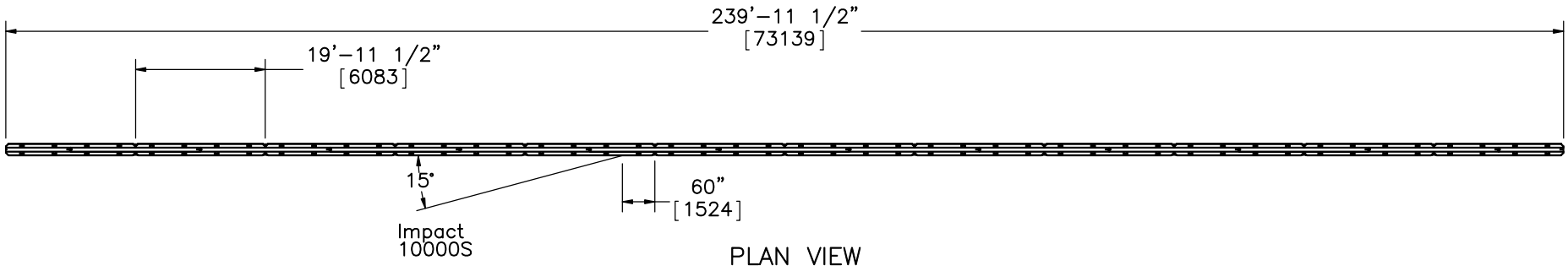
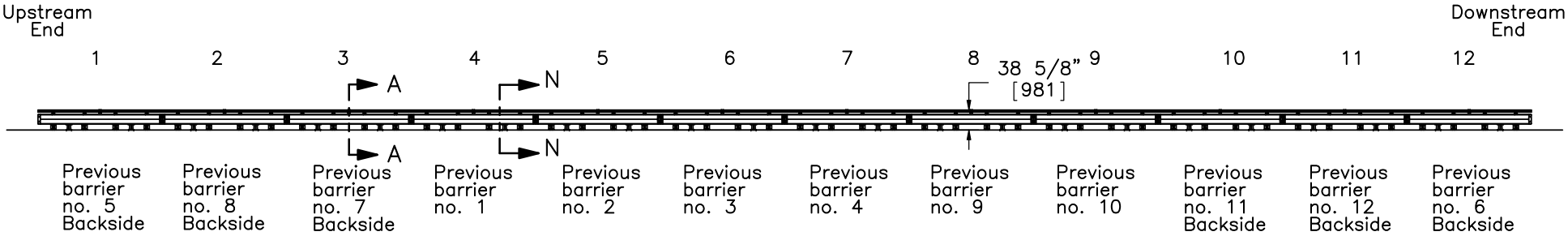


PLAN VIEW



ELEVATION VIEW

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

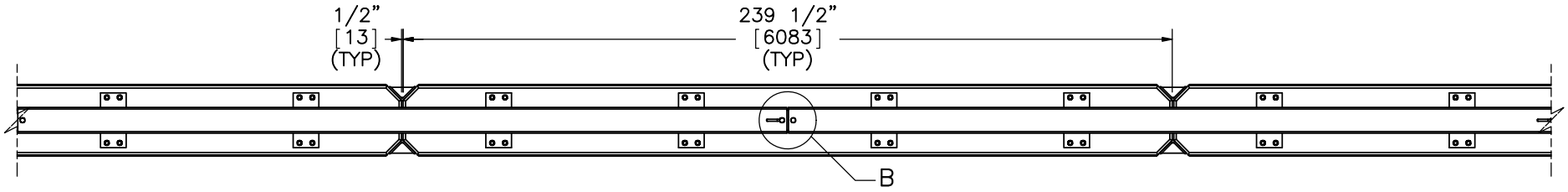
(2) Overall nominal height of barrier may decrease once assembled due to the weight of the rail on rubber.

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

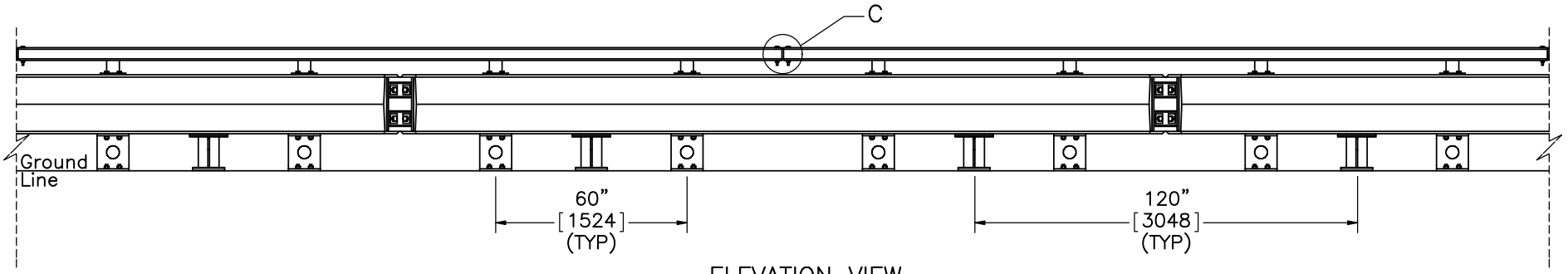
(4) Move damaged posts to the US end of the system.

(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

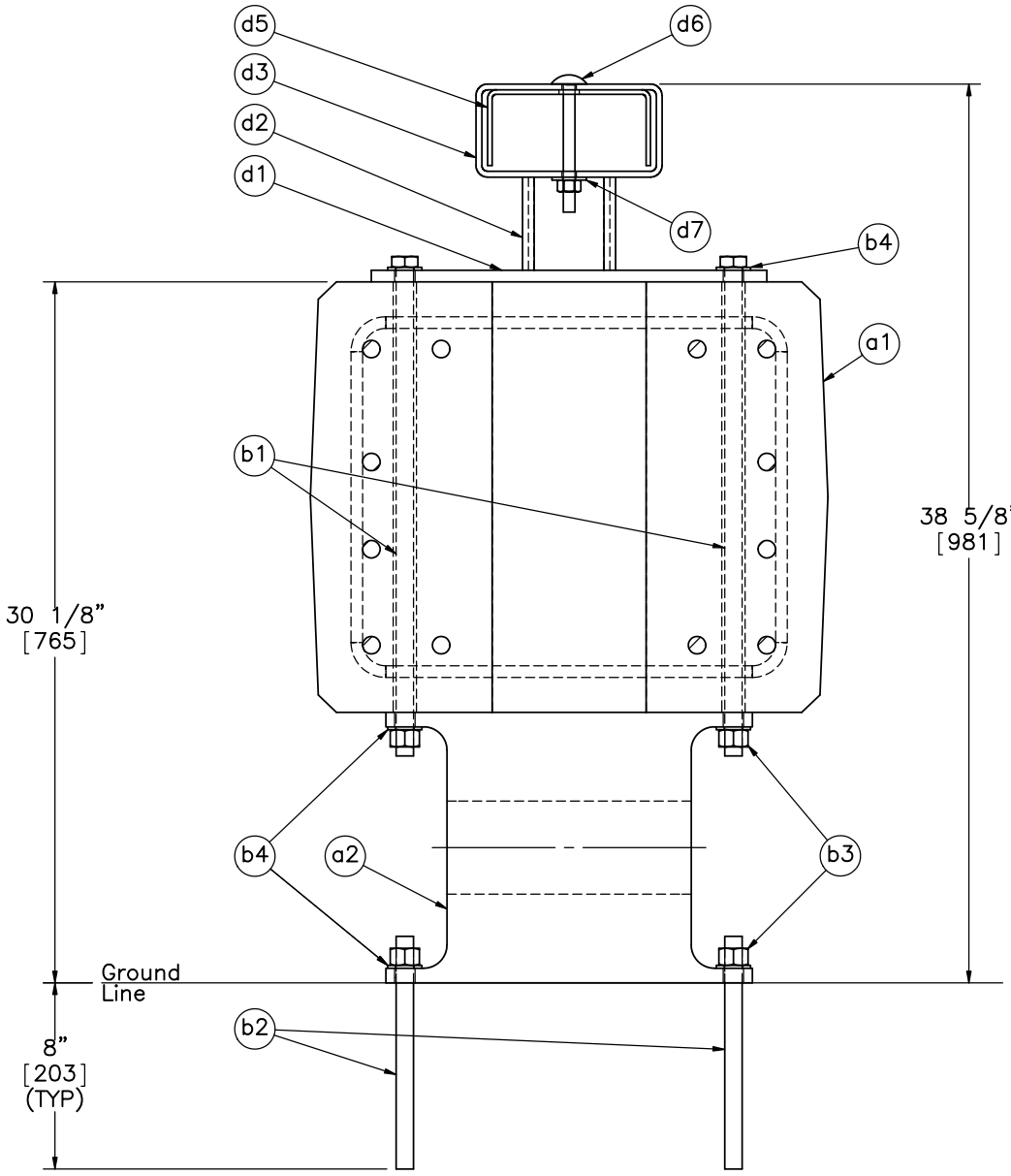


PLAN VIEW

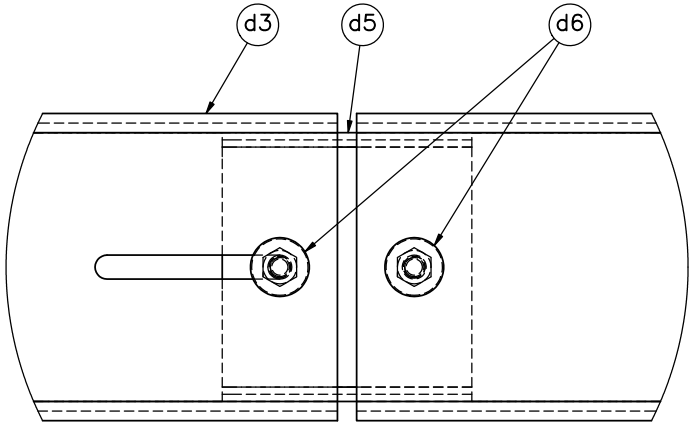


ELEVATION VIEW

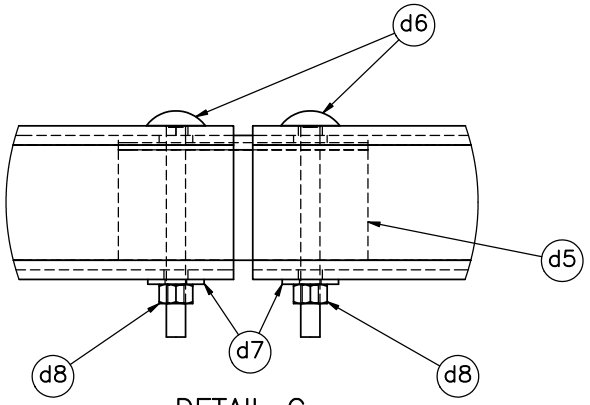
Midwest Roadside Safety Facility	SAFER For Highway – Angle Joint (SFH–3) Barrier Assembly	SHEET: 2 of 23 DATE: 10/16/2014 DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3 SCALE: 1:50 UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



