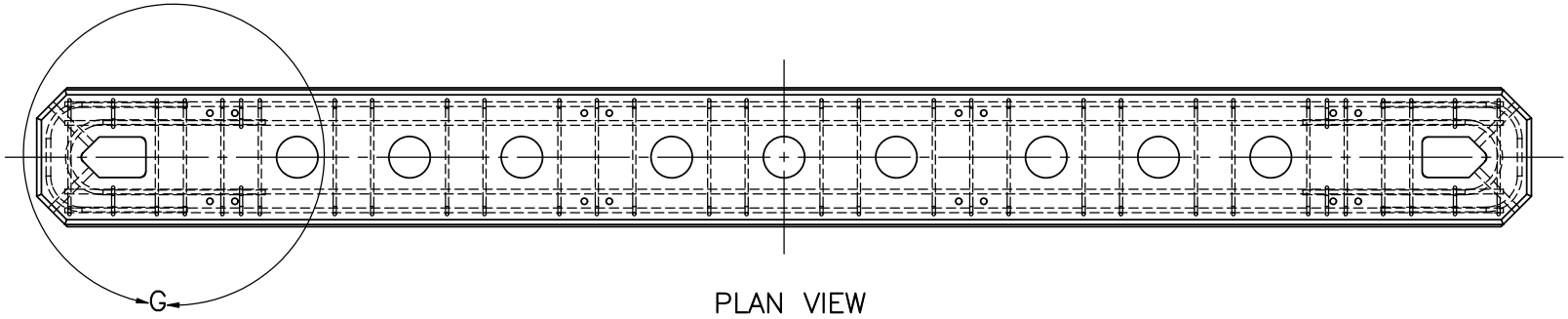
(3) The 3 surfaces at each end of the barrier must be vertical – front and back of rail drafted for casting purposes.

(4) ø1 1/8" [29] holes to be centered on 4 1/2"x4 1/2" [114x114] chamfer.

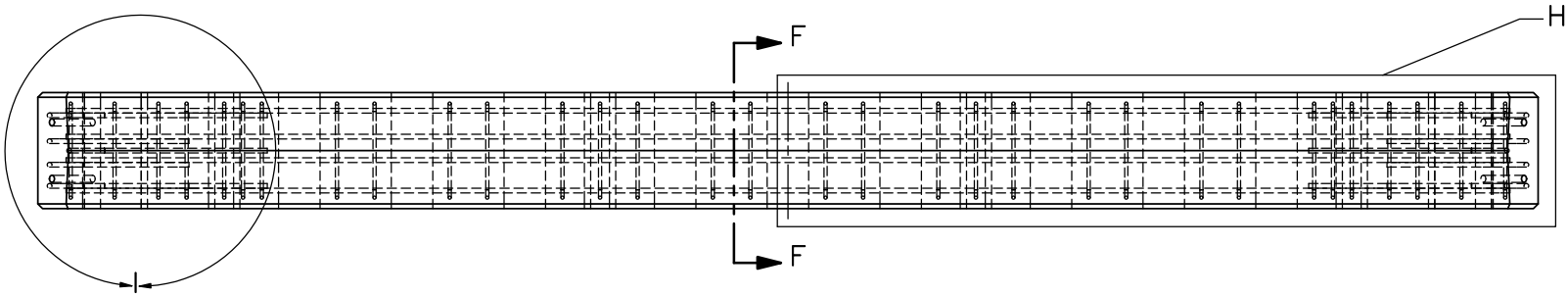
(5) Internal reinforcement not shown.

(6) See as–built drawings from concrete industries for accurate rebar placement and more details.

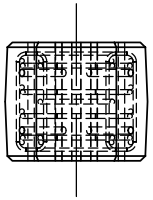
MwRSF	SAFER For Highway – Angle Joint (SFH–3)		SHEET: 7 of 23
			DATE: 10/16/2014
Midwest Roadside Safety Facility	Concrete Rail Details		DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3	SCALE: 1:8 UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



PLAN VIEW



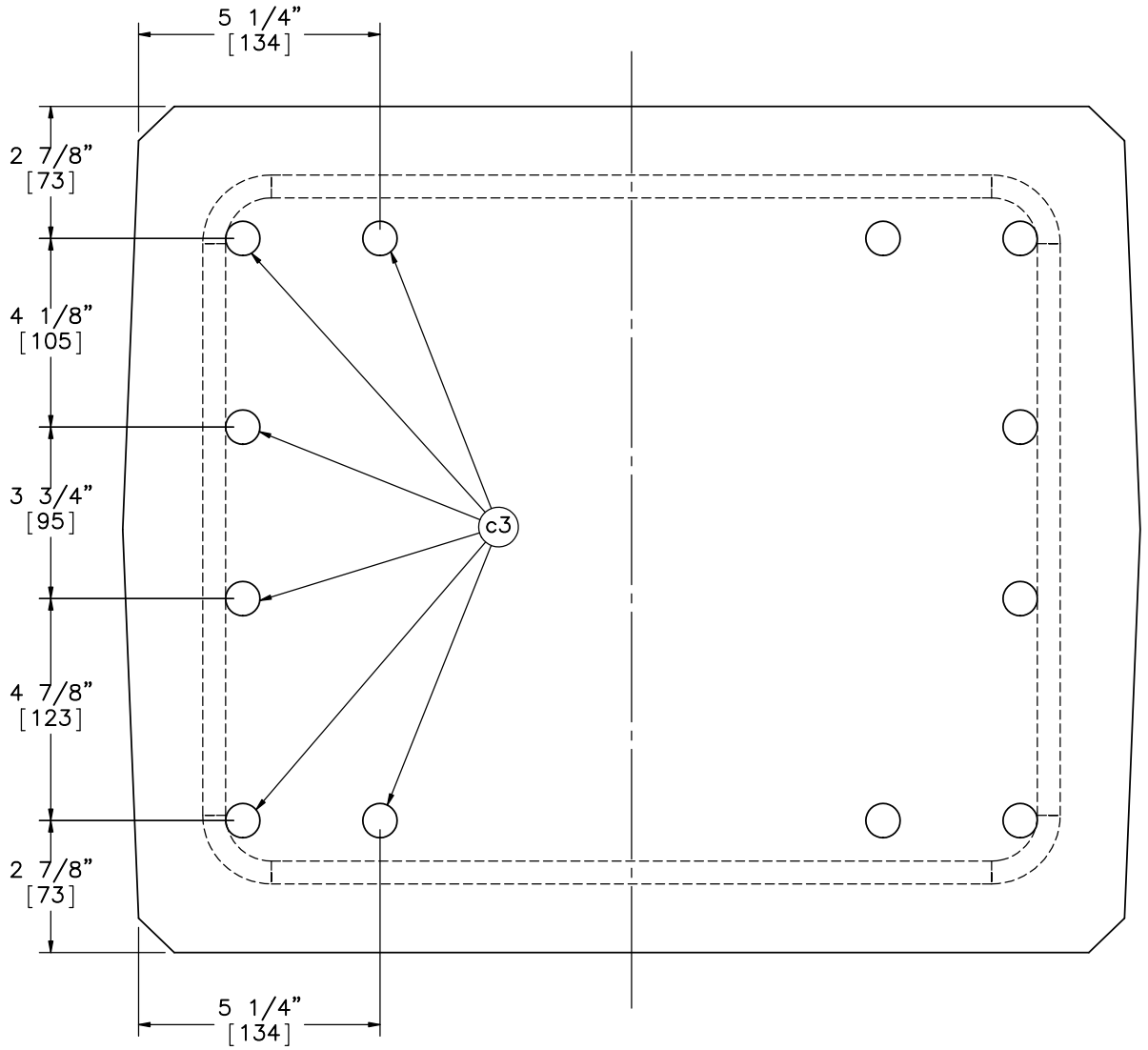
ELEVATION VIEW



PROFILE VIEW

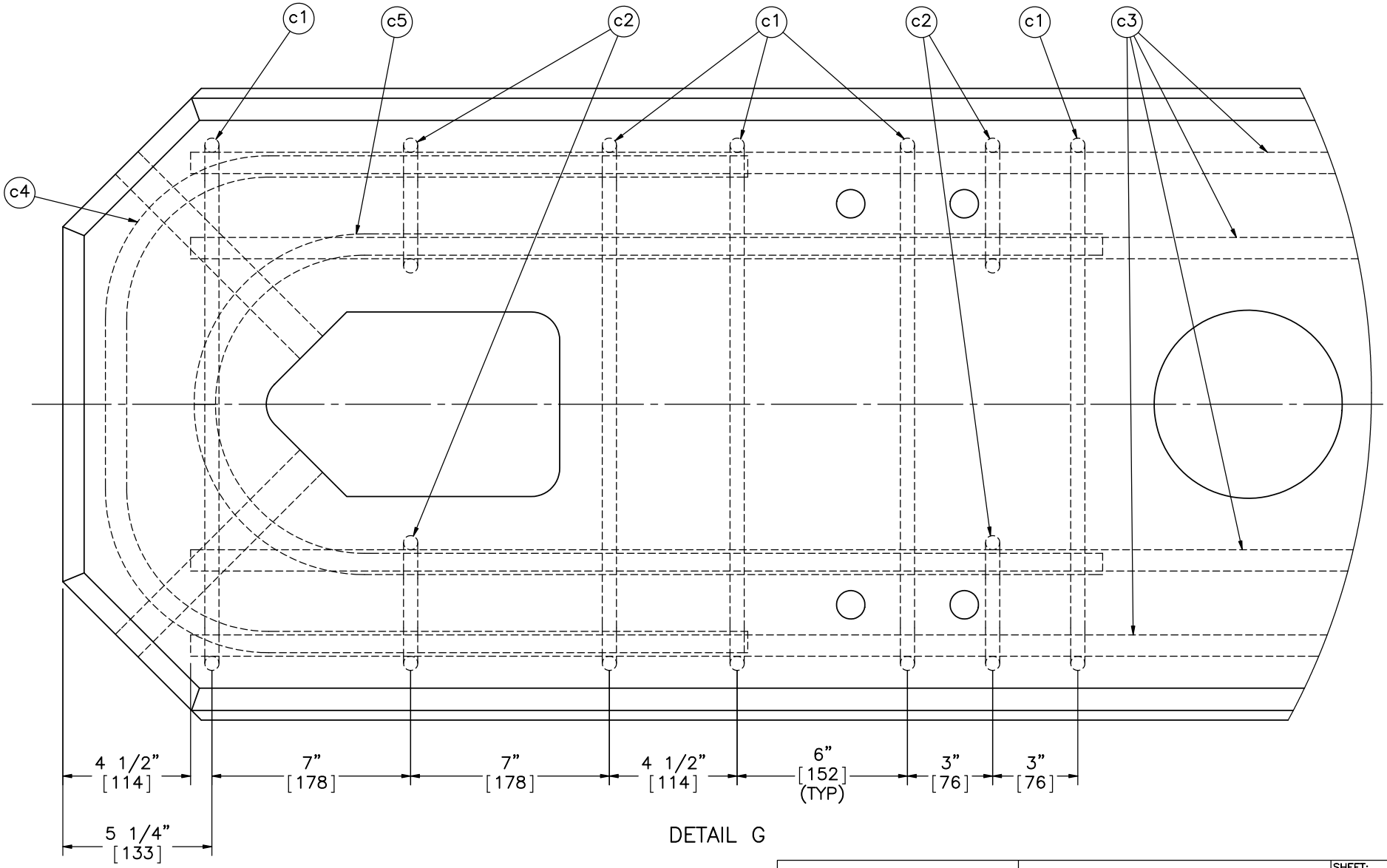
Notes: (1) Two single flared coil loop inserts (not shown) were added to each barrier segment.

