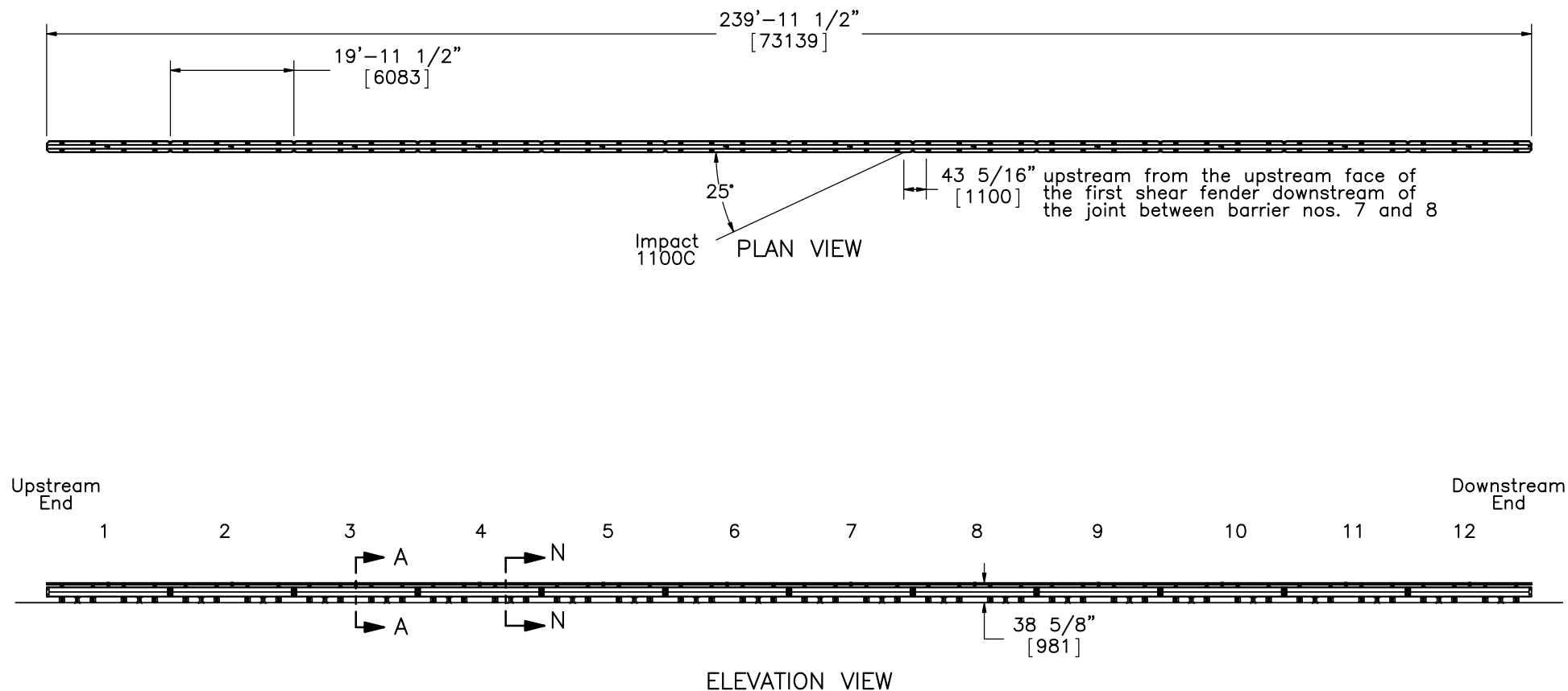




- Notes: (1) Impact location is 43 5/16" [1100] upstream from the upstream face of the first post downstream of the joint between barrier nos. 7 and 8.
- (2) Overall nominal height of barrier may decrease once assembled due to the weight of the rail on rubber.
- (3) Mark existing damage from test no. SFH-1.



Midwest Roadside
Safety Facility

SAFER For Highway –
Angle Joint (SFH-2)