SECTION A–A



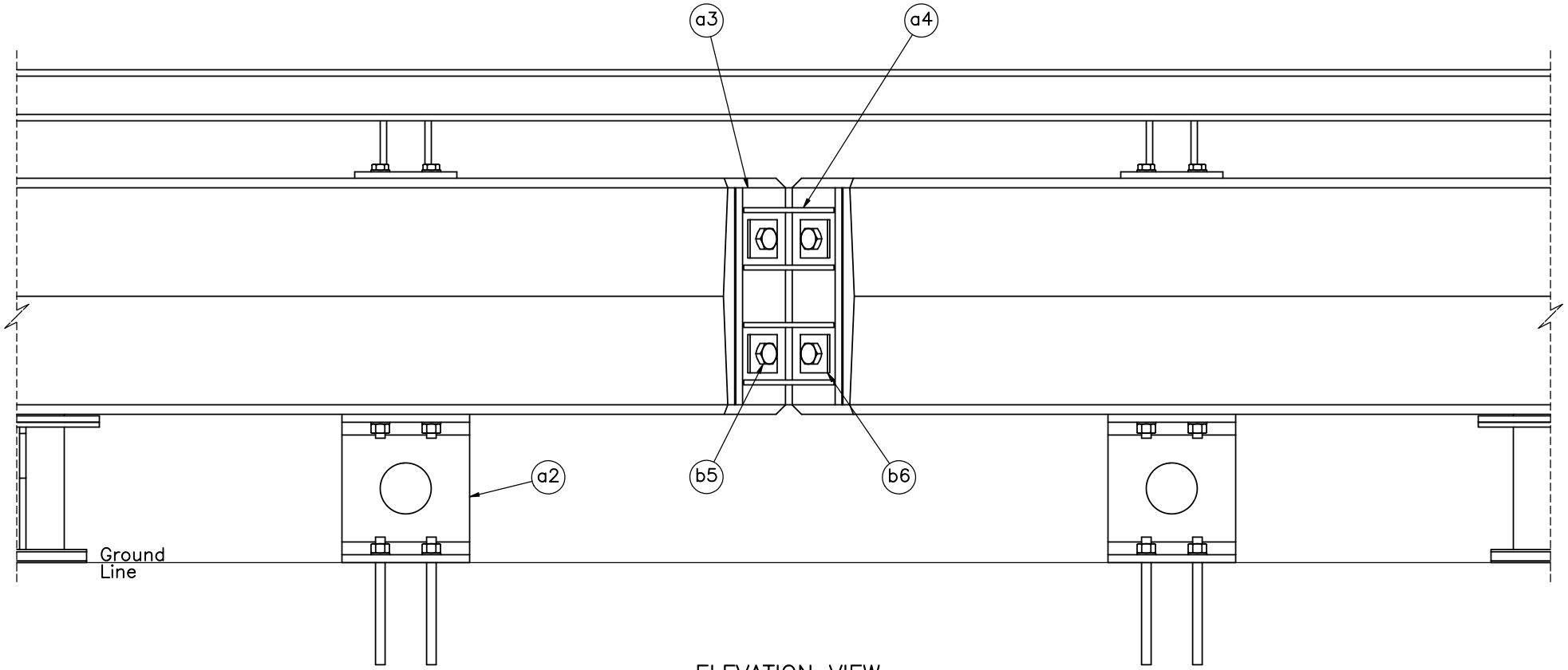
DETAIL B
SCALE 1 : 5



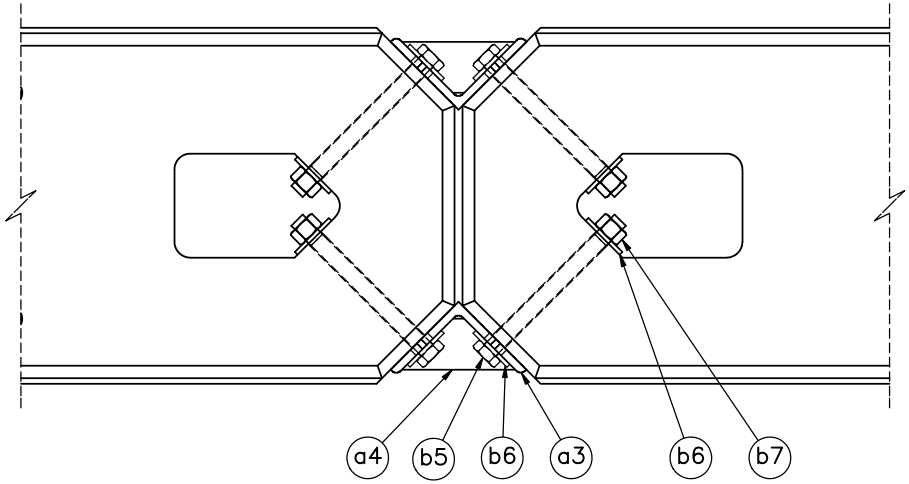
DETAIL C
SCALE 1 : 5

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



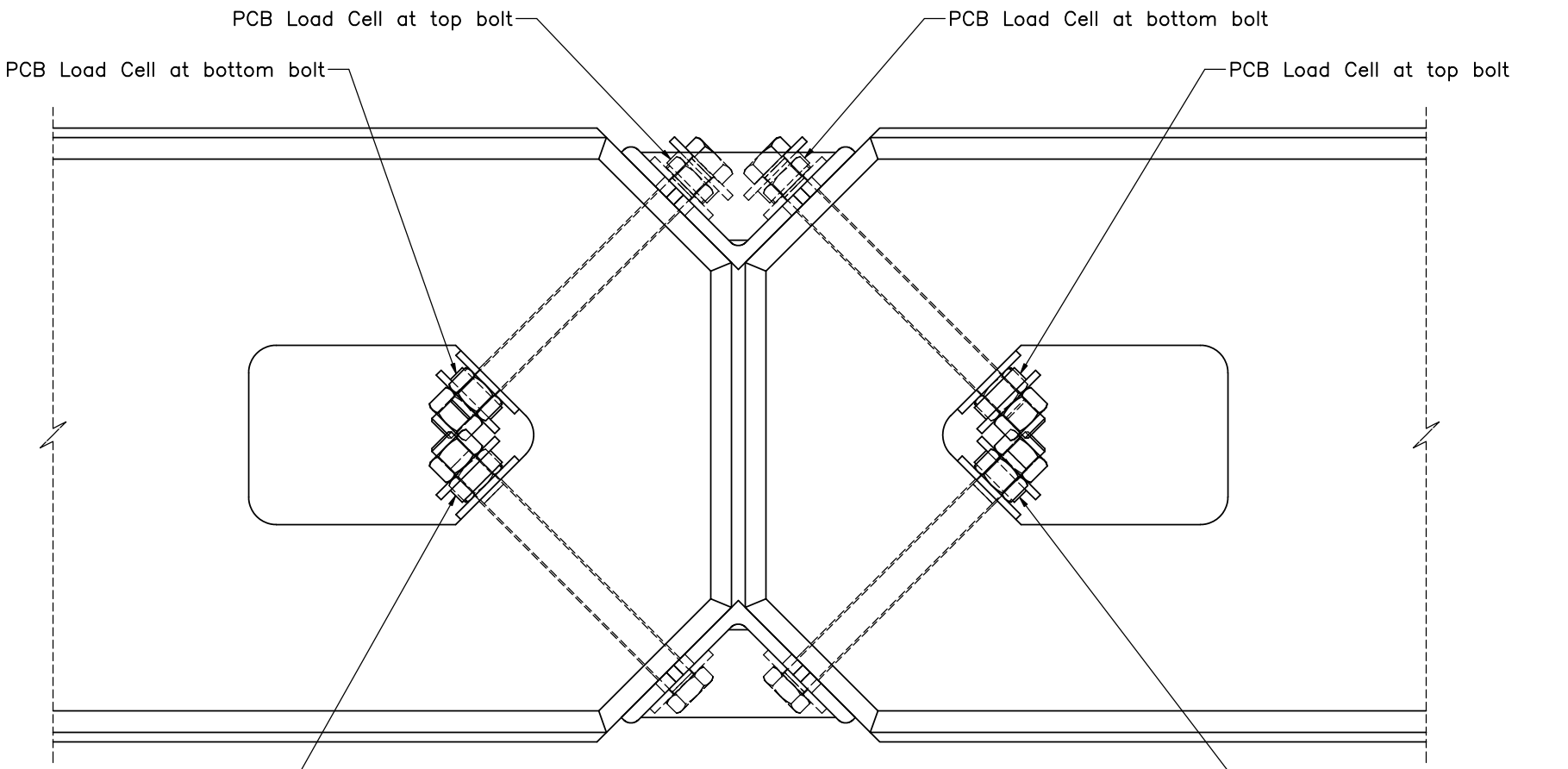
ELEVATION VIEW
SPLICE DETAIL



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.

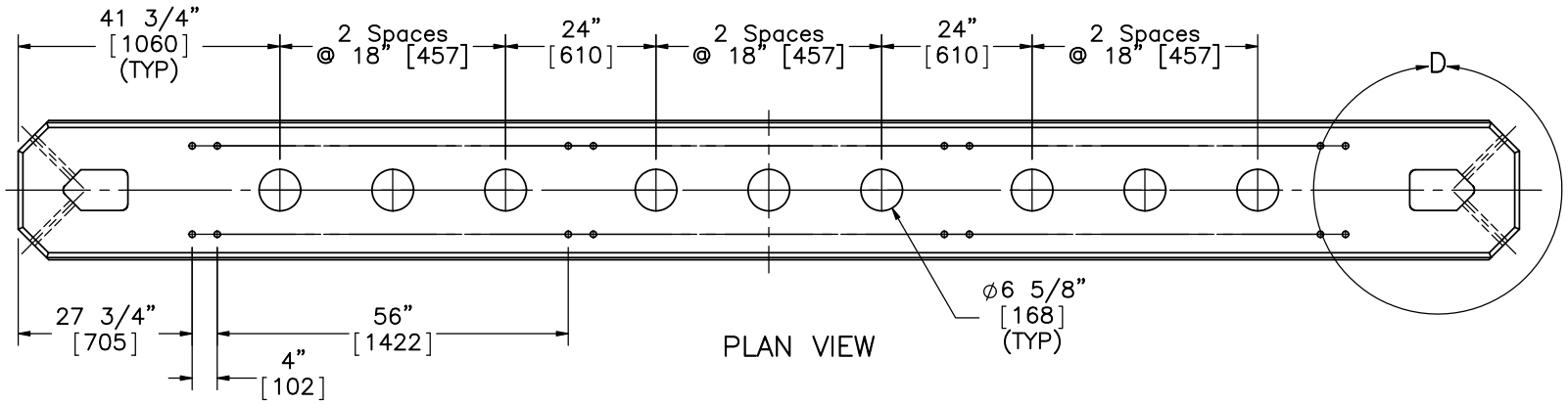
(2) PCB Piezotronics 206C (PCB)
2.00" O.D.
1.024" I.D.
0.500" thickness

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

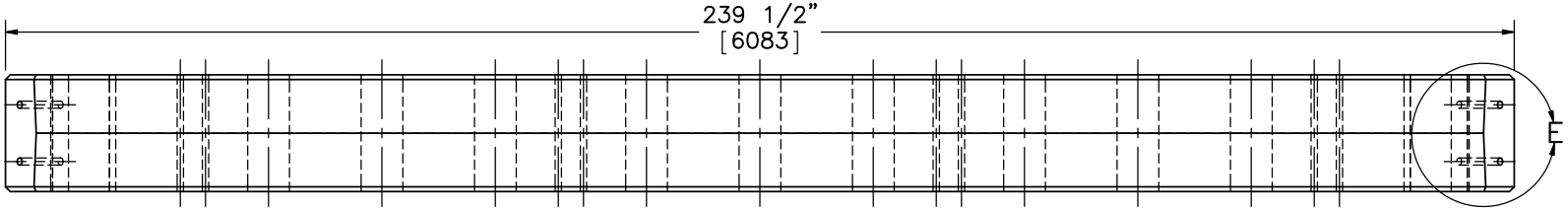
(4) Use additional 3"x3"x1/4" [76x76x6] plate washer if available to sandwich load cell.