Midwest Roadside Safety Facility	SAFER For Highway – Angle Joint (SFH–3) Concrete Rail and Rebar Assembly	SHEET: 8 of 23 DATE: 10/16/2014 DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3 / SCALE: 1:30 / UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



SECTION F–F

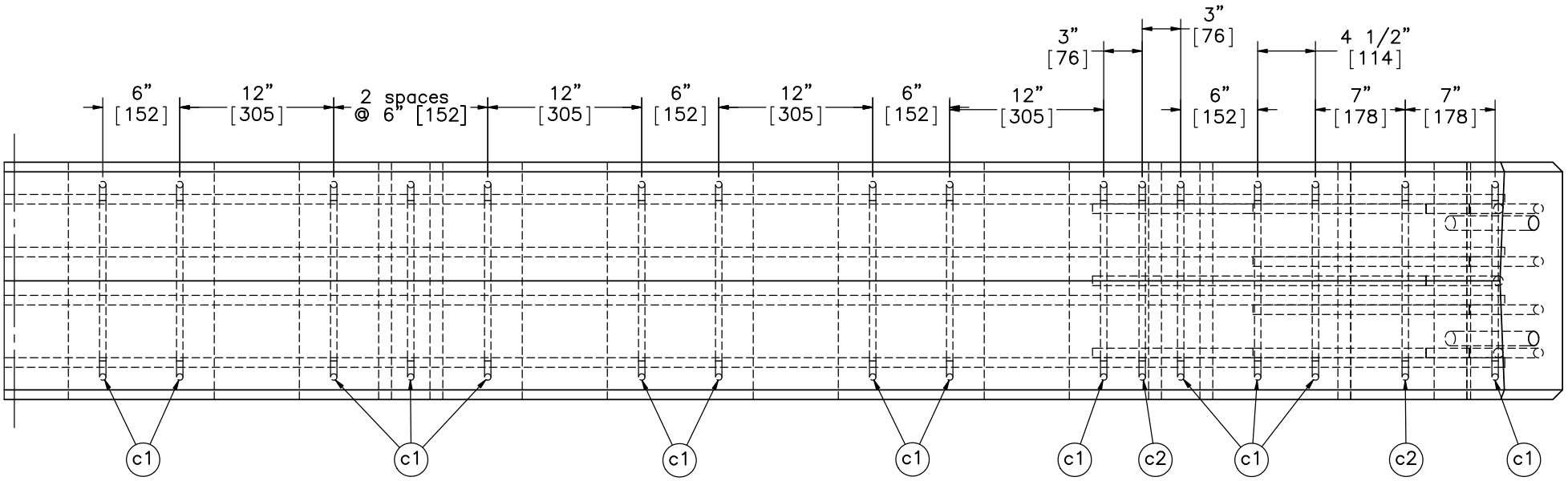
Midwest Roadside Safety Facility	SAFER For Highway – Angle Joint (SFH–3) Concrete Rail – Rebar Assembly Details	SHEET: 9 of 23 DATE: 10/16/2014 DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3 / SCALE: 1:4 / UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



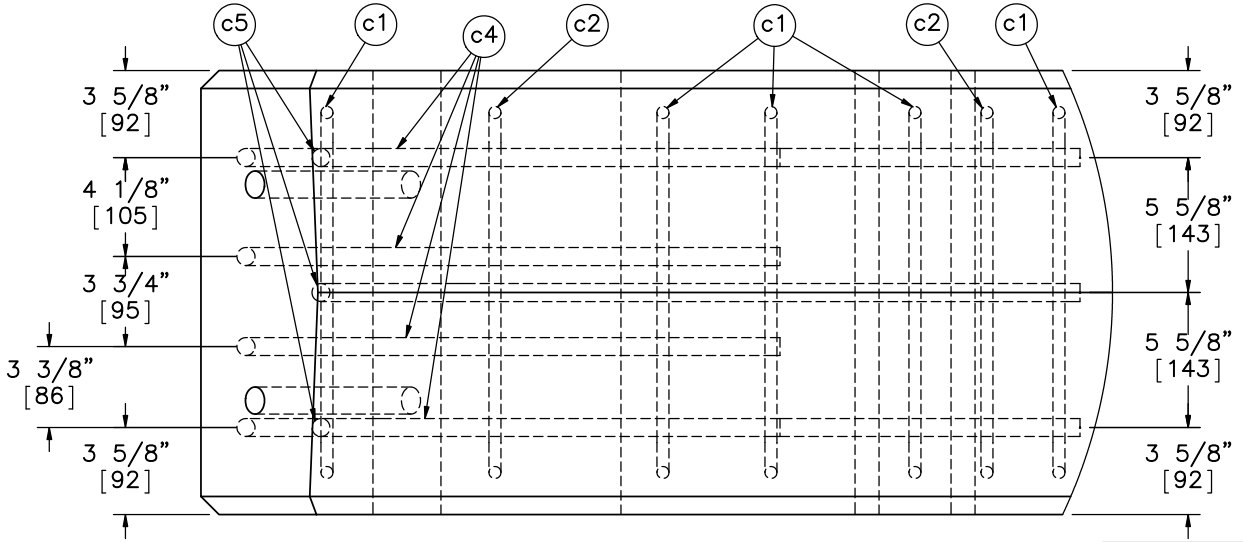
DETAIL G

Notes: (1) 1 1/2" [38] clear cover for all stirrups and c4 bars at ends.

Midwest Roadside Safety Facility	SAFER For Highway – Angle Joint (SFH–3) Concrete Rail – Rebar Assembly Details	SHEET: 10 of 23 DATE: 10/16/2014 DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3 SCALE: 1:5 UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



DETAIL H



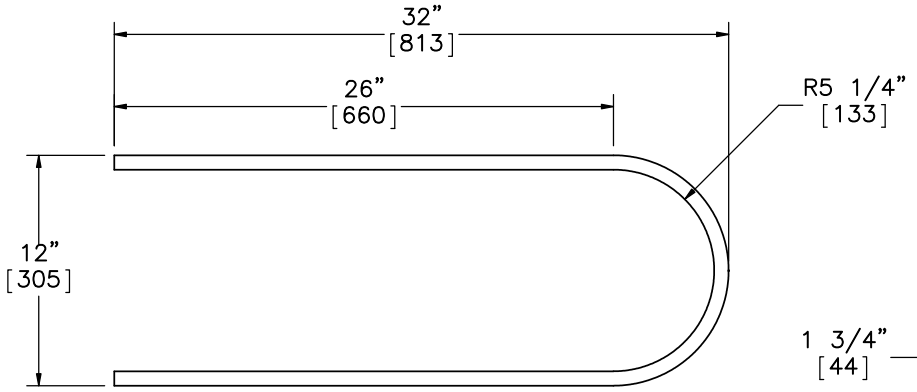
DETAIL I
SCALE 1 : 8

Notes: (1) Longitudinal Rebar, Part c3 removed from Detail I for clarity.

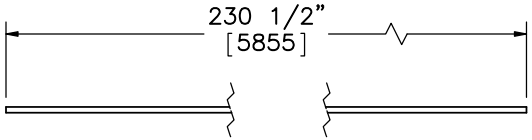
(2) Place top and bottom c4 and c5 bars adjacent to longitudinal c3 bars.