System Layout

DWG. NAME.
SFH-2_R1

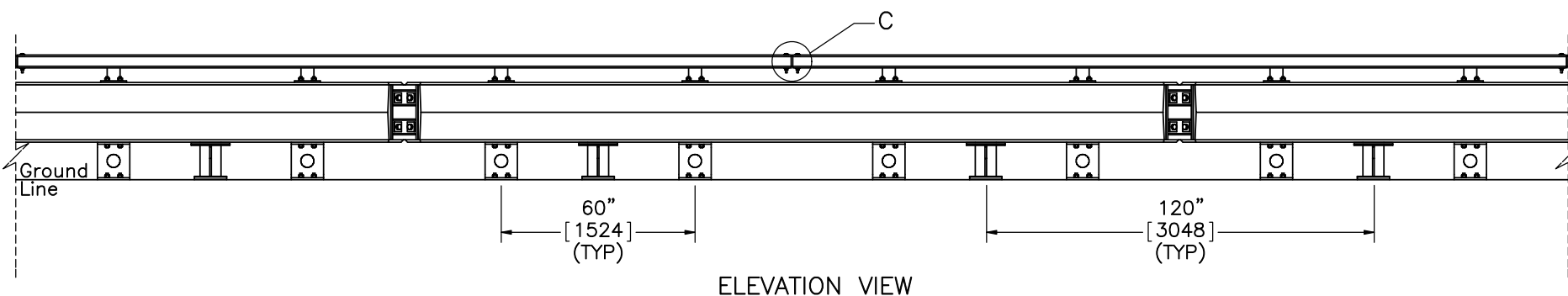
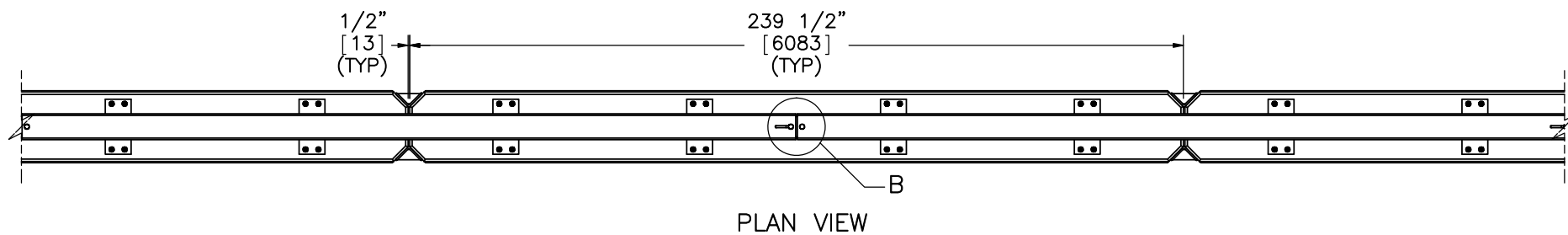
SCALE: 1:300
UNITS: in./mm

SHEET:
1 of 23

DATE:
10/15/2014

DRAWN BY:
SDB

REV. BY:
JDS/SKR/
KAL



Midwest Roadside
Safety Facility

SAFER For Highway -
Angle Joint (SFH-2)

Barrier Assembly

DWG. NAME.
SFH-2_R1

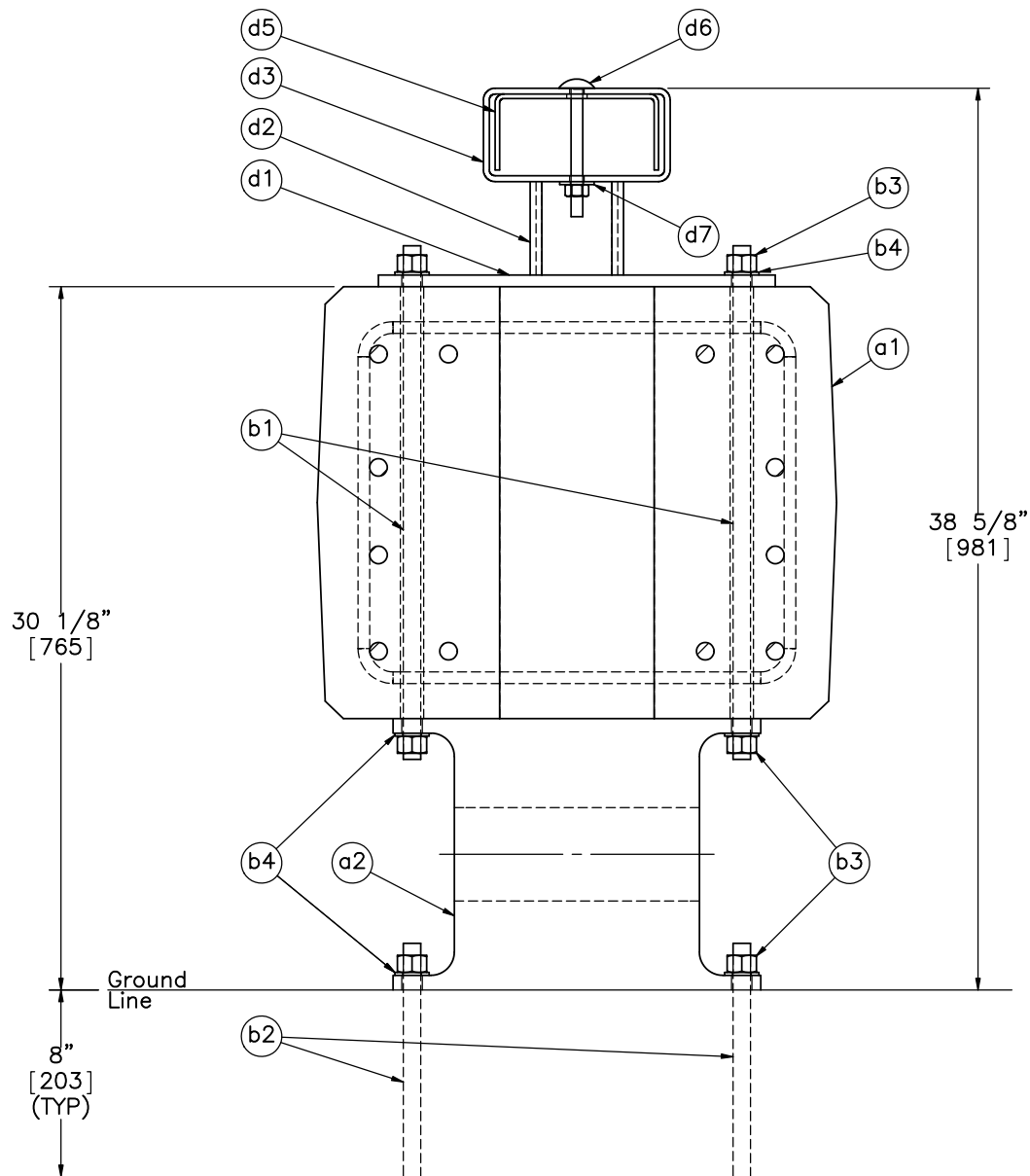
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SHEET:
2 of 23