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

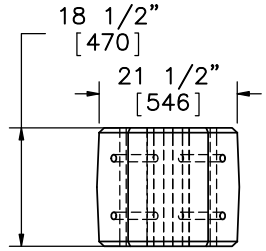
MwRSF	SAFER For Highway – Angle Joint (SFH–3)	SHEET: 5 of 23
		DATE: 10/16/2014
Midwest Roadside Safety Facility	Splice 5–6 Instrumentation Details	DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3 / SCALE: 1:6 / UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



PLAN VIEW



ELEVATION VIEW
Part a1



PROFILE VIEW

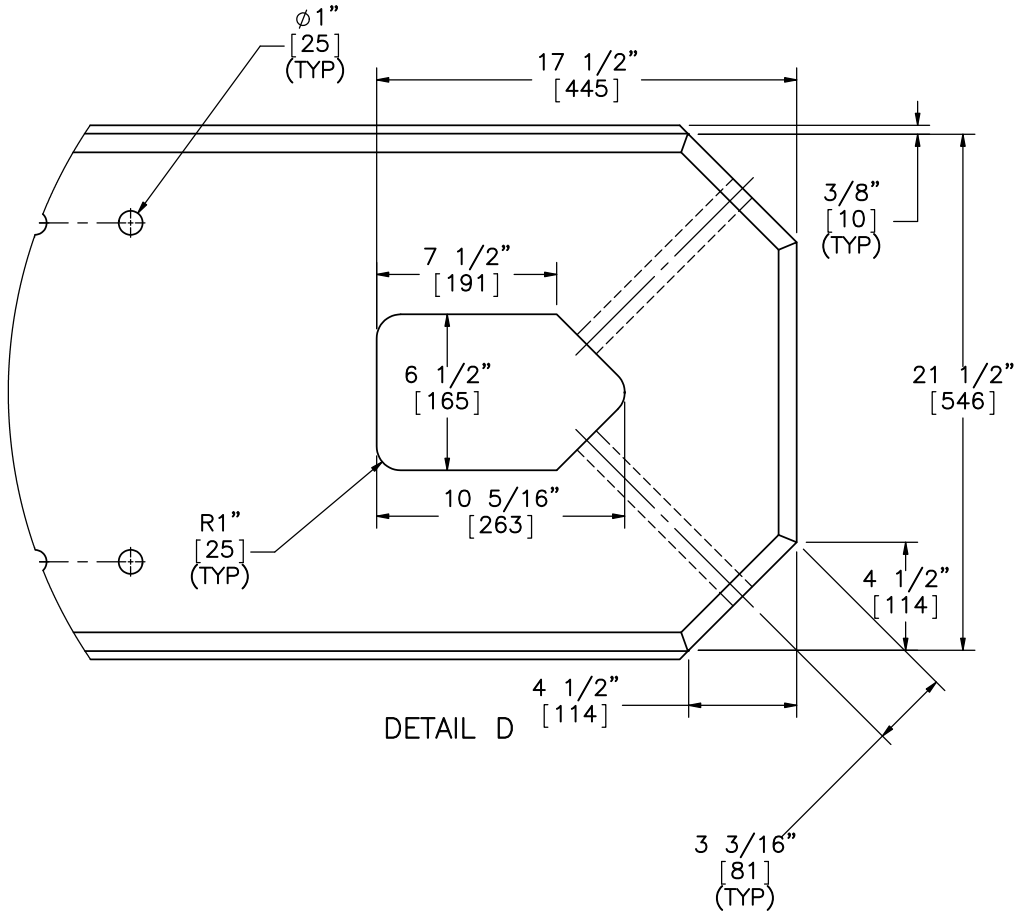
Notes: (1) The ϕ6 5/8" [168] through hole can be cast around a ϕ6" [152] PVC pipe and then the pipe can later be removed.

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

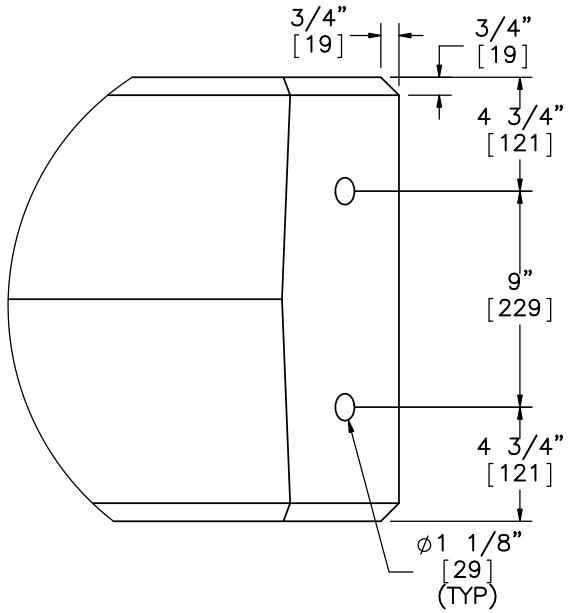
(3) Internal Reinforcement not shown.

(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.

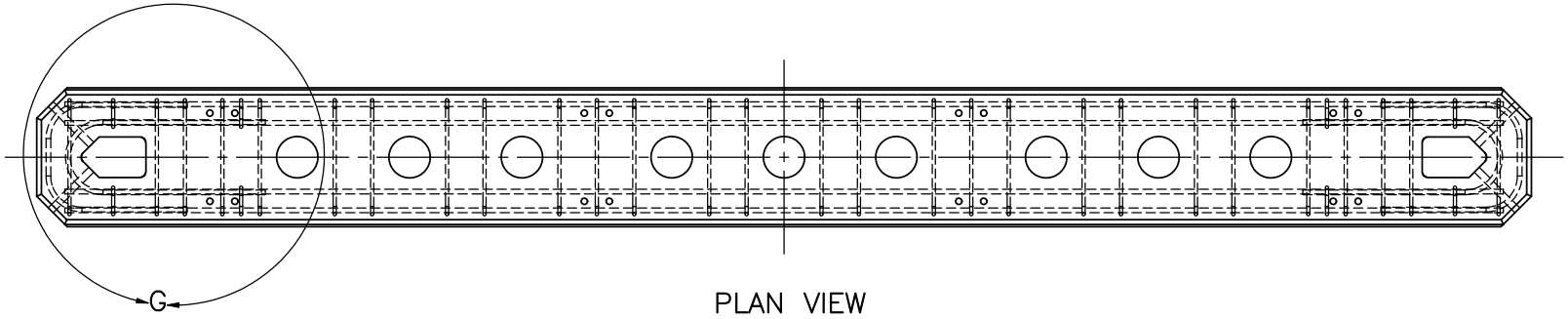
(3) The 3 surfaces at each end of the barrier must be vertical – front and back of rail drafted for casting purposes.

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

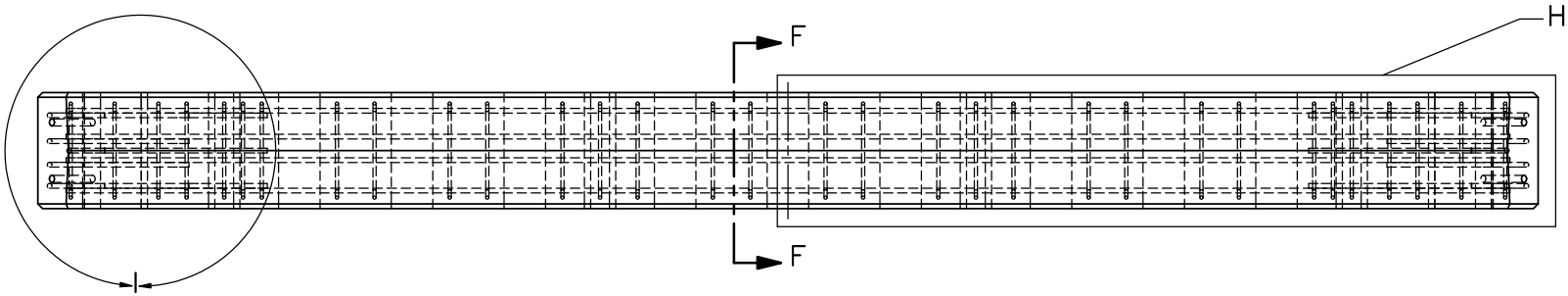
(5) Internal reinforcement not shown.

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

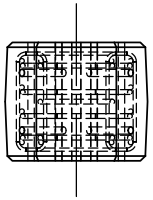
MwRSF	SAFER For Highway – Angle Joint (SFH–3)		SHEET: 7 of 23
			DATE: 10/16/2014
Midwest Roadside Safety Facility	Concrete Rail Details		DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3	SCALE: 1:8 UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