MwRSF	SAFER For Highway – Angle Joint (SFH–3)	SHEET: 11 of 23
		DATE: 10/16/2014
Midwest Roadside Safety Facility	Concrete Rail – Rebar Assembly Details	DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3 / SCALE: 1:12 / UNITS: in.[mm]	REV. BY: JDS/SKR/KAL

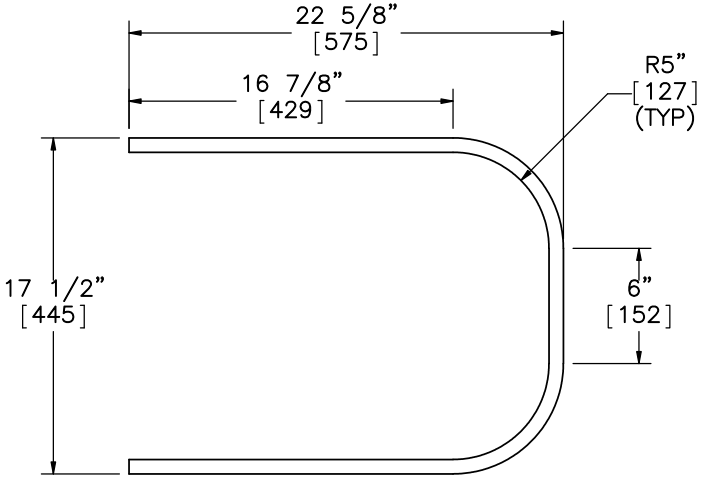
Bill of Bars			
Item No.	QTY.	Description	Material Specification
c1	28	1/2" [13] Dia., 77" [1956] Long Bent Rebar	A615 Grade 60
c2	8	1/2" [13] Dia., 49" [1245] Long Bent Rebar	A615 Grade 60
c3	12	3/4" [19] Dia., 231" [5867] Long Rebar	A615 Grade 60
c4	8	3/4" [19] Dia., 63" [1600] Long Bent Rebar	A615 Grade 60
c5	6	3/4" [19] Dia., 69" [1753] Long Bent Rebar	A615 Grade 60



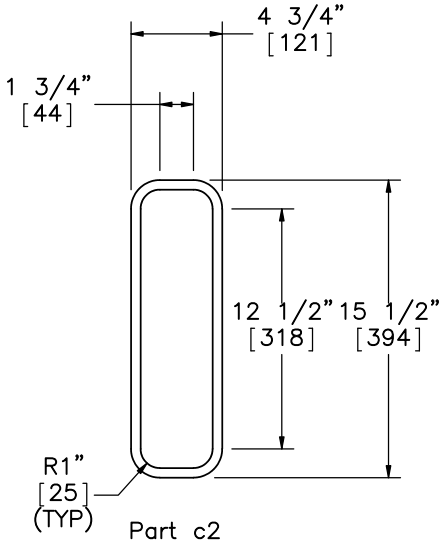
Part c5



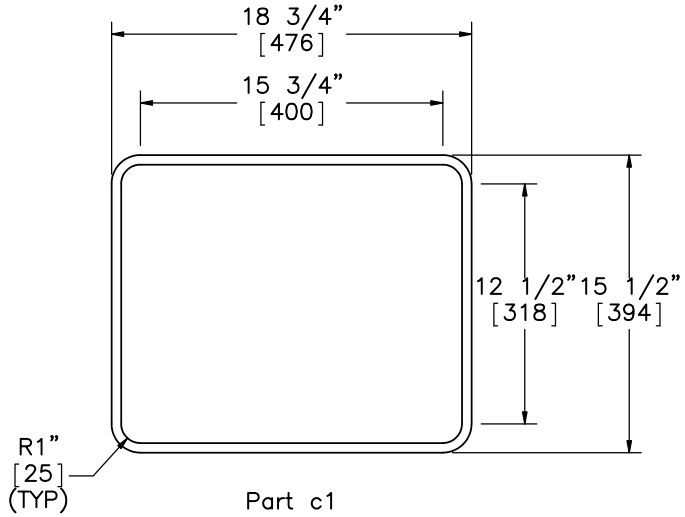
Part c3



Part c4



Part c2



Part c1

Midwest Roadside Safety Facility

SAFER For Highway – Angle Joint (SFH–3)

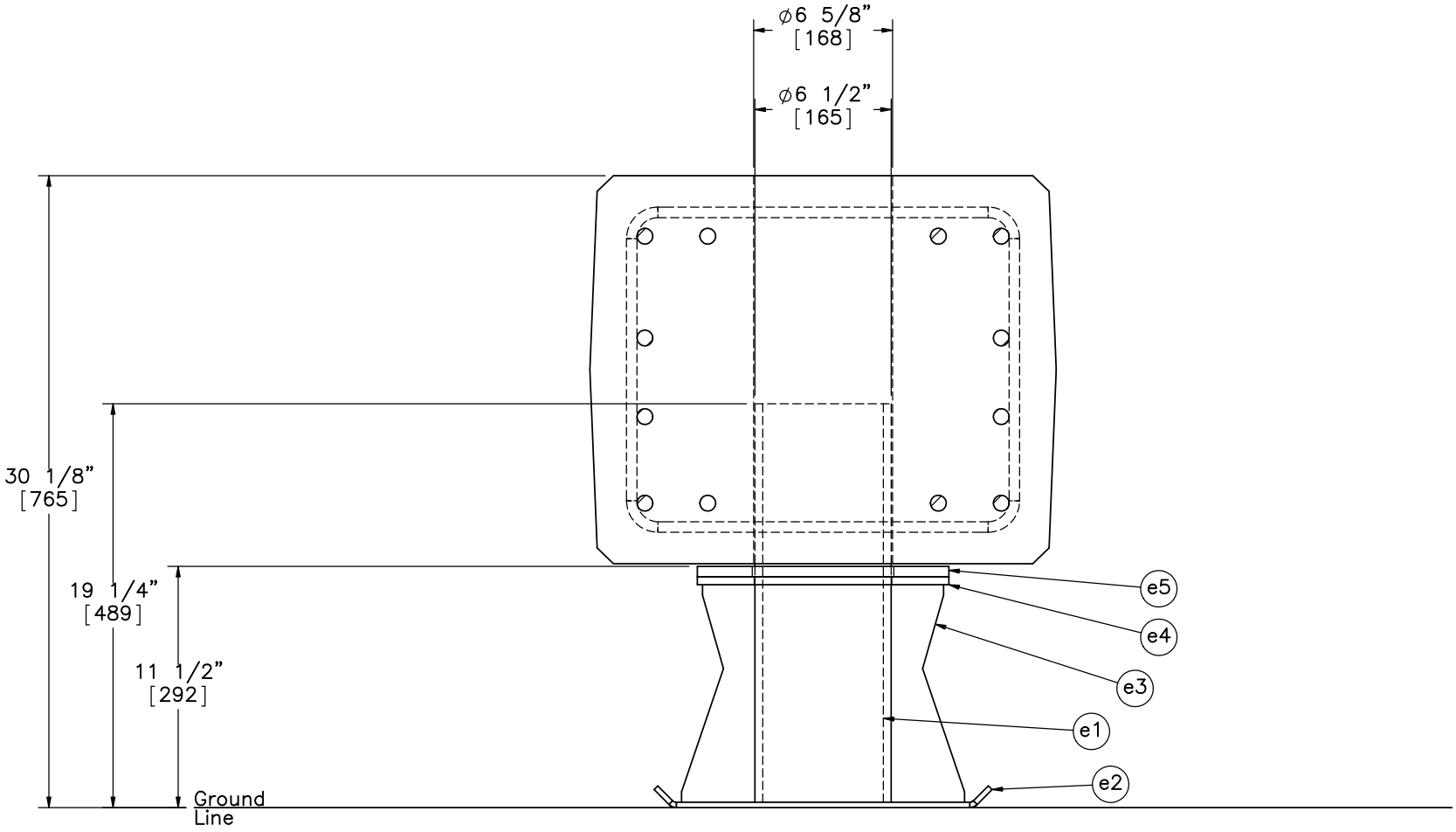
Bill of Bars

DWG. NAME. SFH–3_AJ_R3	SCALE: 1:10 UNITS: in.[mm]	REV. BY: JDS/SKR/KAL

SHEET: 12 of 23

DATE: 10/16/2014

DRAWN BY: JEK/SDB

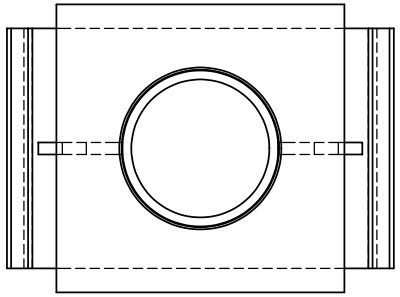


SECTION N–N

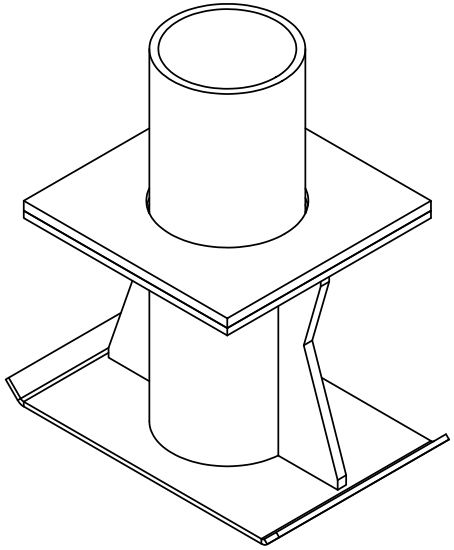
Note: (1) Steel Rail not shown for clarity.

(2) Part e5 can compress as needed due to weight of rail.