DATE:
10/15/2014

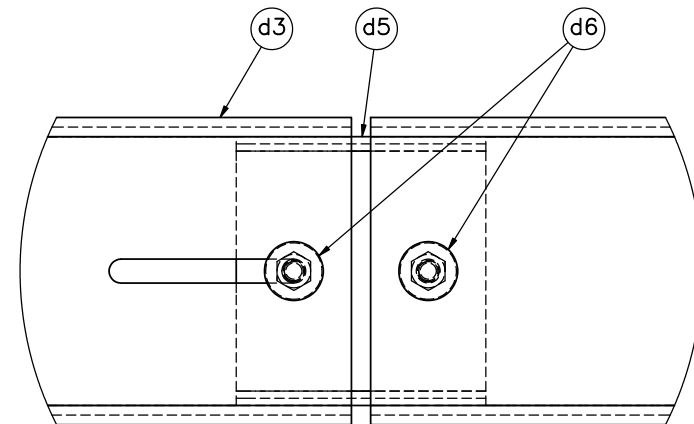
DRAWN BY:
SDB

REV. BY:
JDS/SKR/
KAL

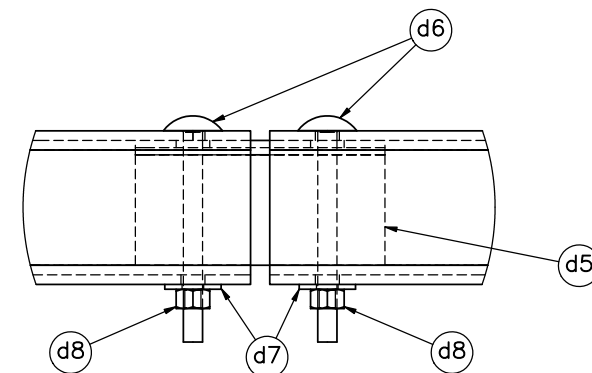


SECTION A-A

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



DETAIL B
SCALE 1 : 5



DETAIL C
SCALE 1 : 5



Midwest Roadside
Safety Facility

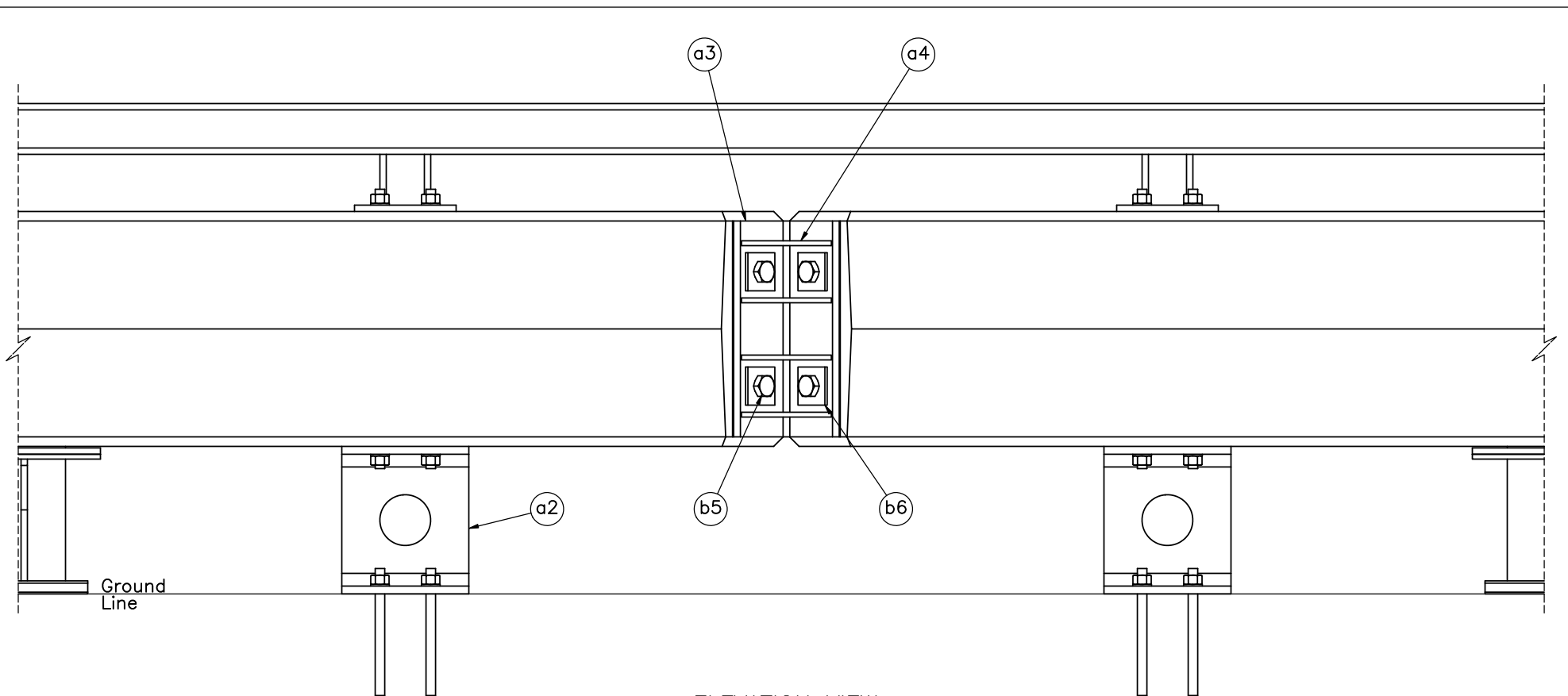
SAFER For Highway -
Angle Joint (SFH-2)

Post and Tubing Details

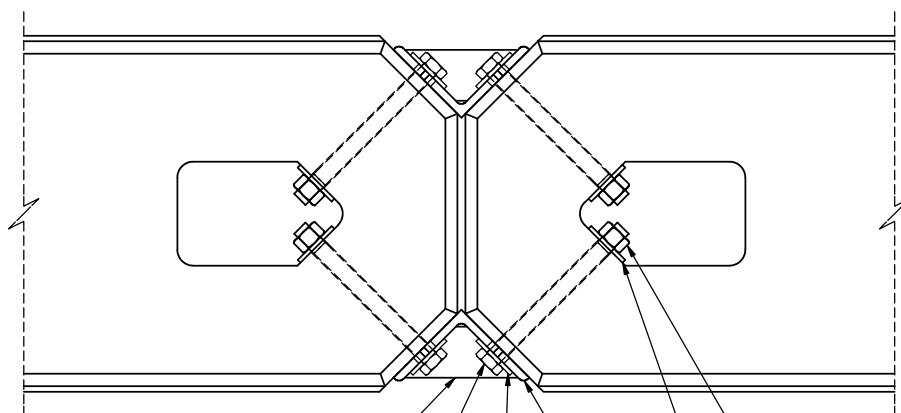
DWG. NAME.
SFH-2_R1

SCALE: 1:8
UNITS: in.[mm]