PLAN VIEW



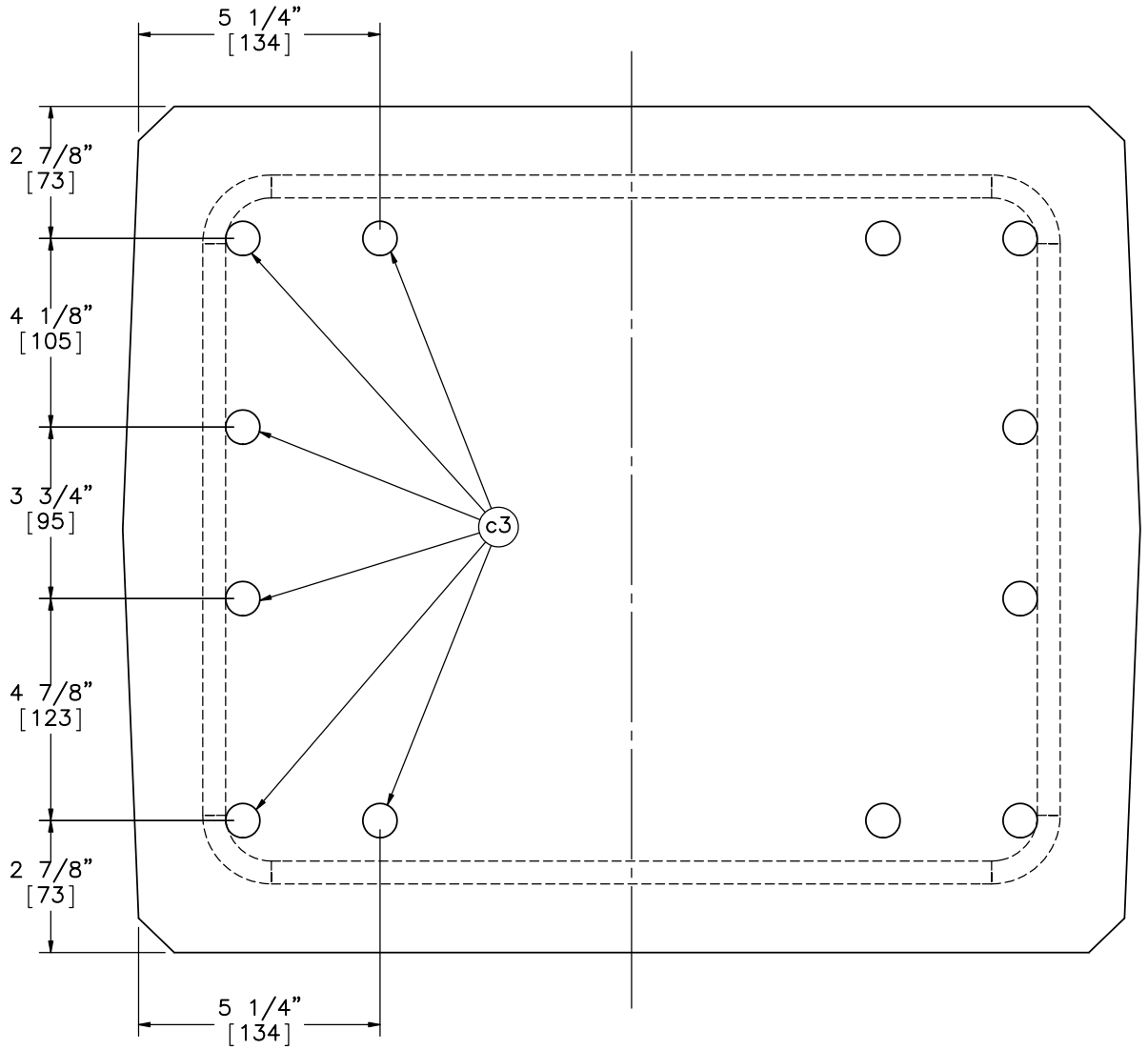
ELEVATION VIEW



PROFILE VIEW

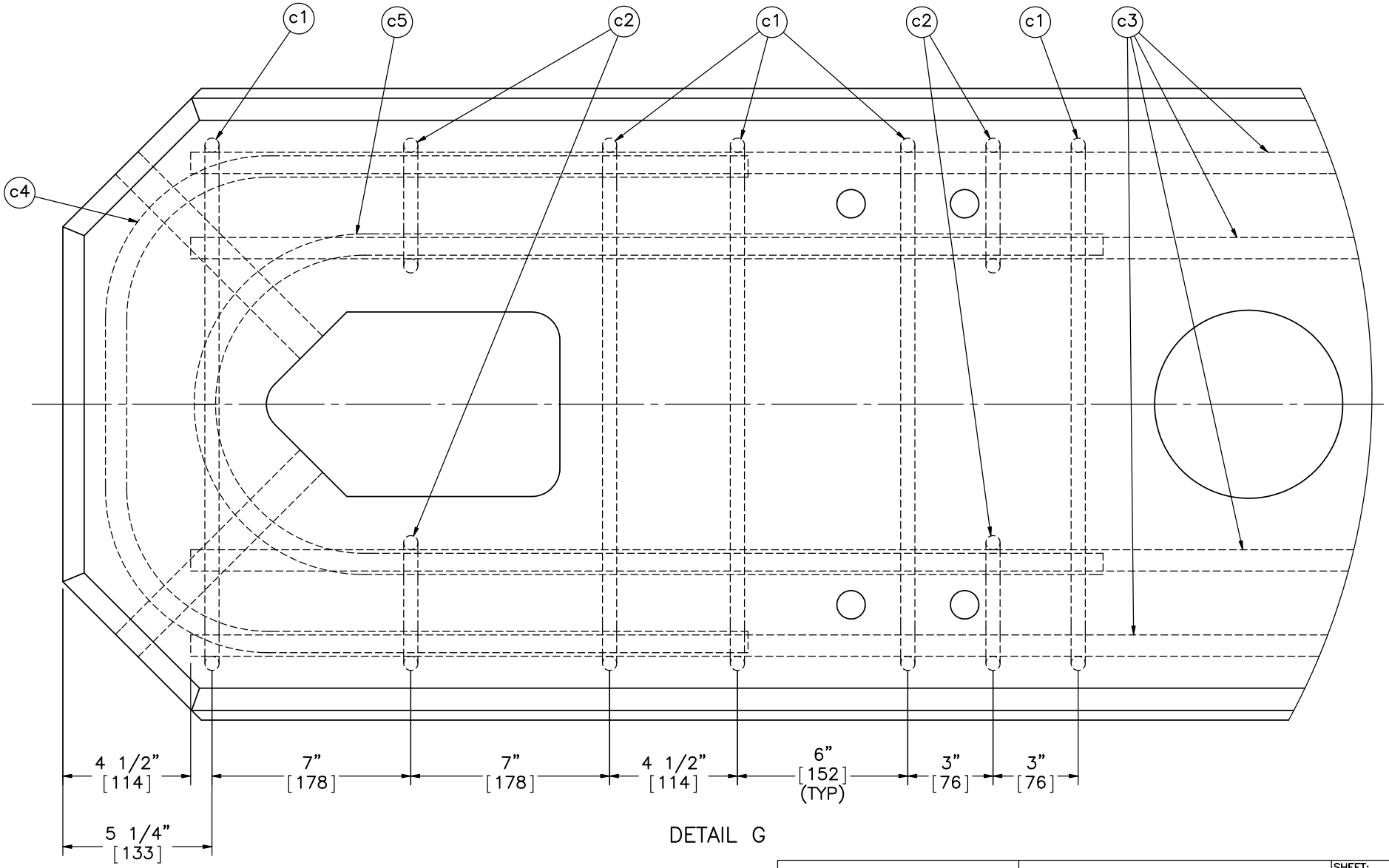
Notes: (1) Two single flared coil loop inserts (not shown) were added to each barrier segment.

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

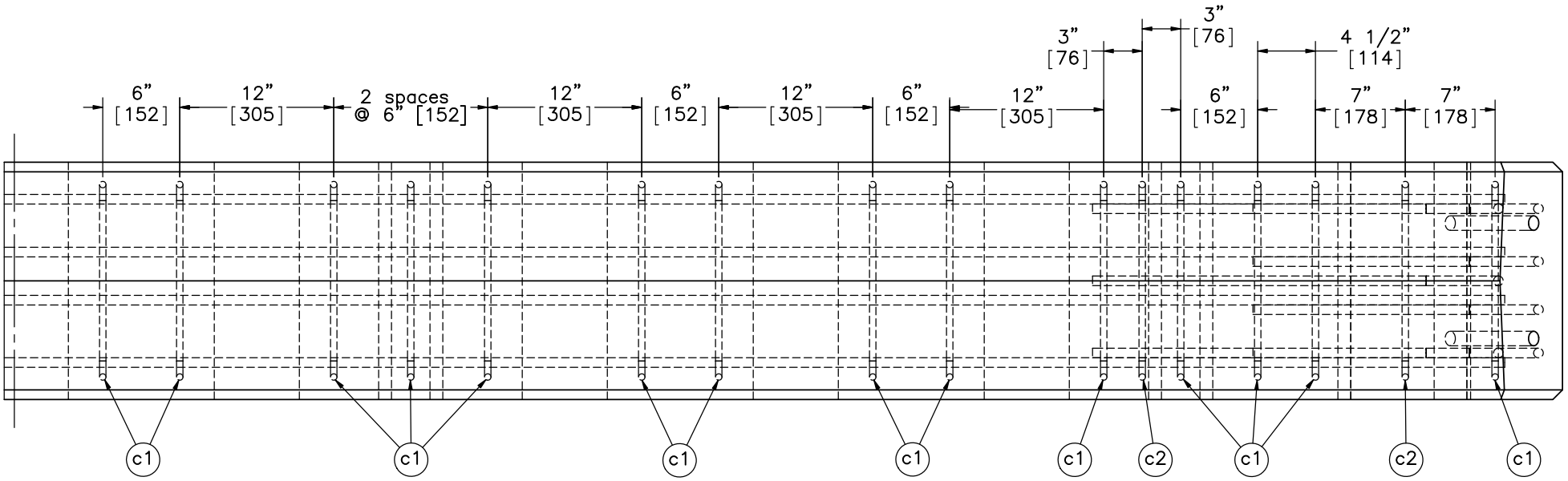
Midwest Roadside Safety Facility	SAFER For Highway – Angle Joint (SFH–3) Concrete Rail – Rebar Assembly Details	SHEET: 9 of 23 DATE: 10/16/2014 DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3 / SCALE: 1:4 / UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



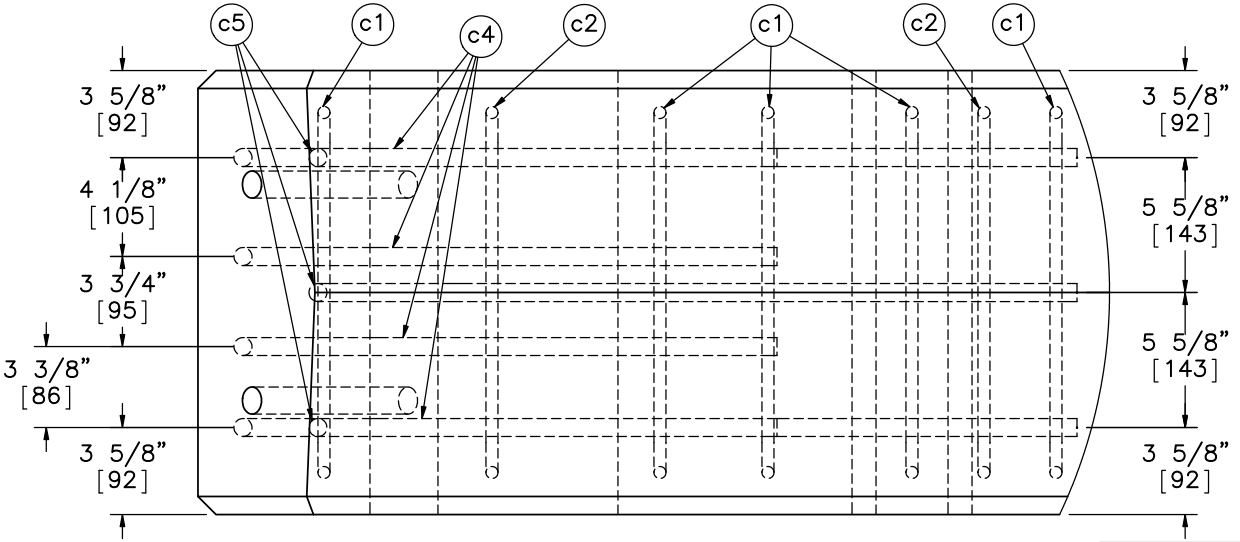
DETAIL G

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



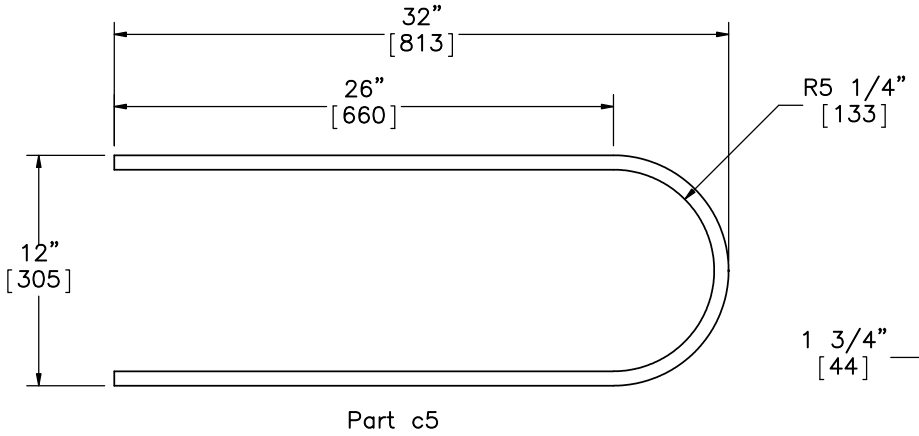
DETAIL I
SCALE 1 : 8

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

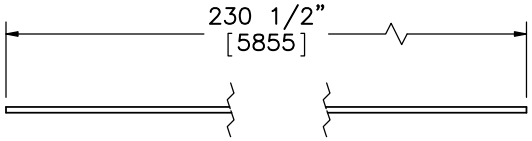
(2) Place top and bottom c4 and c5 bars adjacent to longitudinal c3 bars.

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

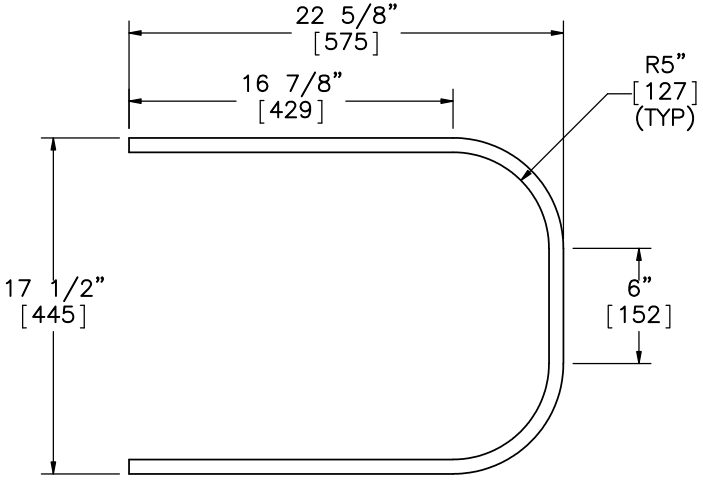
Bill of Bars			
Item No.	QTY.	Description	Material Specification
c1	28	1/2" [13] Dia., 77" [1956] Long Bent Rebar	A615 Grade 60
c2	8	1/2" [13] Dia., 49" [1245] Long Bent Rebar	A615 Grade 60
c3	12	3/4" [19] Dia., 231" [5867] Long Rebar	A615 Grade 60
c4	8	3/4" [19] Dia., 63" [1600] Long Bent Rebar	A615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