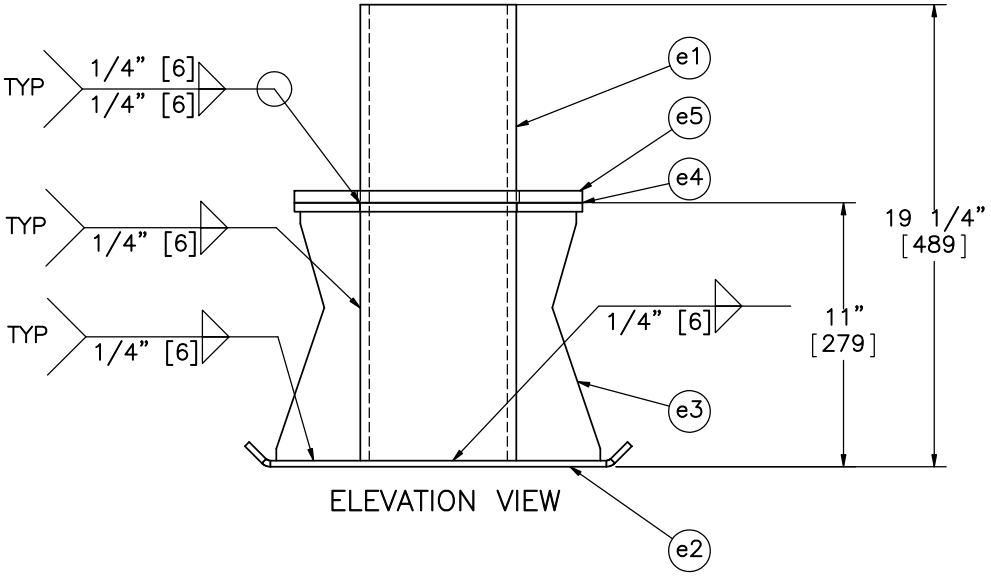
Midwest Roadside Safety Facility	SAFER For Highway – Angle Joint (SFH–3)		SHEET: 13 of 23
			DATE: 10/16/2014
	Skid Details		DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3	SCALE: 1:8 UNITS: in.[mm]	REV. BY: JDS/SKR/ KAL



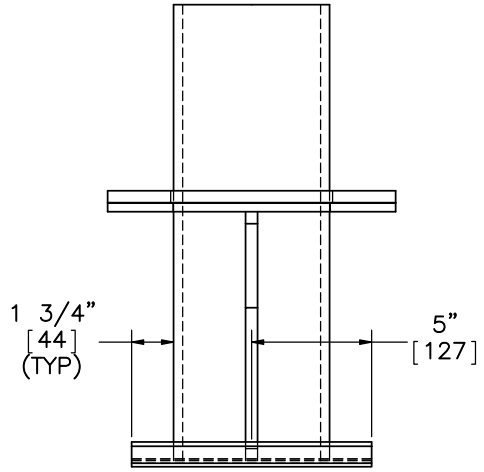
PLAN VIEW



ISOMETRIC VIEW

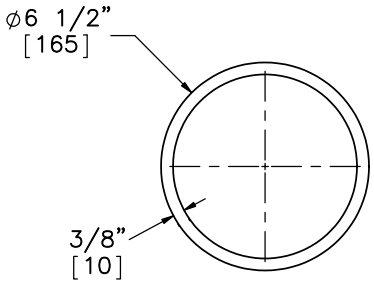


ELEVATION VIEW

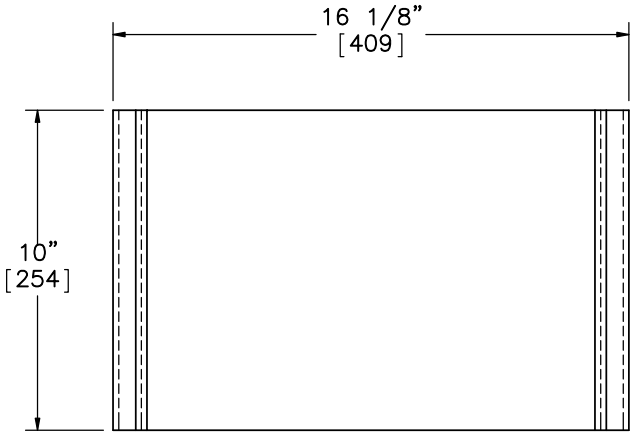


PROFILE VIEW

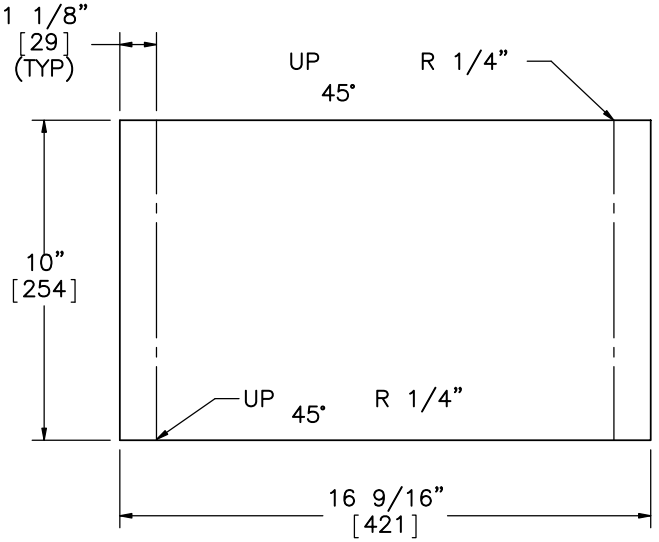
MwRSF	SAFER For Highway – Angle Joint (SFH–3)	SHEET: 14 of 23
		DATE: 10/16/2014
	Skid Assembly Details	DRAWN BY: JEK/SDB
Midwest Roadside Safety Facility	DWG. NAME. SFH–3_AJ_R3 / SCALE: 1:8 / UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



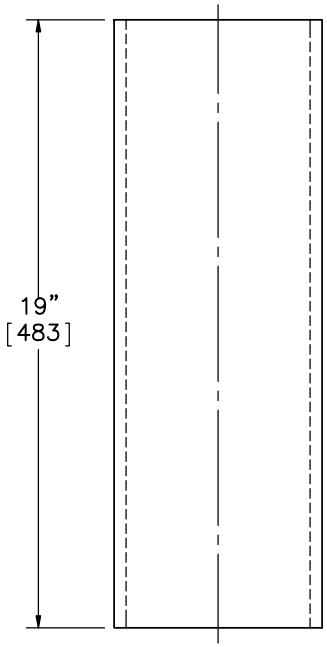
PLAN VIEW



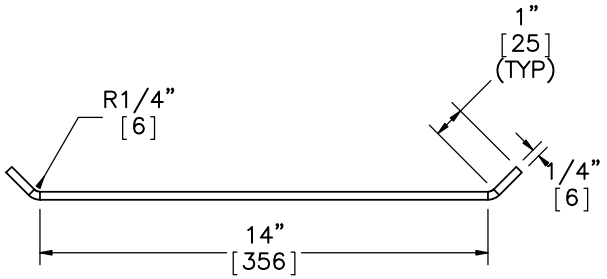
PLAN VIEW



FLAT PATTERN
Part e2



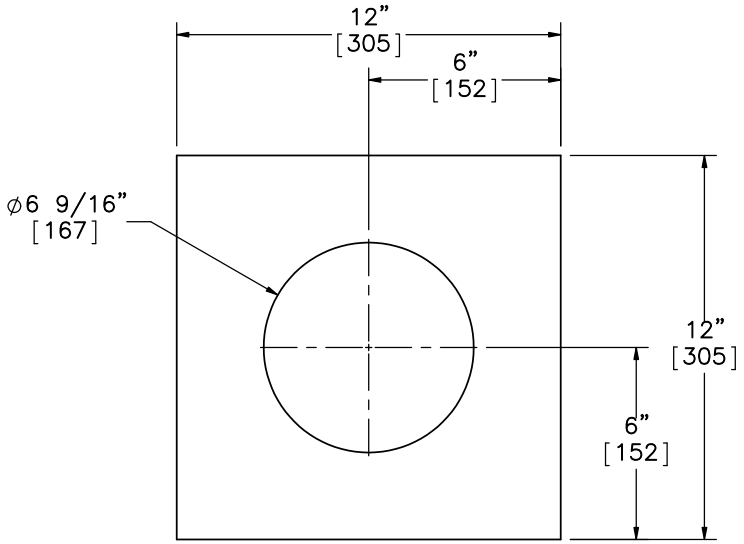
ELEVATION VIEW
Part e1



ELEVATION VIEW
Part e2

Notes: (1) Material for Part a1 can be DOM 6 1/2"x3/8", DOM 6 1/2"x1/2", or HFS 6 1/2"x1/2" or equivalent.

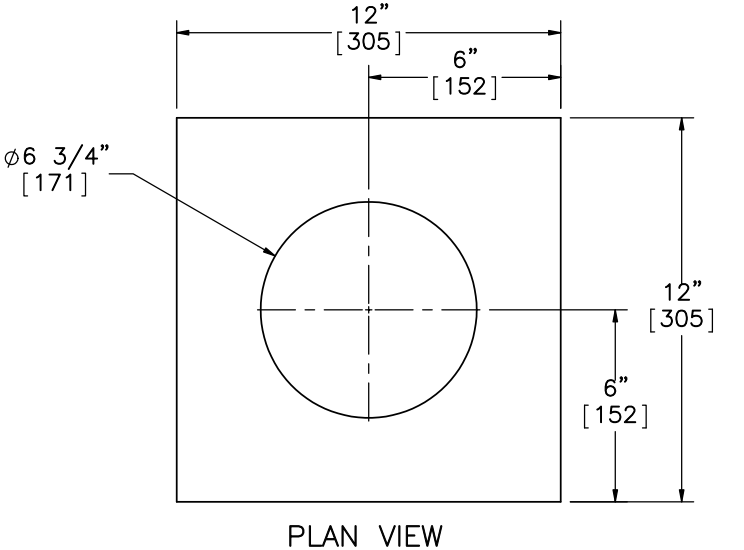
MwRSF	SAFER For Highway – Angle Joint (SFH–3)	SHEET: 15 of 23
		DATE: 10/16/2014
Midwest Roadside Safety Facility	Skid Component Details	DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3 / SCALE: 1:6 / UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