SHEET:
3 of 23
DATE:
10/15/2014
DRAWN BY:
SDB
REV. BY:
JDS/SKR/
KAL



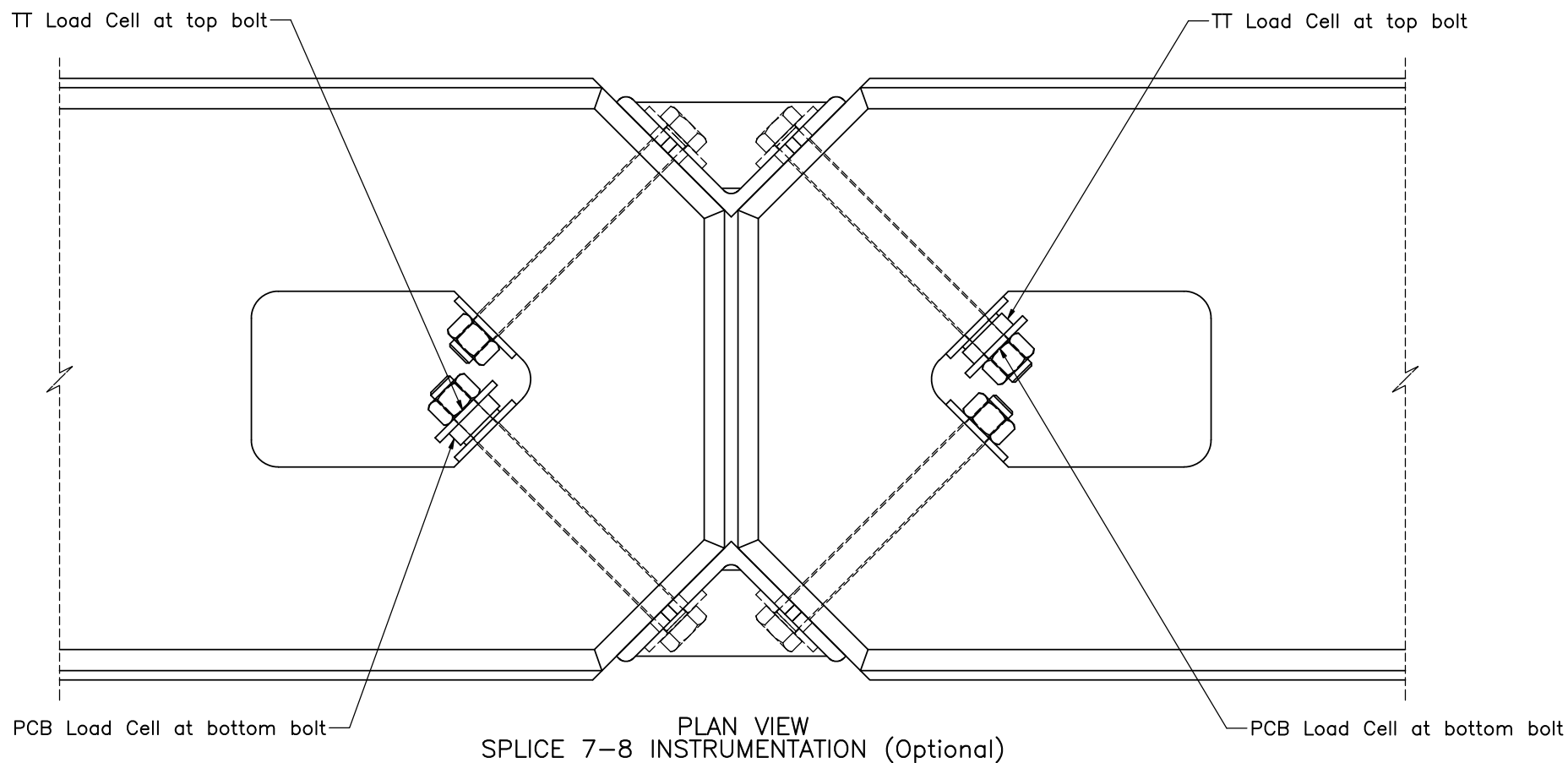
ELEVATION VIEW
SPICE DETAIL



PLAN VIEW
SPICE DETAIL

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

	SAFER For Highway – Angle Joint (SFH-2)		SHEET: 4 of 23
	Splice Details		DATE: 10/15/2014
Midwest Roadside Safety Facility	DWG. NAME: SFH-2_R1		DRAWN BY: SDB
	SCALE: 1:12 UNITS: in./mm		REV. BY: JDS/SKR/ KAL



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.

(6) Load cells were stacked for preload and comparison.



Midwest Roadside
Safety Facility

SAFER For Highway –
Angle Joint (SFH-2)