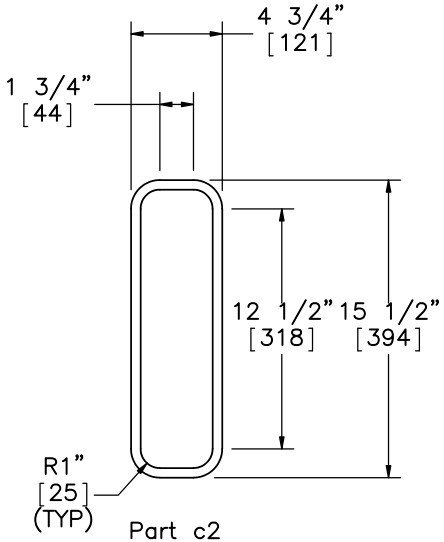
Part c5



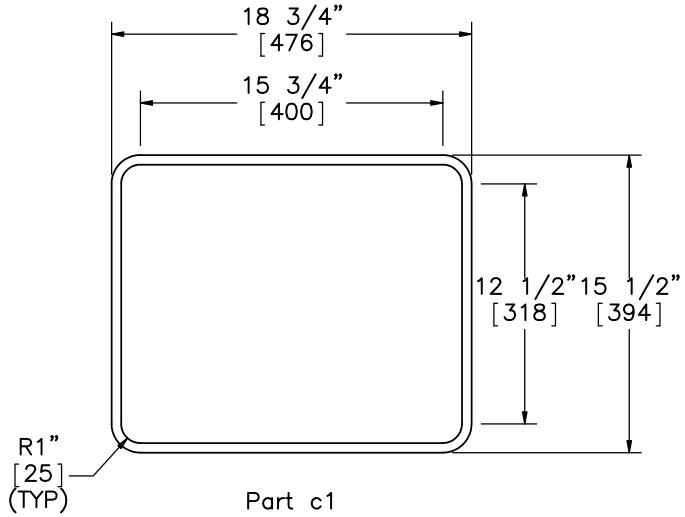
Part c3



Part c4



Part c2



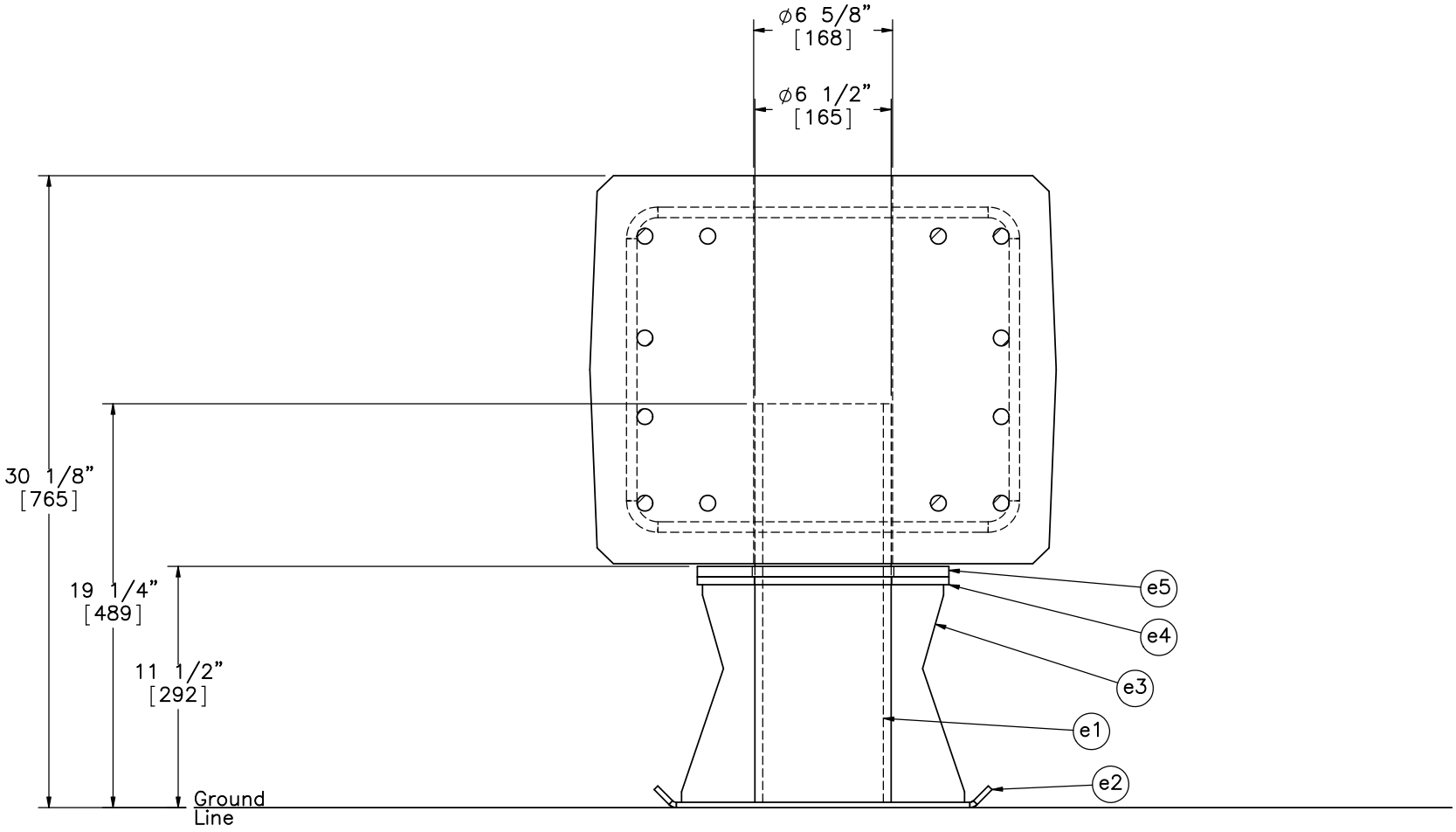
Part c1

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
		DRAWN BY: JEK/SDB	DATE: 10/16/2014

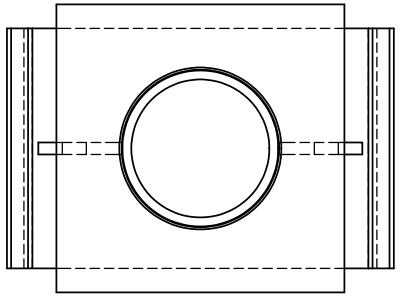


SECTION N–N

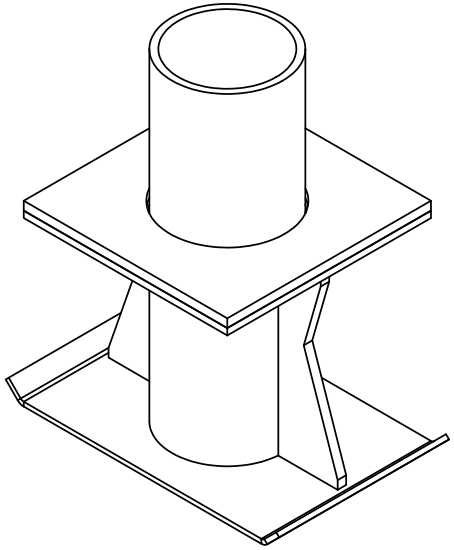
Note: (1) Steel Rail not shown for clarity.

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

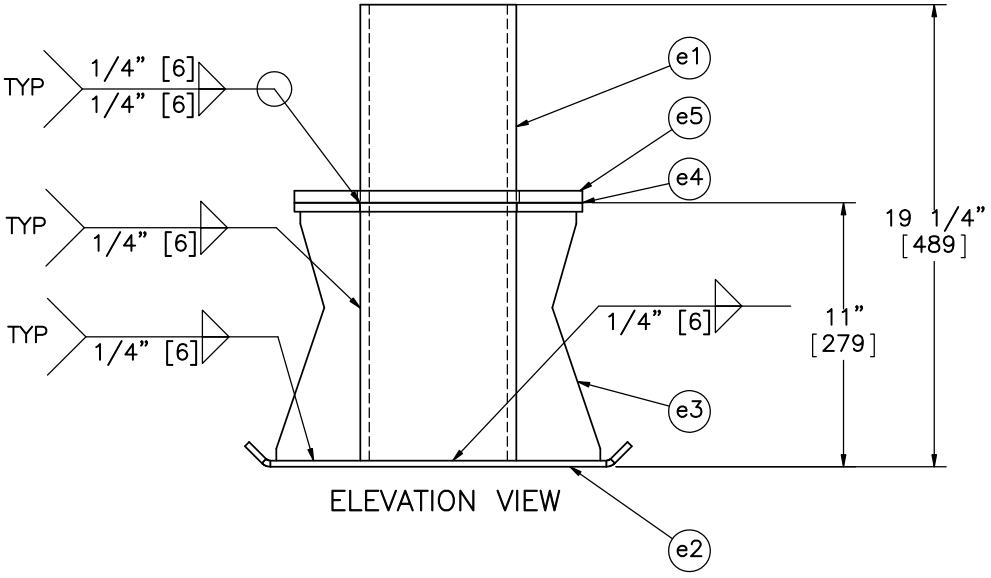
Midwest Roadside Safety Facility	SAFER For Highway – Angle Joint (SFH–3)		SHEET: 13 of 23
			DATE: 10/16/2014
	Skid Details		DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3	SCALE: 1:8 UNITS: in.[mm]	REV. BY: JDS/SKR/ KAL



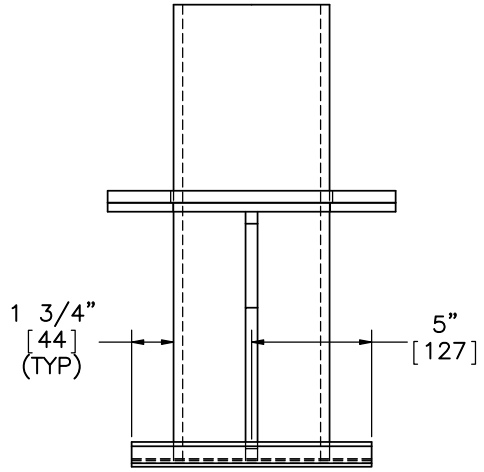
PLAN VIEW



ISOMETRIC VIEW

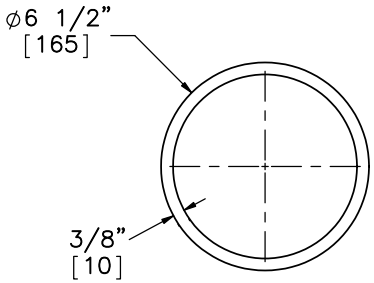


ELEVATION VIEW

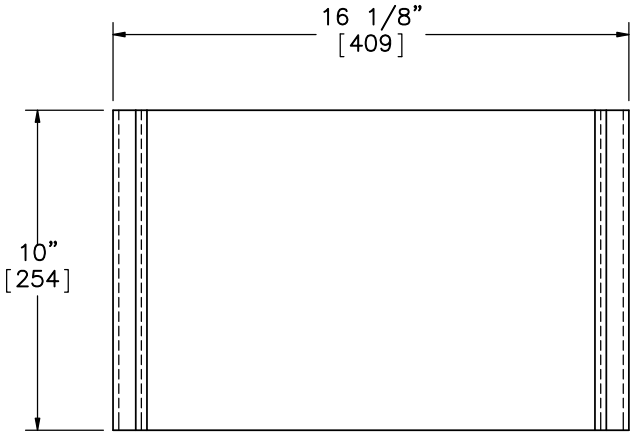


PROFILE VIEW

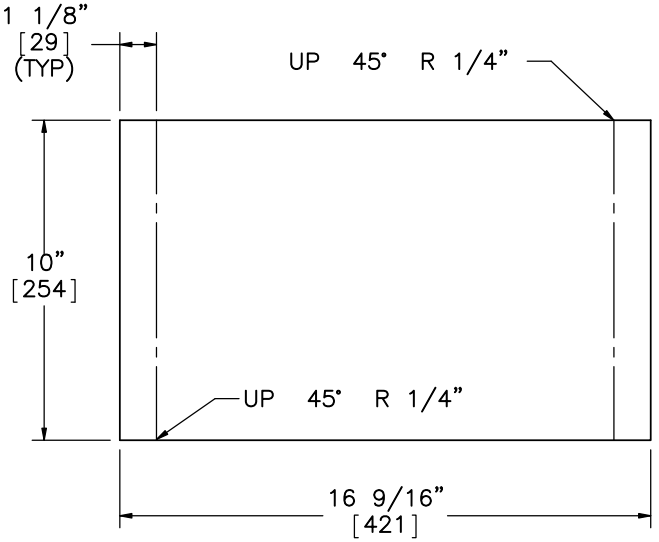
Midwest Roadside Safety Facility	SAFER For Highway – Angle Joint (SFH–3) Skid Assembly Details	SHEET: 14 of 23 DATE: 10/16/2014 DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3 / SCALE: 1:8 / UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