PLAN VIEW

PROFILE VIEW

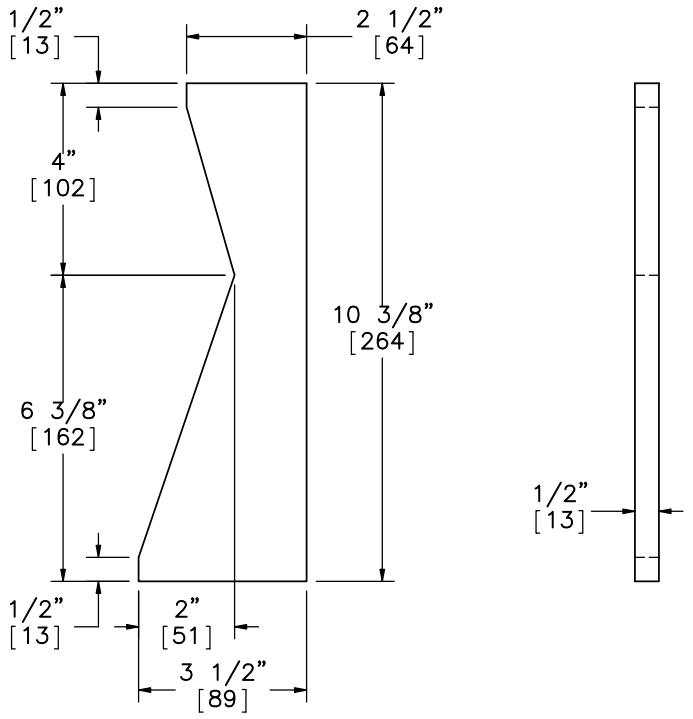
Part e4



PLAN VIEW

PROFILE VIEW

Part e5

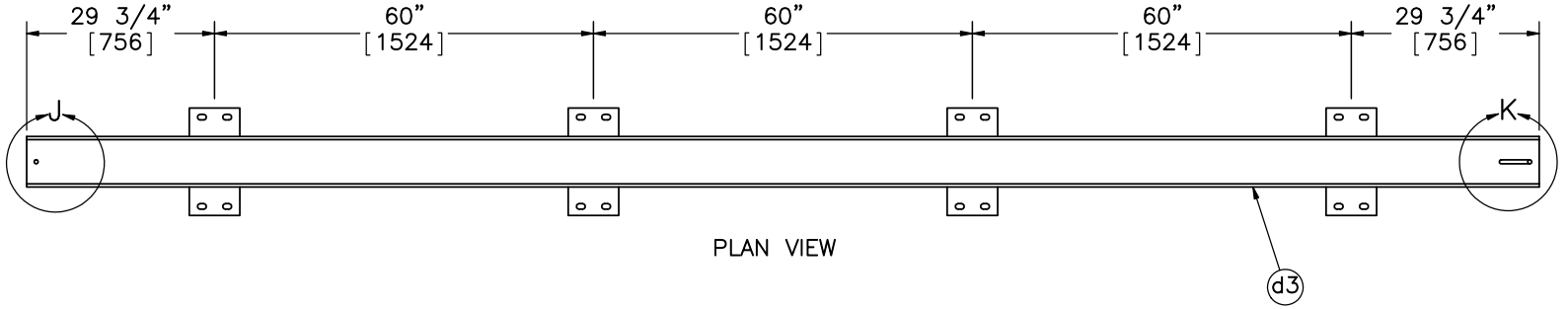


ELEVATION VIEW

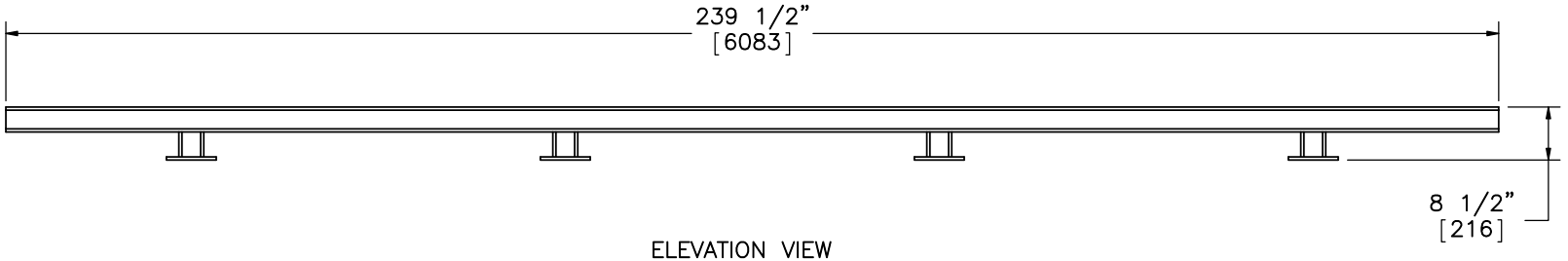
PROFILE VIEW

Part e3
SCALE 1:4

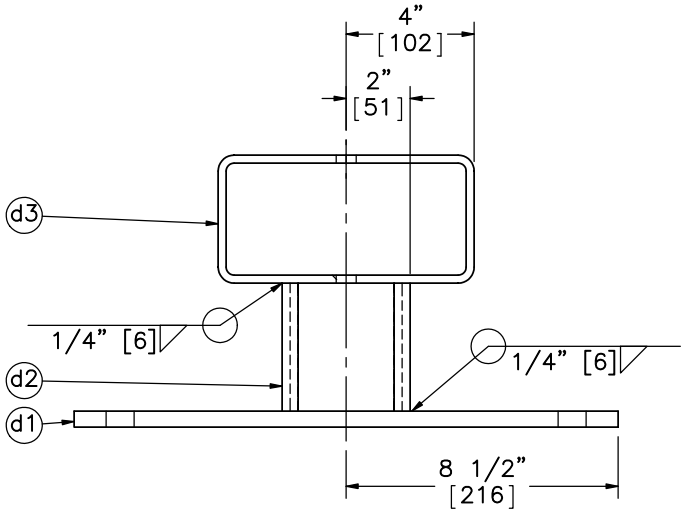
Midwest Roadside Safety Facility	SAFER For Highway – Angle Joint (SFH–3)		SHEET: 16 of 23
	Skid Top Plate Detail		DATE: 10/16/2014
			DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3	SCALE: 1:6 UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



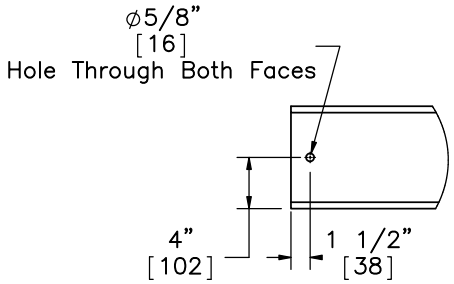
PLAN VIEW



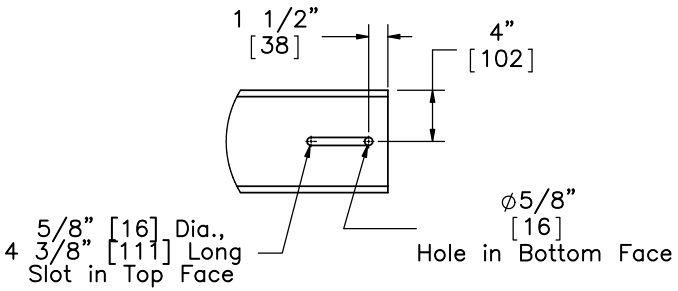
ELEVATION VIEW



PROFILE VIEW
SCALE 1:6



DETAIL J
SCALE 1 : 15



DETAIL K
SCALE 1 : 15

NOTE: (1) Dimensions are symmetric across the center line.
(2) Slot dimensions are measured to far exterior points.

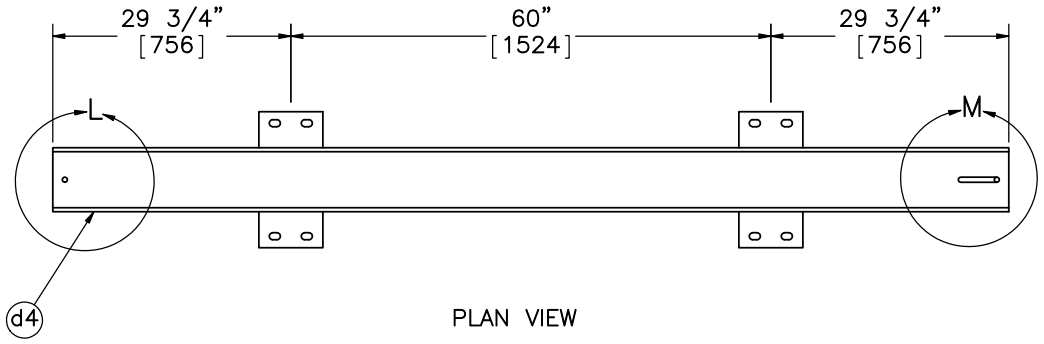
Midwest Roadside Safety Facility

SAFER For Highway – Angle Joint (SFH–3)