Splice 7-8 Instrumentation
Details

DWG. NAME:
SFH-2_R1

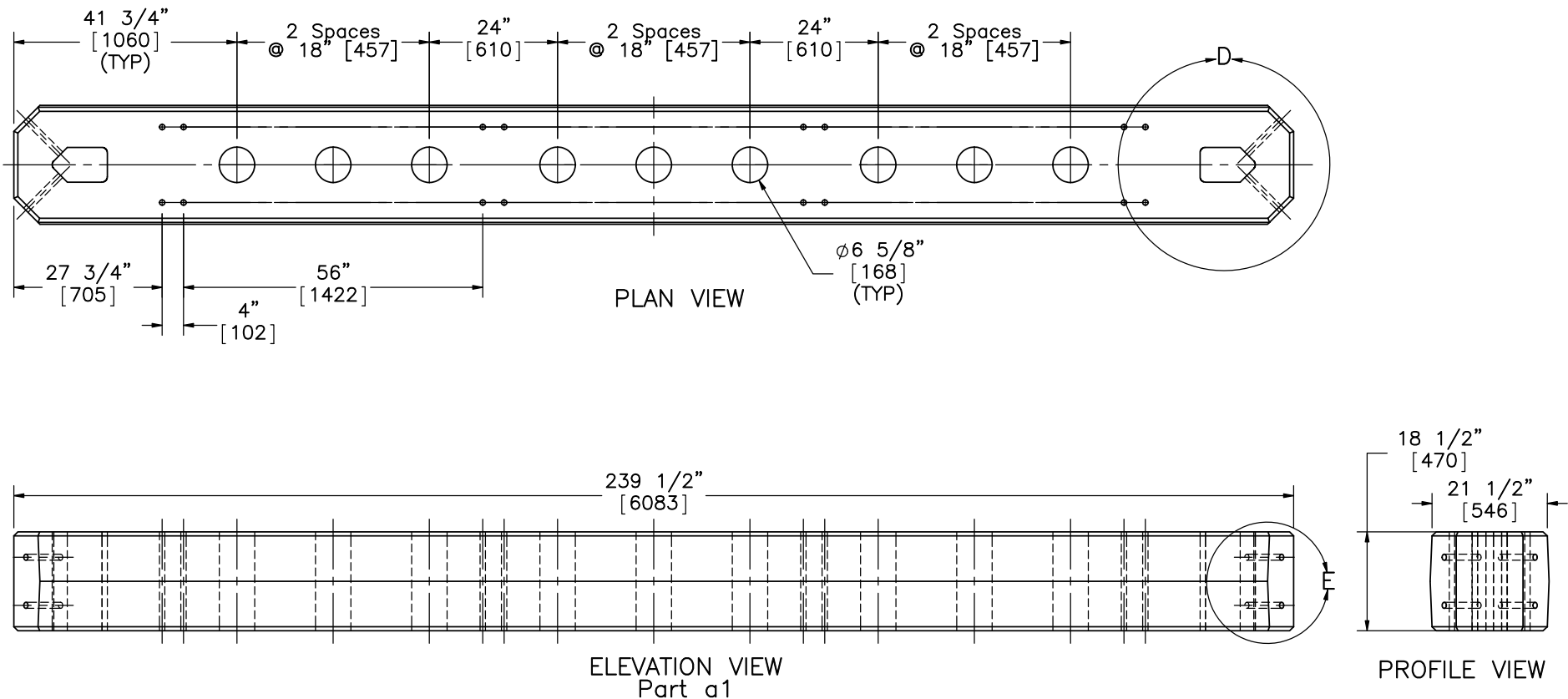
SCALE: 1:6
UNITS: in./mm

SHEET:
5 of 23

DATE:
10/15/2014

DRAWN BY:
SDB

REV. BY:
JDS/SKR/
KAL



- Notes: (1) The $\phi 6 \frac{5}{8}"$ [168] through hole can be cast around a $\phi 6"$ [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.