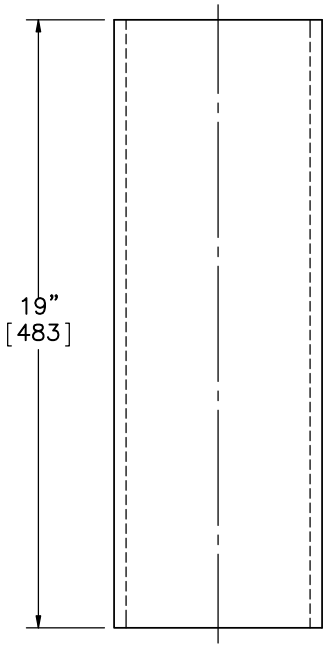
PLAN VIEW



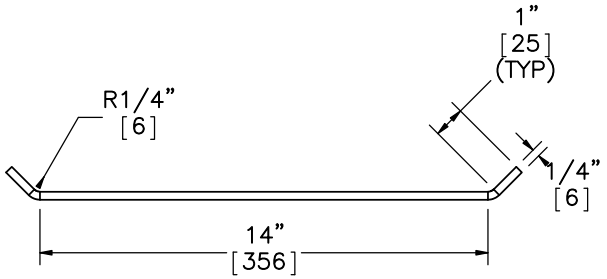
PLAN VIEW



FLAT PATTERN
Part e2



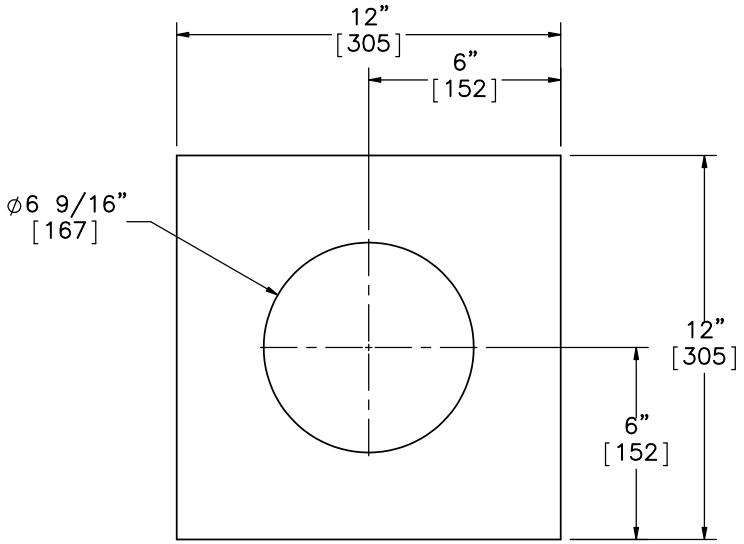
ELEVATION VIEW
Part e1



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.

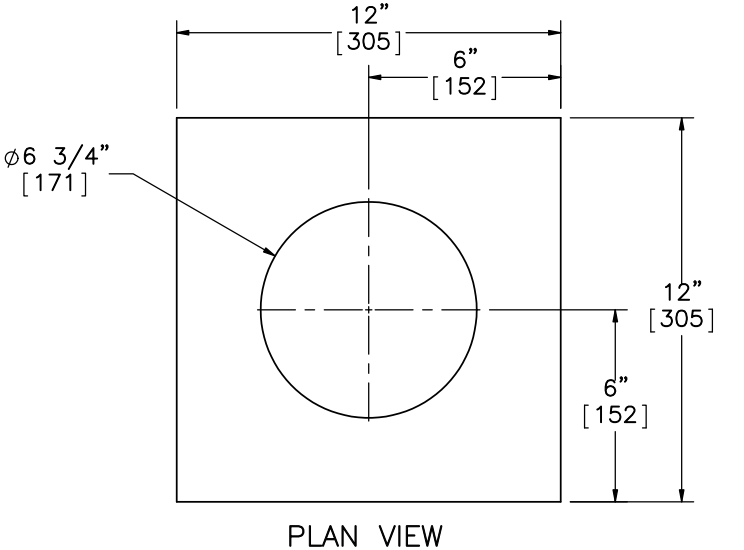
MwRSF	SAFER For Highway – Angle Joint (SFH–3)	SHEET: 15 of 23
		DATE: 10/16/2014
Midwest Roadside Safety Facility	Skid Component Details	DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3 / SCALE: 1:6 / UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



PLAN VIEW

PROFILE VIEW

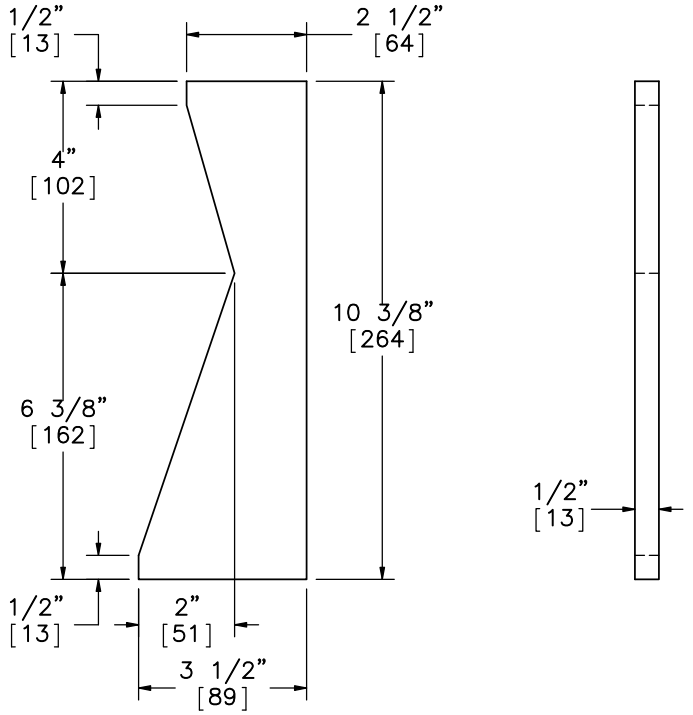
Part e4



PLAN VIEW

PROFILE VIEW

Part e5

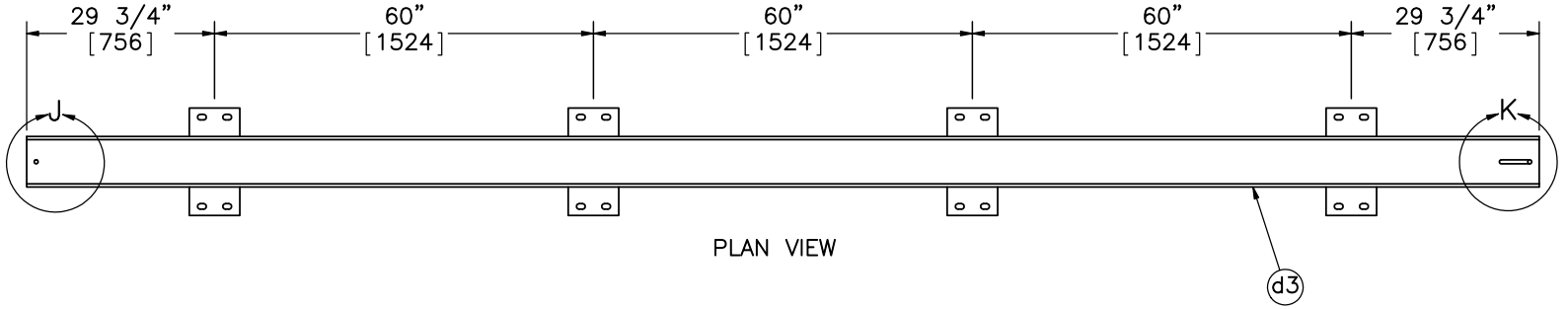


ELEVATION VIEW

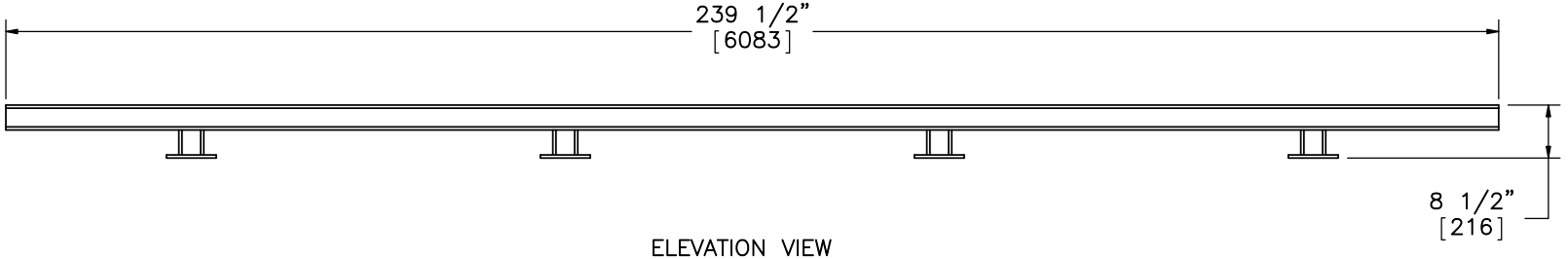
PROFILE VIEW

Part e3
SCALE 1:4

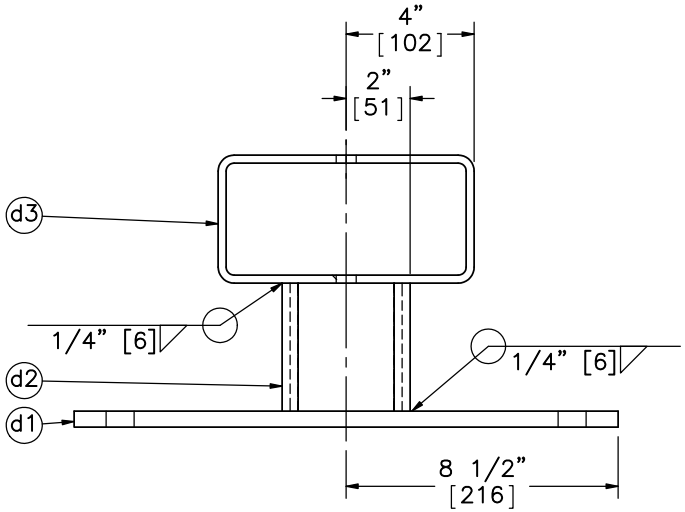
Midwest Roadside Safety Facility	SAFER For Highway – Angle Joint (SFH–3) Skid Top Plate Detail	SHEET: 16 of 23 DATE: 10/16/2014 DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3 SCALE: 1:6 UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



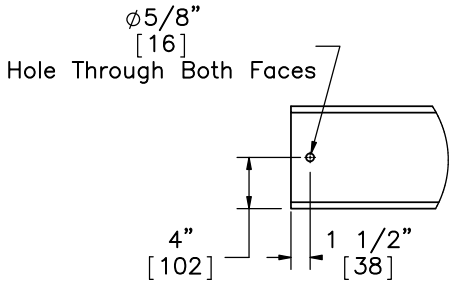
PLAN VIEW



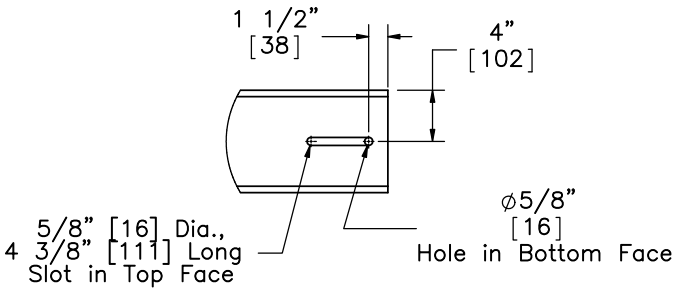
ELEVATION VIEW



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.