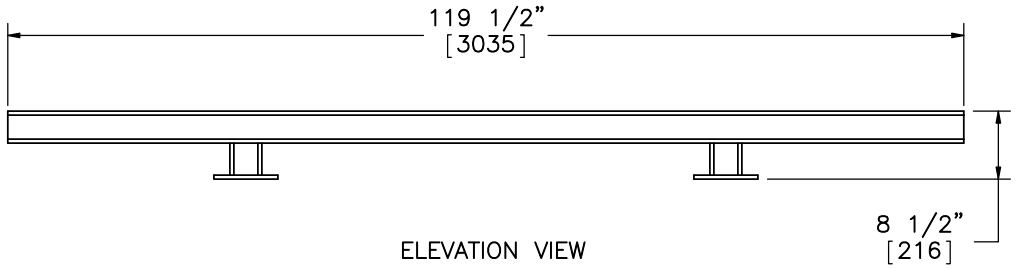
Steel Rail Assembly

DWG. NAME. SFH–3_AJ_R3	SCALE: 1:30 UNITS: in.[mm]	REV. BY: JDS/SKR/KAL

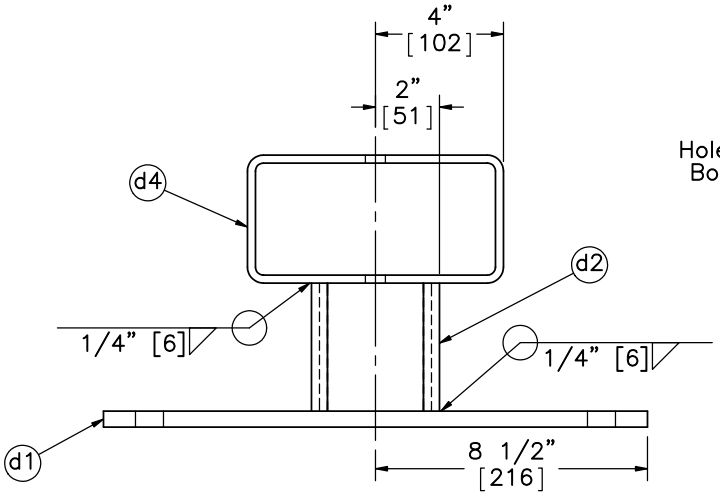
SHEET: 17 of 23
DATE: 10/16/2014
DRAWN BY: JEK/SDB



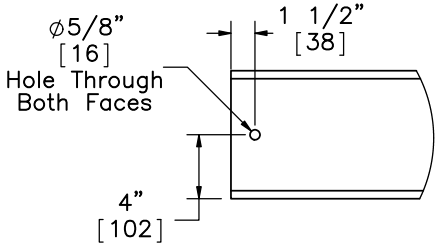
PLAN VIEW



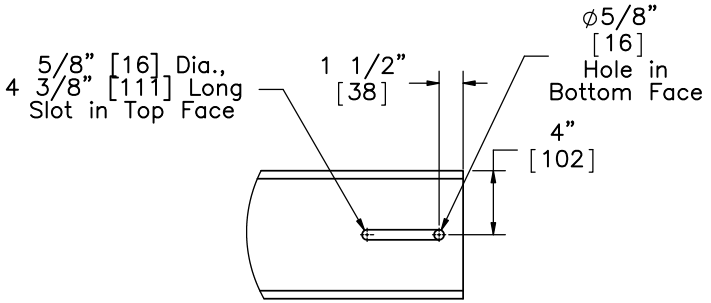
ELEVATION VIEW



PROFILE VIEW
SCALE 1:6



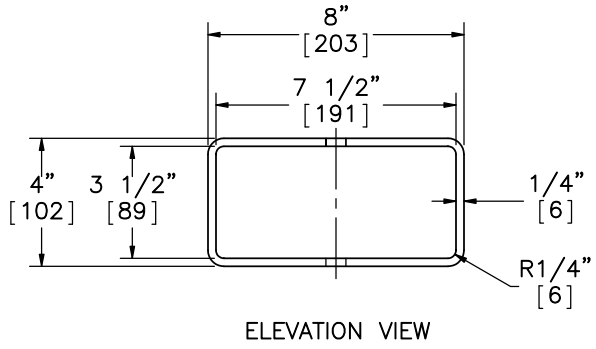
DETAIL L
SCALE 1 : 12



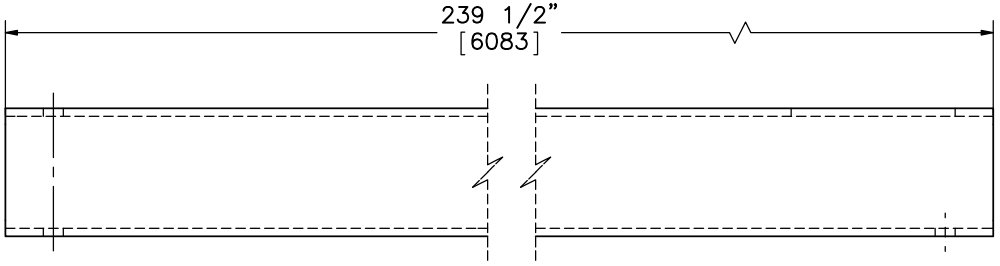
DETAIL M
SCALE 1 : 12

NOTE: (1) Dimensions are symmetric across the center line.
(2) Slot dimensions are measured to far exterior points.

Midwest Roadside Safety Facility	SAFER For Highway – Angle Joint (SFH–3) Steel End Tubing Assembly	SHEET: 18 of 23 DATE: 10/16/2014 DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3 / SCALE: 1:24 / UNITS: in.[mm]	REV. BY: JDS/SKR/KAL

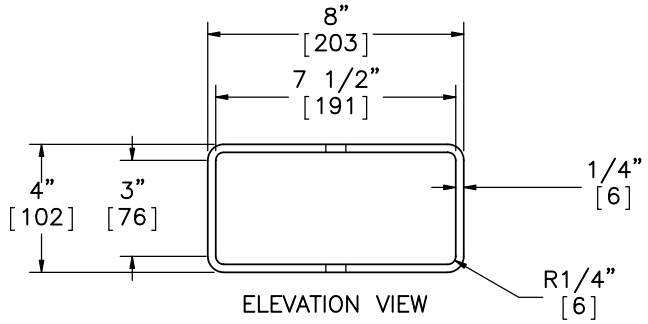


ELEVATION VIEW

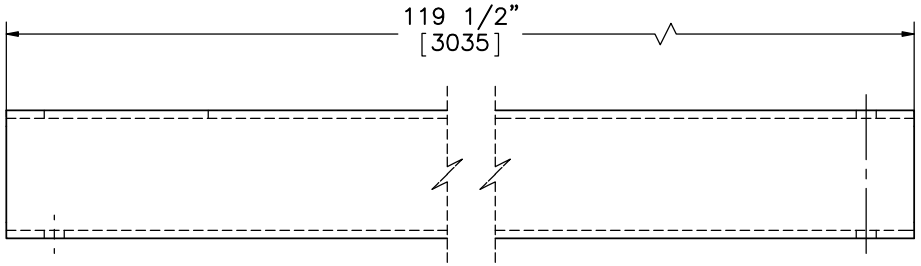


PROFILE VIEW

Part d3

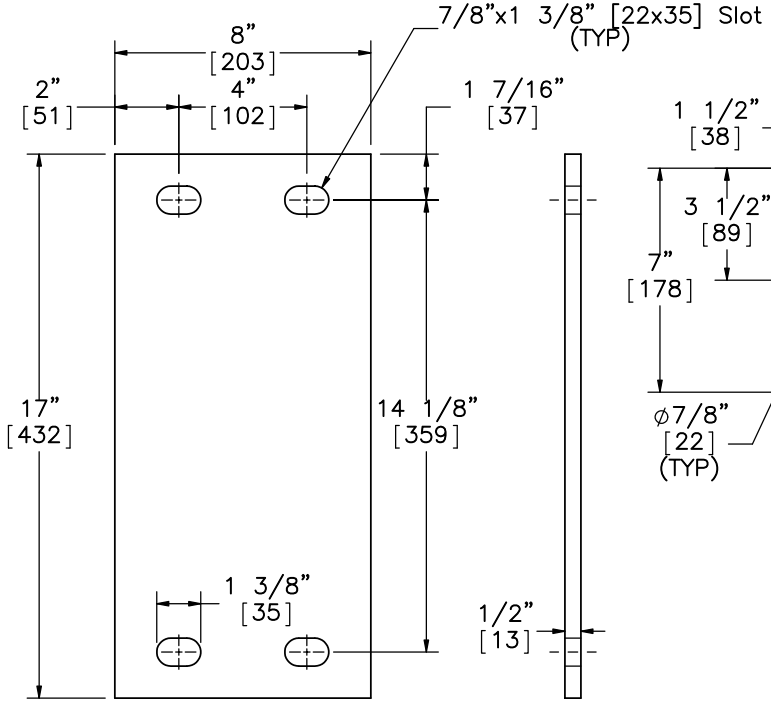


ELEVATION VIEW



PROFILE VIEW

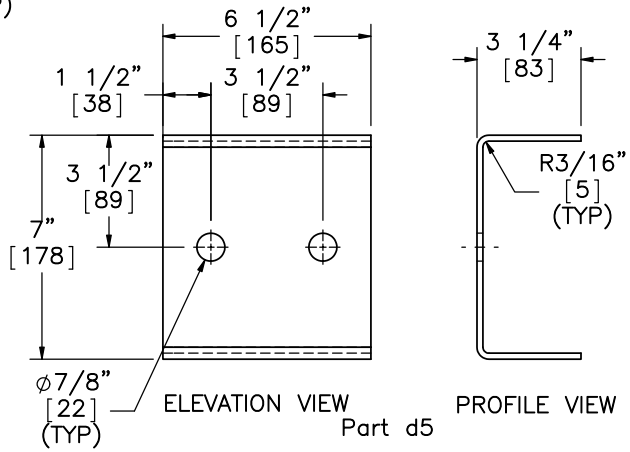
Parts d4



ELEVATION VIEW

PROFILE VIEW

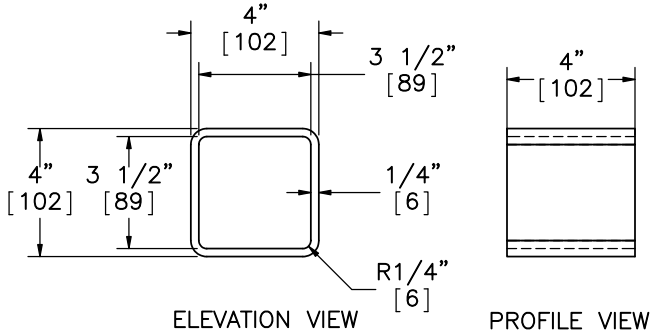
Part d1



ELEVATION VIEW

Part d5

PROFILE VIEW



ELEVATION VIEW

PROFILE VIEW

Part d2

Midwest Roadside Safety Facility

SAFER For Highway – Angle Joint (SFH–3)