Midwest Roadside
Safety Facility

SAFER For Highway –
Angle Joint (SFH-2)

Concrete Rail Geometry

DWG. NAME.
SFH-2_R1

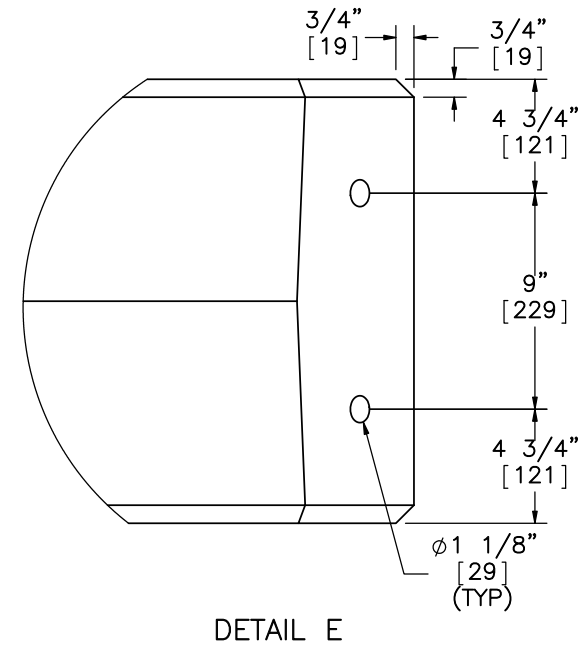
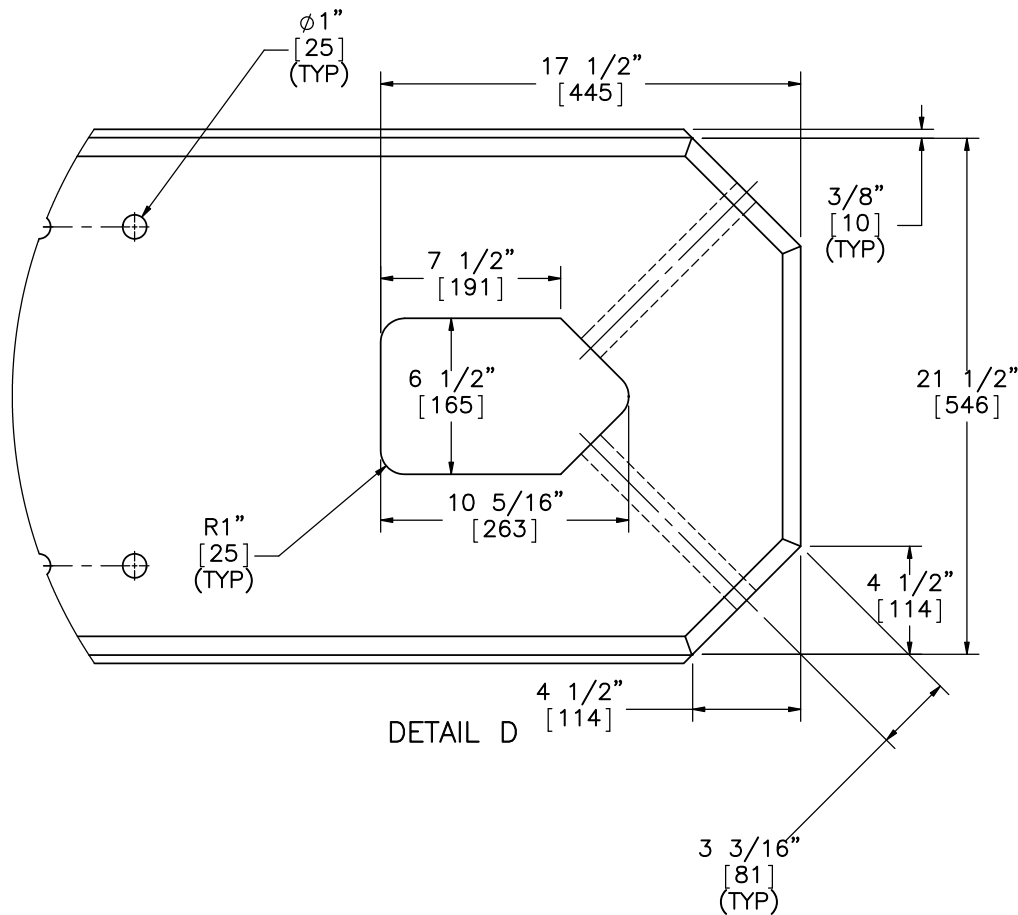
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UNITS: in./mm