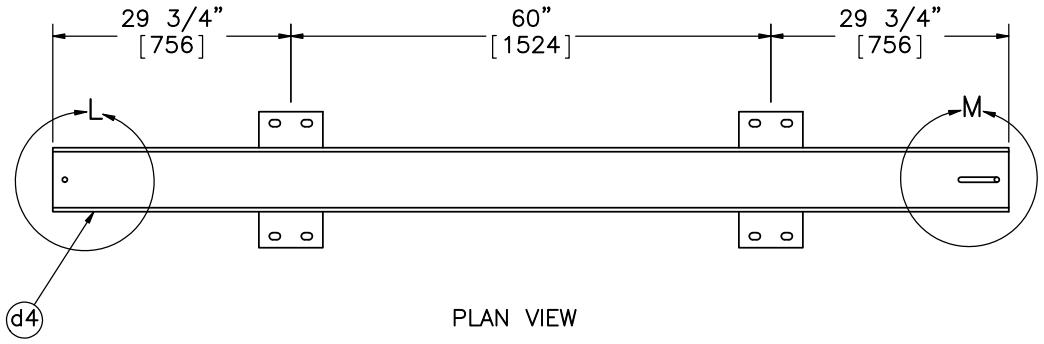
Midwest Roadside Safety Facility

SAFER For Highway – Angle Joint (SFH–3)

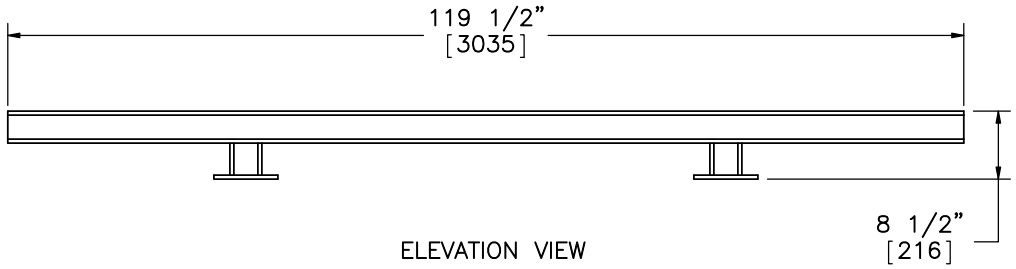
Steel Rail Assembly

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

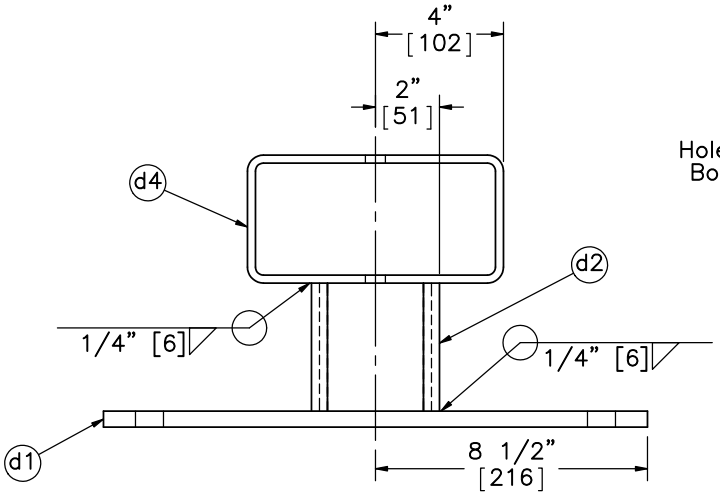
SHEET: 17 of 23
DATE: 10/16/2014
DRAWN BY: JEK/SDB



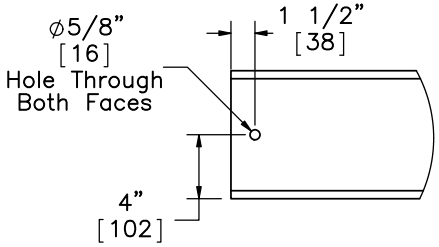
PLAN VIEW



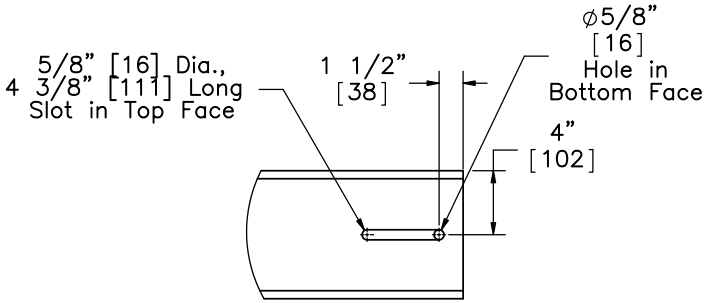
ELEVATION VIEW



PROFILE VIEW
SCALE 1:6



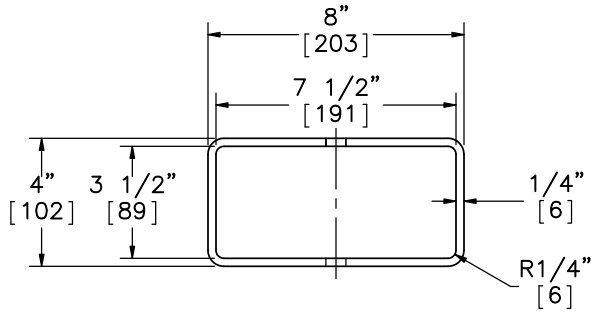
DETAIL L
SCALE 1 : 12



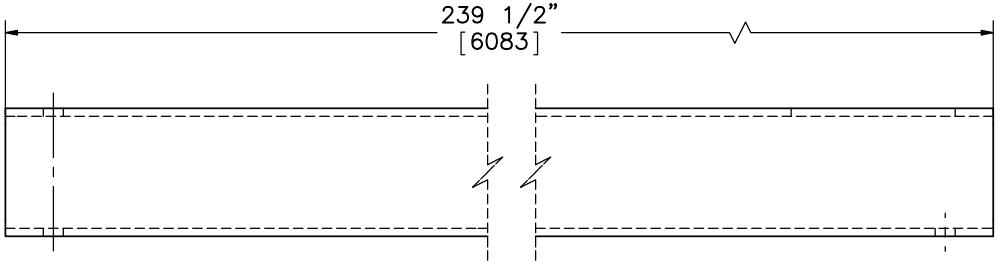
DETAIL M
SCALE 1 : 12

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

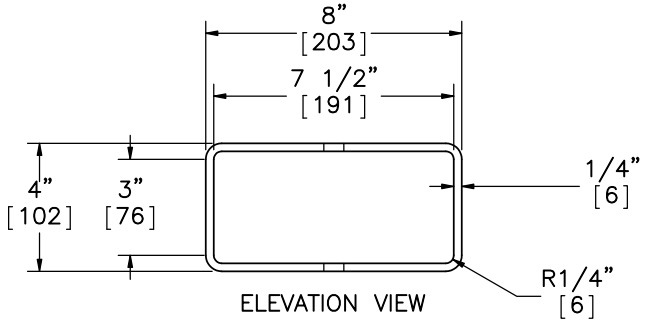


ELEVATION VIEW

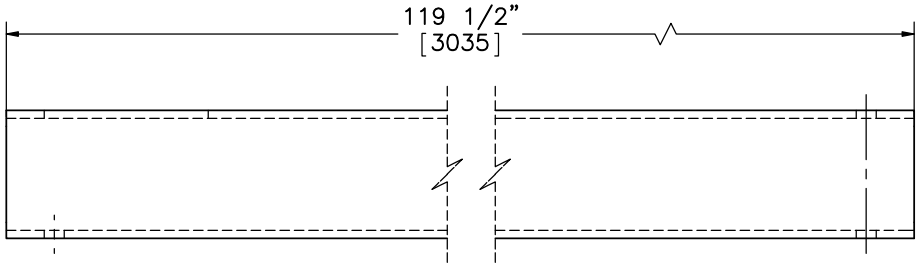


PROFILE VIEW

Part d3

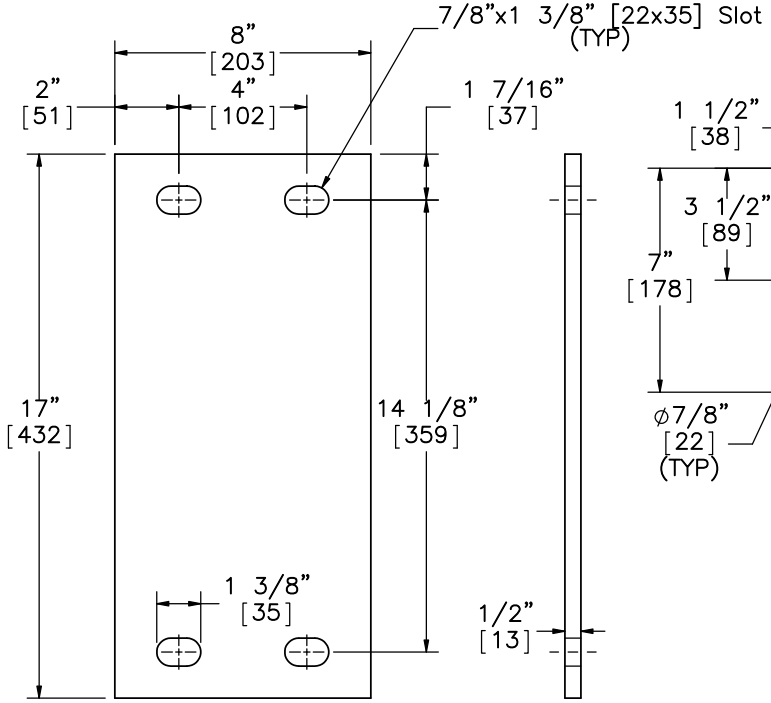


ELEVATION VIEW



PROFILE VIEW

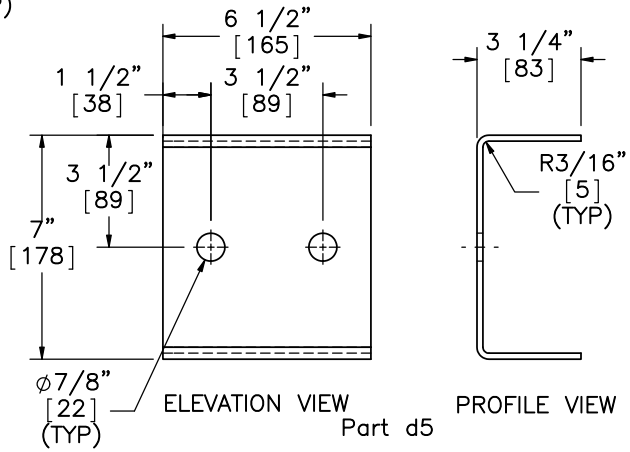
Parts d4



ELEVATION VIEW

PROFILE VIEW

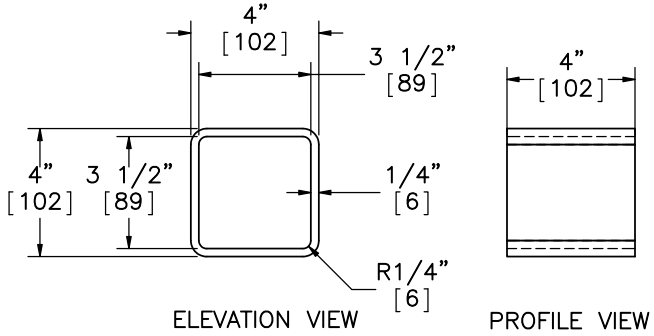
Part d1



ELEVATION VIEW

Part d5

PROFILE VIEW



ELEVATION VIEW

PROFILE VIEW

Part d2

Midwest Roadside Safety Facility

SAFER For Highway – Angle Joint (SFH–3)