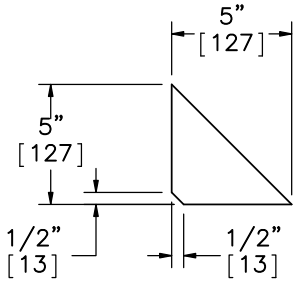
Steel Rail Components

DWG. NAME. SFH–3_AJ_R3	SCALE: 1:6 UNITS: in.[mm]	REV. BY: JDS/SKR/KAL

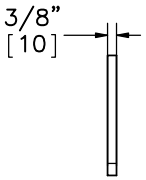
SHEET: 19 of 23

DATE: 10/16/2014

DRAWN BY: JEK/SDB

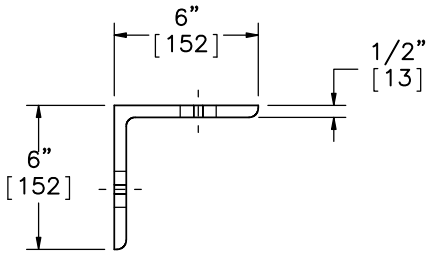


ELEVATION VIEW

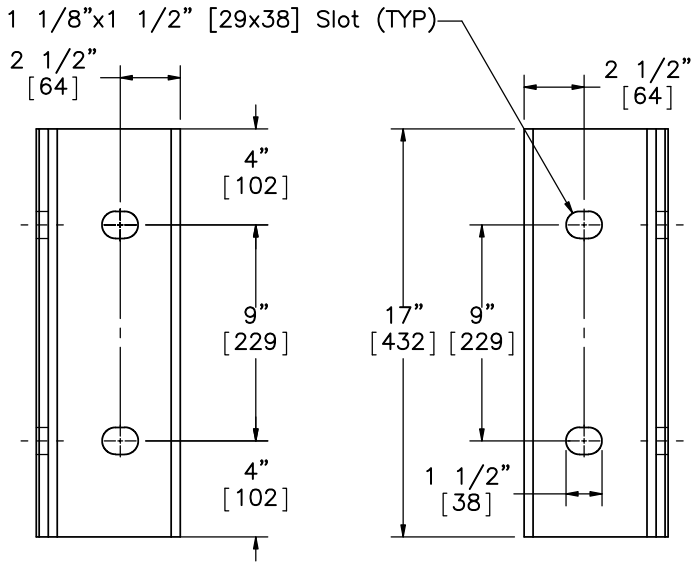


PROFILE VIEW

Part a4

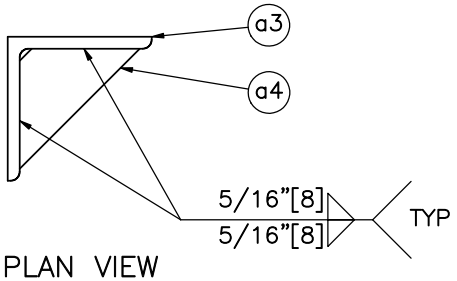


PLAN VIEW

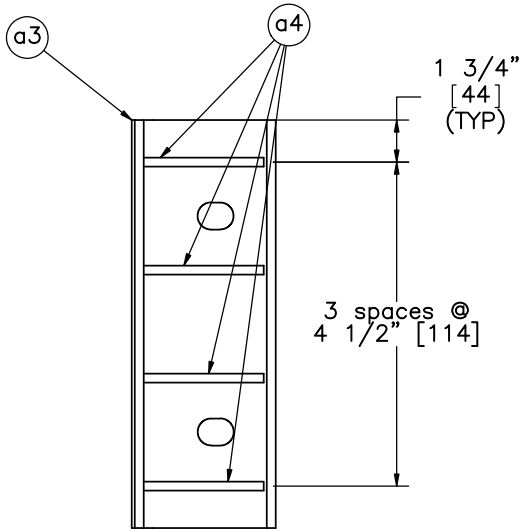


ELEVATION VIEW PROFILE VIEW

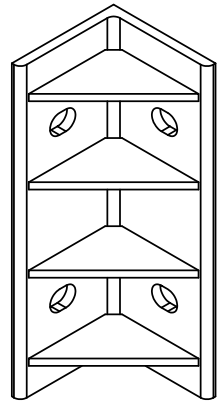
Part a3



PLAN VIEW



ELEVATION VIEW

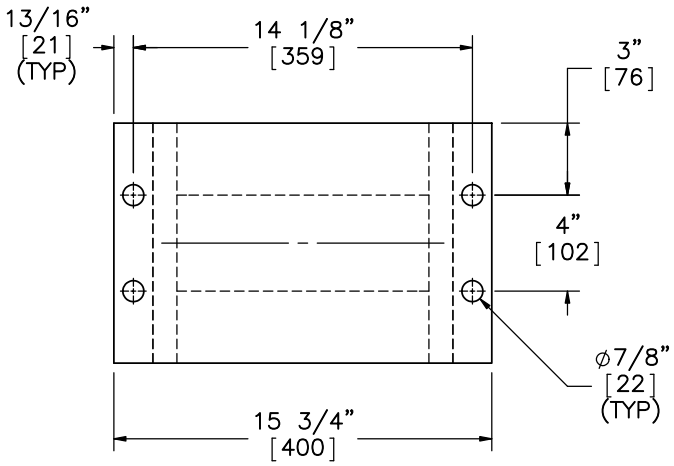


ISOMETRIC VIEW

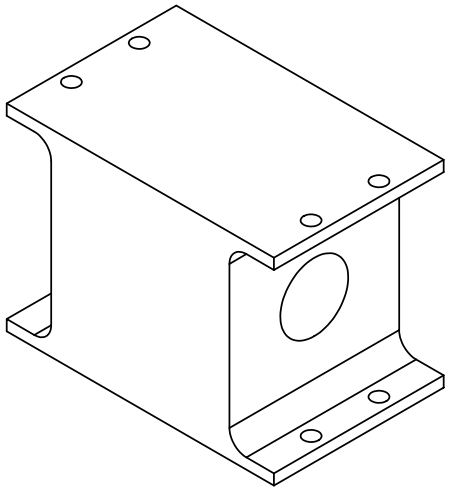
Notes: (1) Slot dimensions measured from exterior points.

(2) Dimensions shown are to center of slot.

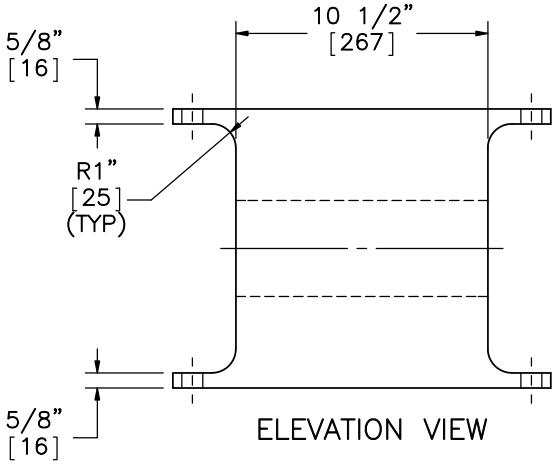
Midwest Roadside Safety Facility	SAFER For Highway – Angle Joint (SFH–3)	SHEET: 20 of 23
		DATE: 10/16/2014
	Angle Joint Details	DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3 / SCALE: 1:8 / UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



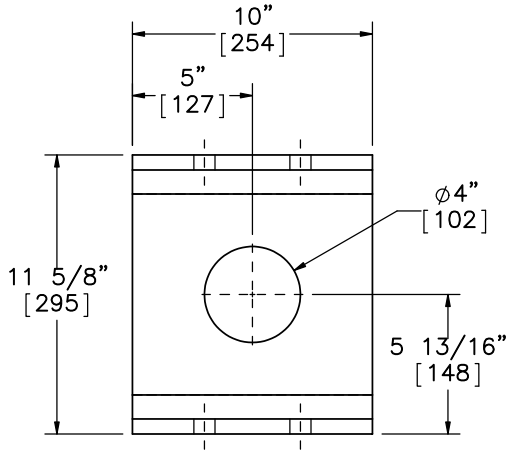
PLAN VIEW



ISOMETRIC VIEW



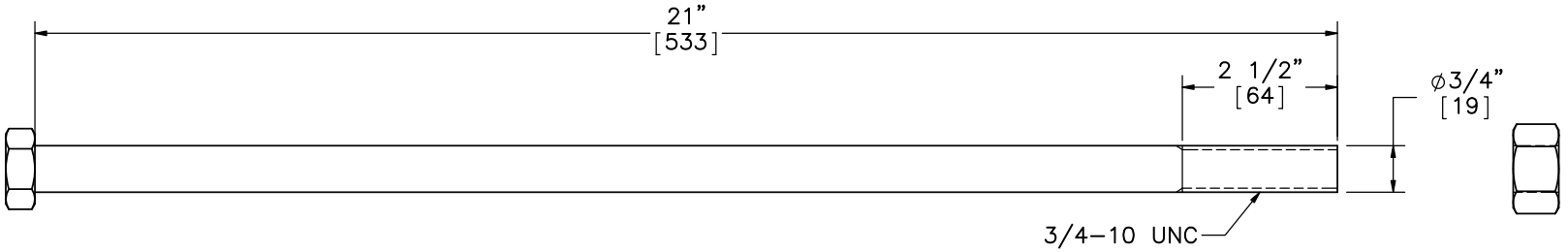
ELEVATION VIEW



PROFILE VIEW

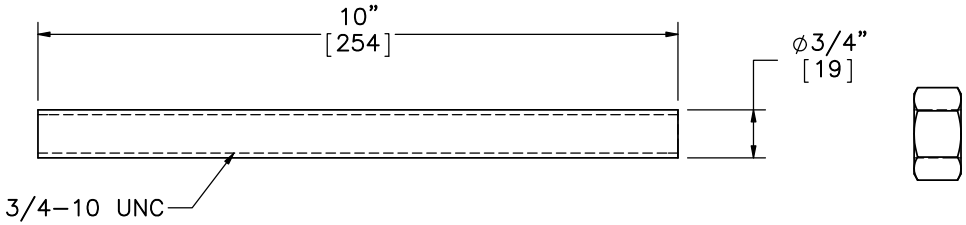
Part a2

MwRSF	SAFER For Highway – Angle Joint (SFH–3)		SHEET: 21 of 23
			DATE: 10/16/2014
Midwest Roadside Safety Facility	Rubber Post Details		DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3	SCALE: 1:8 UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