SHEET:
6 of 23

DATE:
10/15/2014

DRAWN BY:
SDB

REV. BY:
JDS/SKR/
KAL



- Notes:
- (1) $\phi 1''$ [25] and $\phi 1 \frac{1}{8}''$ [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) $\phi 1 \frac{1}{8}''$ [29] holes to be centered on $4 \frac{1}{2}'' \times 4 \frac{1}{2}''$ [114x114] chamfer.
 - (5) Internal reinforcement not shown.
 - (6) See as-built drawings from concrete industries for accurate rebar placement and more details.



Midwest Roadside
Safety Facility

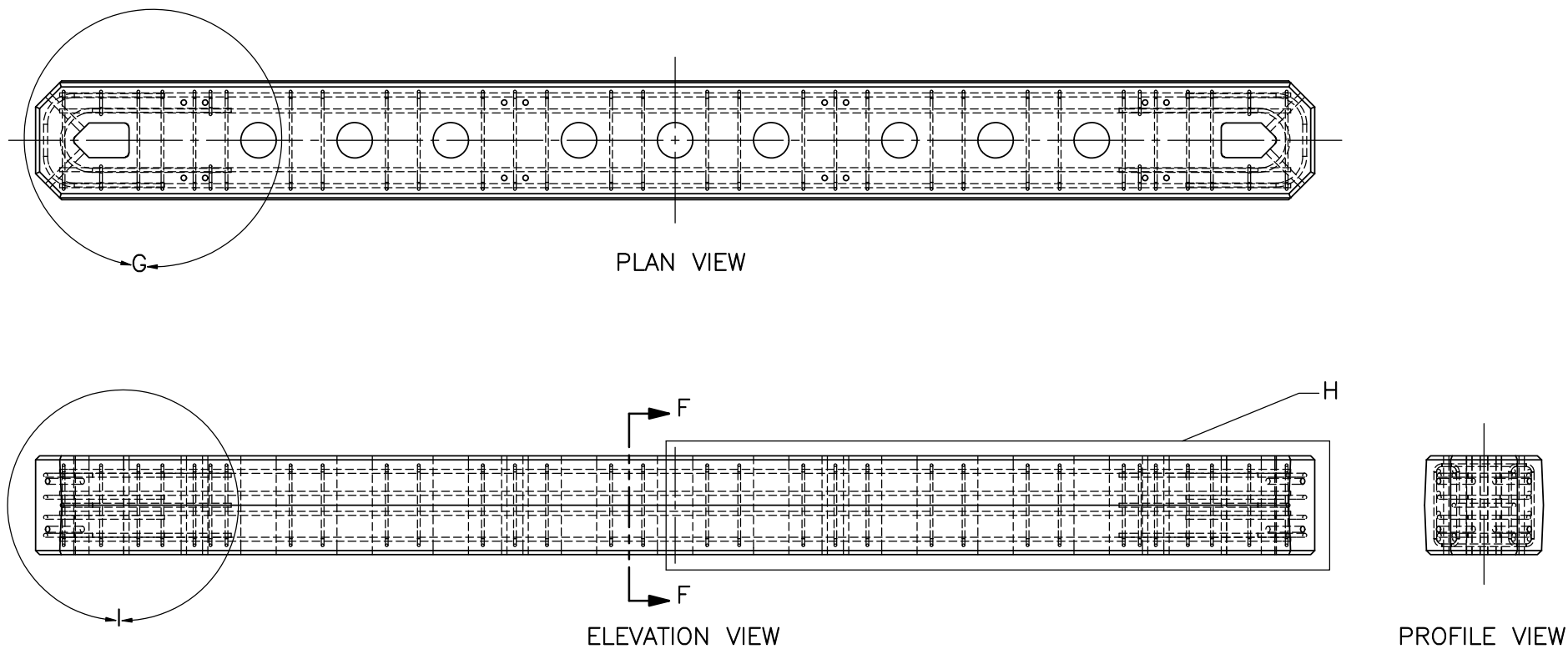
SAFER For Highway –
Angle Joint (SFH-2)