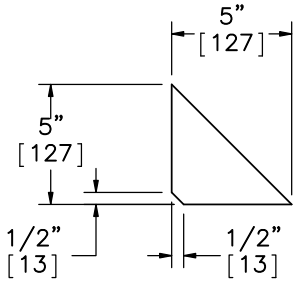
Steel Rail Components

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

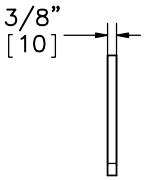
SHEET: 19 of 23

DATE: 10/16/2014

DRAWN BY: JEK/SDB

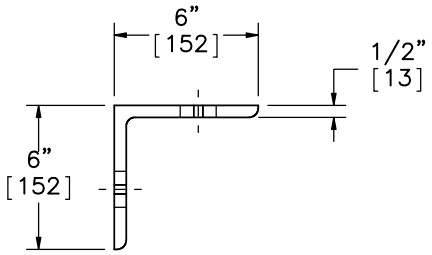


ELEVATION VIEW

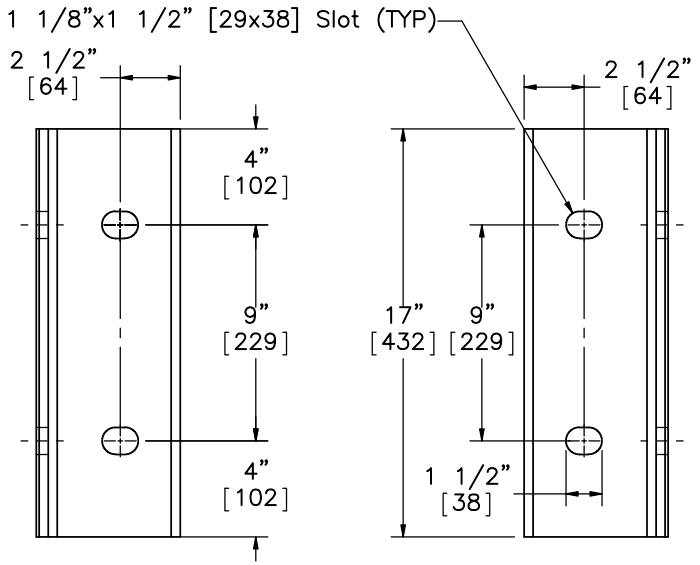


PROFILE VIEW

Part a4

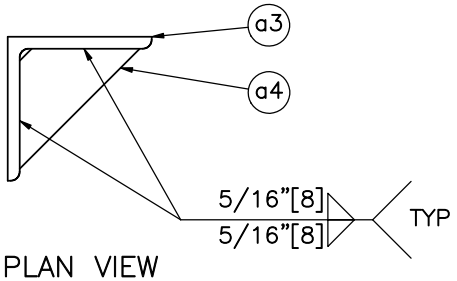


PLAN VIEW

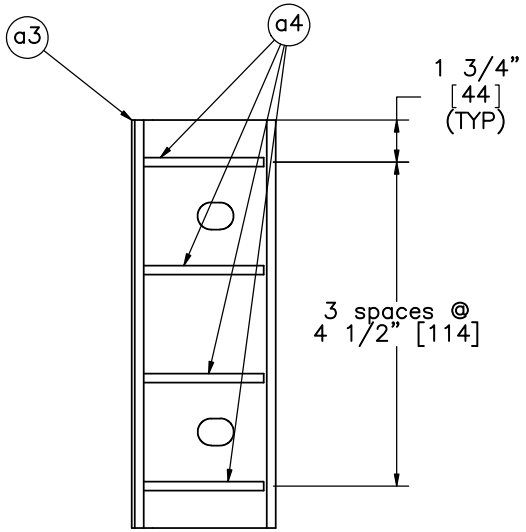


ELEVATION VIEW PROFILE VIEW

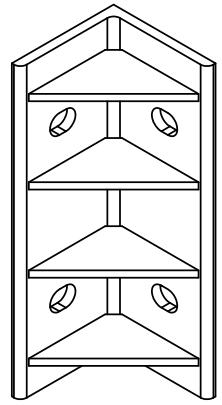
Part a3



PLAN VIEW



ELEVATION VIEW

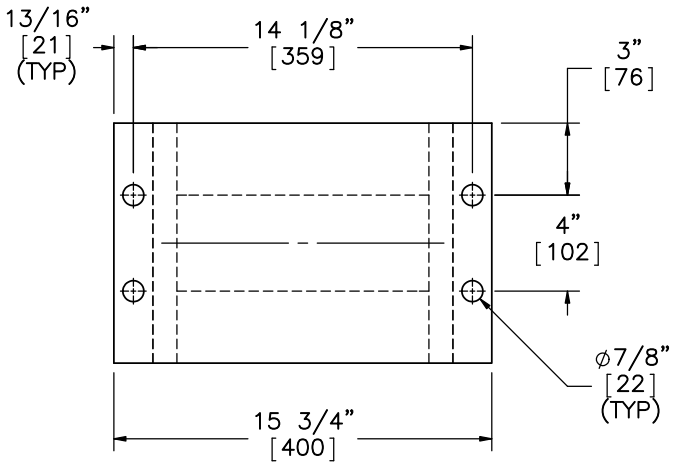


ISOMETRIC VIEW

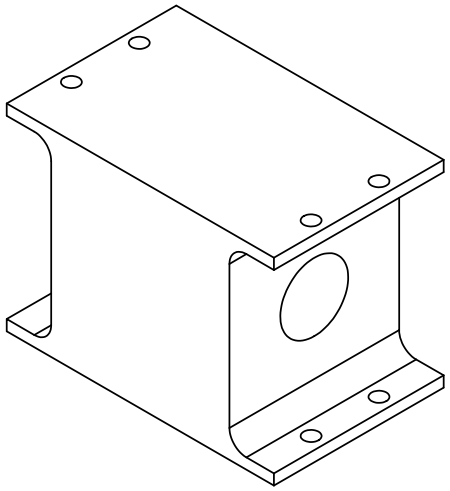
Notes: (1) Slot dimensions measured from exterior points.

(2) Dimensions shown are to center of slot.

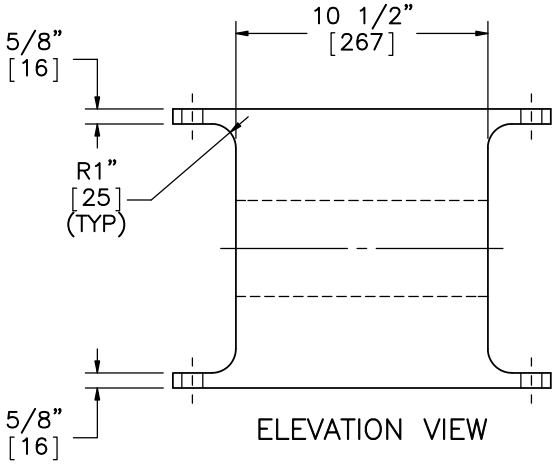
Midwest Roadside Safety Facility	SAFER For Highway – Angle Joint (SFH–3)	SHEET: 20 of 23
		DATE: 10/16/2014
	Angle Joint Details	DRAWN BY: JEK/SDB
	DWG. NAME. SFH–3_AJ_R3 / SCALE: 1:8 / UNITS: in.[mm]	REV. BY: JDS/SKR/KAL



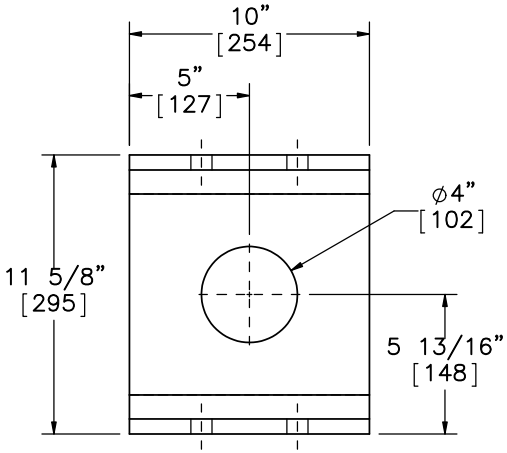
PLAN VIEW



ISOMETRIC VIEW



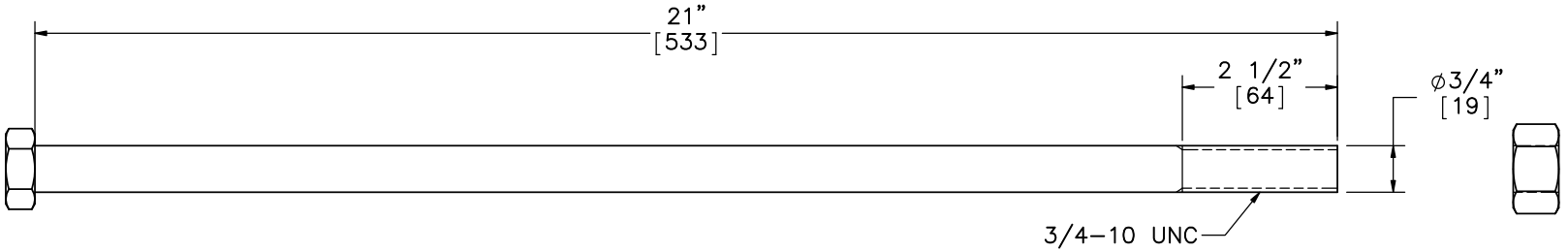
ELEVATION VIEW



PROFILE VIEW

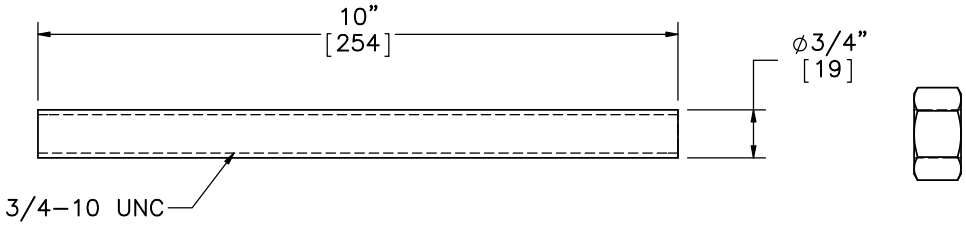
Part a2

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



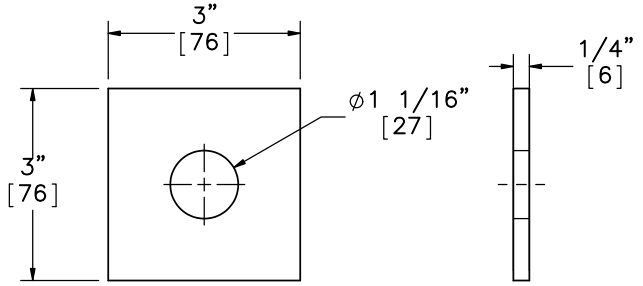
ELEVATION VIEW
Part b1

ELEVATION VIEW
Part b3

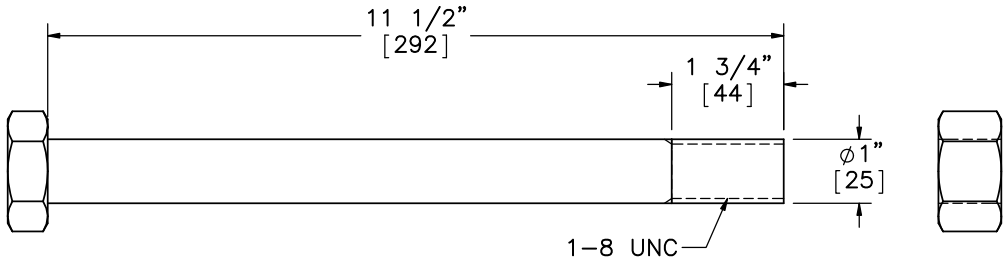


ELEVATION VIEW
Part b2

ELEVATION VIEW
Part b3

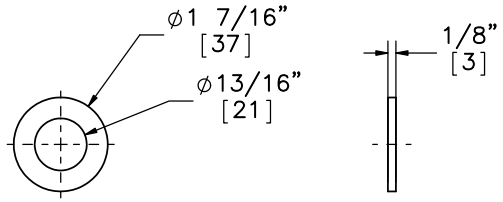


ELEVATION VIEW PROFILE VIEW
Part b6

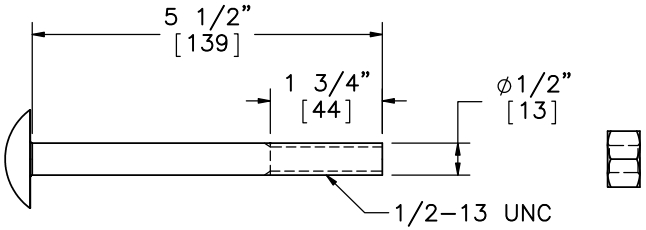


ELEVATION VIEW
Part b5

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.	