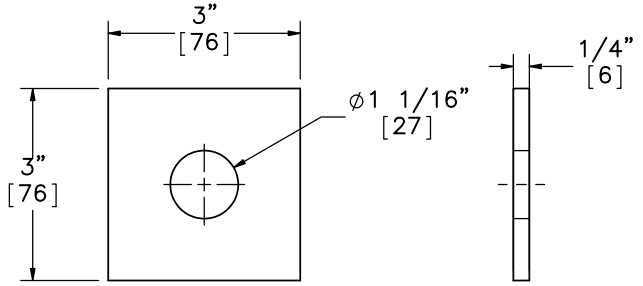
ELEVATION VIEW
Part b1

ELEVATION VIEW
Part b3

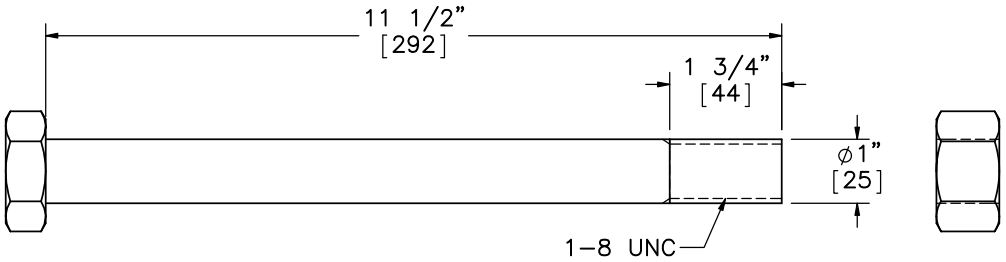


ELEVATION VIEW
Part b2

ELEVATION VIEW
Part b3

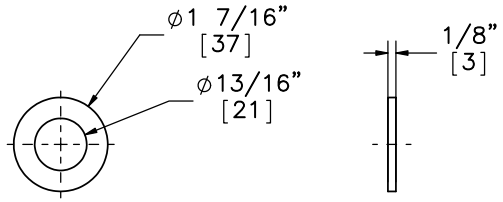


ELEVATION VIEW PROFILE VIEW
Part b6

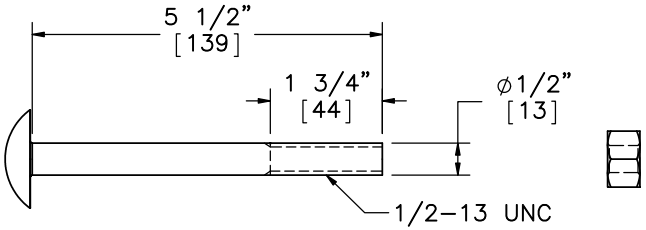


ELEVATION VIEW
Part b5

ELEVATION VIEW
Part b7



ELEVATION VIEW PROFILE VIEW
Part b4



ELEVATION VIEW
Part d6

ELEVATION VIEW
Part d8

Midwest Roadside Safety Facility

SAFER For Highway – Angle Joint (SFH–3)

Fasterner Details

SHEET: 22 of 23

DATE: 10/16/2014

DRAWN BY: JEK/SDB

DWG. NAME. SFH–3_AJ_R3

SCALE: 1:3

UNITS: in.[mm]

REV. BY: JDS/SKR/KAL

Item No.	QTY.	Description	Material Specification	Hardware Guide
a1	12	Lightweight Concrete Rail	min f'c=5 ksi [34.5 MPa], density=110 pcf	–
a2	48	Morse E46496 Shear Fender	ASTM D2000	–
a3	22	6"x6"x1/2" [152x152x13], 17" [432] Long L–Bracket	A992 Galvanized	–
a4	88	5"x5"x3/8" [127x127x10] Gusset Plate	A572 Grade 50 Galvanized	–
b1	192	3/4" [19] Dia. UNC, 21" [533] Long Hex Bolt	Grade 5 Galvanized	FBX20a
b2	192	3/4" [19] Dia. UNC, 10" [254] Long Threaded Rod	ASTM A193 Grade B7 Galvanized	–
b3	384	3/4" [19] Dia. UNC Heavy Hex Nut	ASTM A194 Grade 2H Galv.	–
b4	576	3/4" [19] Dia. Flat Washer	ASTM F436 Galv.	–
b5	88	1" [25] Dia. UNC, 11 1/2" [292] Long Hex Head Bolt	ASTM A325 Galv.	FBX24b
b6	176	3"x3"x1/4" [76x76x6] Square Washer	A572 Grade 50 Galvanized	–
b7	88	1" [25] Dia. UNC Heavy Hex Nut	ASTM A563 DH Galv.	FNX24b
c1	336	1/2" [13] Dia., 77" [1956] Long Bent Rebar	A615 Grade 60	–
c2	96	1/2" [13] Dia., 49" [1245] Long Bent Rebar	A615 Grade 60	–
c3	144	3/4" [19] Dia., 231" [5867] Long Rebar	A615 Grade 60	–
c4	96	3/4" [19] Dia., 63" [1600] Long Bent Rebar	A615 Grade 60	–
c5	72	3/4" [19] Dia., 69" [1753] Long Bent Rebar	A615 Grade 60	–
d1	48	17"x8"x1/2" [431x203x13] Anchor Plate	ASTM A572 Grade 50 Galvanized	–
d2	48	4"x4"x1/4" [102x102x6], 4" [102] Long Tube	A500 Grade B Galvanized	–
d3	11	8"x4"x1/4" [203x102x6], 239 1/2" [6083] Long Tube	A500 Grade B Galvanized	–
d4	2	8"x4"x1/4" [203x102x6], 119 1/2" [3035] Long End Tube	A500 Grade B Galvanized	–
d5	12	12 3/4"x6 1/2"x3/16" [324x165x5] Bent Plate	ASTM A572 Grade 50 Galvanized	–
d6	24	1/2" [13] Dia. UNC, 5 1/2" [140] Long Dome (Round) Head Bolt	ASTM A307 Grade A Galvanized	–
d7	24	1/2" [13] Dia. Flat Washer	ASTM F844 Galvanized	FWC12a
d8	24	1/2" [13] Dia. UNC Heavy Hex Nut	A563A Galvanized	FNX12b
d9	–	Epoxy	HILTI HIT–RE500	–
e1	24	6 1/2" [165] Dia., 3/8" [10] Thick, 19" [483] Long Steel Pipe	AISI 1026	–
e2	24	16 9/16"x10"x1/4" [421x254x6] Base Plate	ASTM A572 Grade 50 Steel	–
e3	48	3 1/2"x10 3/8"x1/2" [89x264x13] Plate Gusset	ASTM A572 Grade 50 Steel	–
e4	24	12"x12"x3/8" [305x305x10] Top Plate	ASTM A572 Grade 50 Steel	–
e5	24	12"x12"x1/2" [305x305x13] EPDM Rubber Sheet	Minimum 50 durometer	–

Midwest Roadside Safety Facility

SAFER For Highway – Angle Joint (SFH–3)

Bill of Materials

SHEET:	23 of 23
DATE:	10/16/2014
DRAWN BY:	JEK/SDB
DWG. NAME.	SFH–3_AJ_R3
SCALE: 1:8 UNITS: in.[mm]	
REV. BY:	JDS/SKR/KAL

System: SAFER For Highway – Angle Joint

Drawing: SFH–3

Revision History

REV.	DATE OF ISSUE	Page	NATURE OF CHANGES	REVISED BY
R0	8/26/2014	–	Drawing originated from SFH_AJ_R7.	JEK
		1	Impact location moved to 60" US of the joint between 5 and 6. Impact angle changed. Test vehicle changed. Barriers labeled to indicate where barriers previously used in test shall be placed. Note 1 corrected. Notes 3 and 4 added. General format changes. General dimension changes.	
		5	Optional note added to the spice instrumentation.	
R1	8/28/2014	–	Part b1 switched to a 21" hex head bolt.	JEK
		1	Note 5 added. Barrier layout rearranged.	
		3	Part b1 replaced. Nut on top of barrier removed.	
		22	Part b1 replaced. New part dimensioned.	
		23	Part b1 replaced. Description and material of b1 changed. Quantity of b3 changed.	
R2	10/15/2014	–	Rebar corrected to "as built" and hardware changed to cosmetic thread.	SDB
		8	Note 1 added.	
		9	Rebar corrected to CI drawings.	
		10	Rebar corrected to CI drawings.	
		11	Rebar corrected to CI drawings.	
		12	Rebar corrected to CI drawings. Parts c1–c5 length and assembly dimensions corrected.	
		22	Hardware changed to cosmetic threads. Part d6 and d8 added to page	
		23	Nuts and Bolts separated into two parts. Hardware guide designations added to parts b4, b7, d7, and d8.	
R3	10/16/2014	3	Part b1 corrected back to bolt.	SDB
		22	Part b1 corrected back to bolt.	
		23	Part b1 replaced. Description and material of b1 changed. Quantity of b3 changed.	