Concrete Rail Details

DWG. NAME.
SFH-2_R1

SCALE: 1:8
UNITS: in.[mm]

SHEET:
7 of 23
DATE:
10/15/2014
DRAWN BY:
SDB
REV. BY:
JDS/SKR/
KAL



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-2)

Concrete Rail and Rebar
Assembly

DWG. NAME:
SFH-2_R1

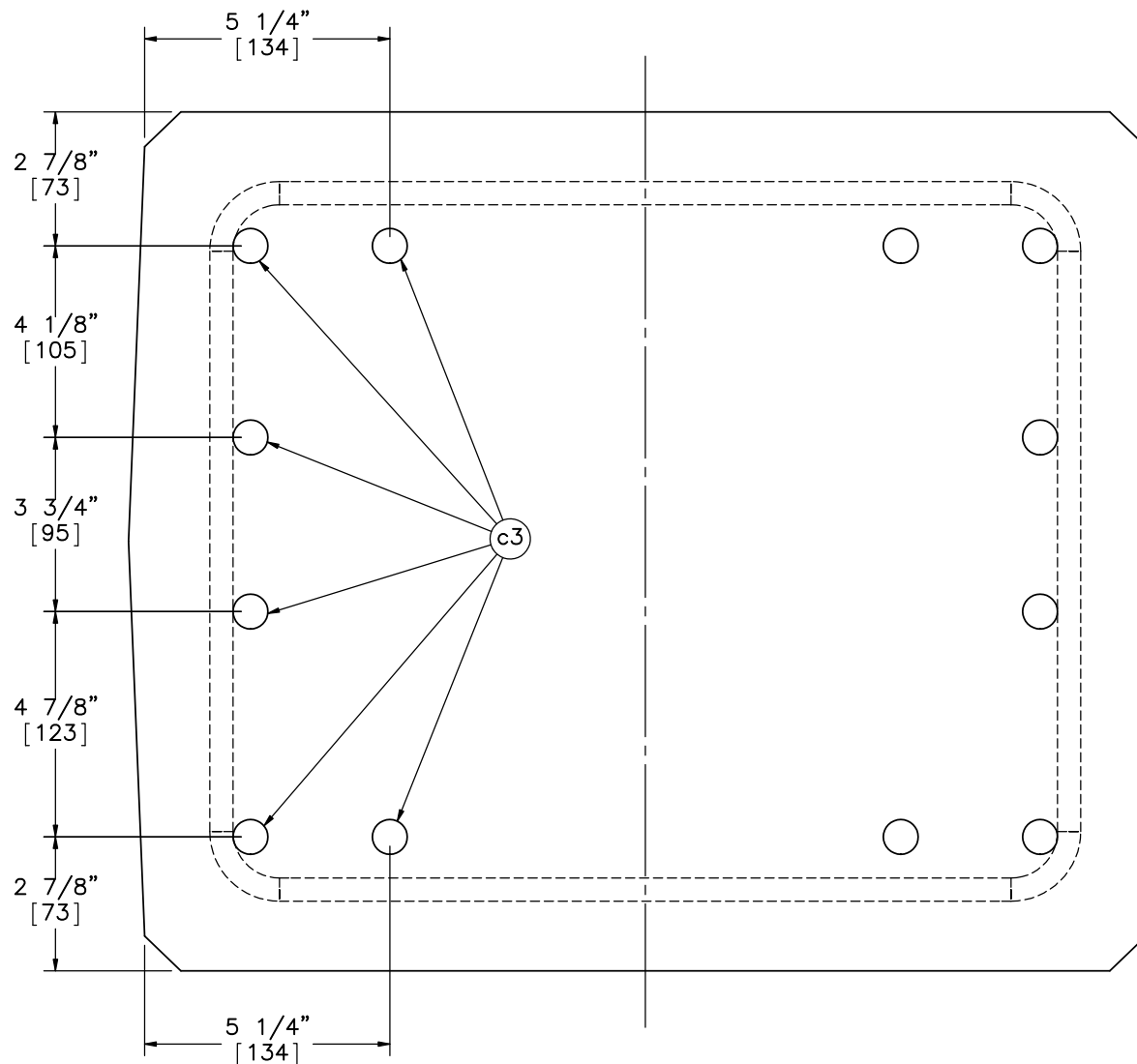
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SHEET:
8 of 23

DATE:
10/15/2014

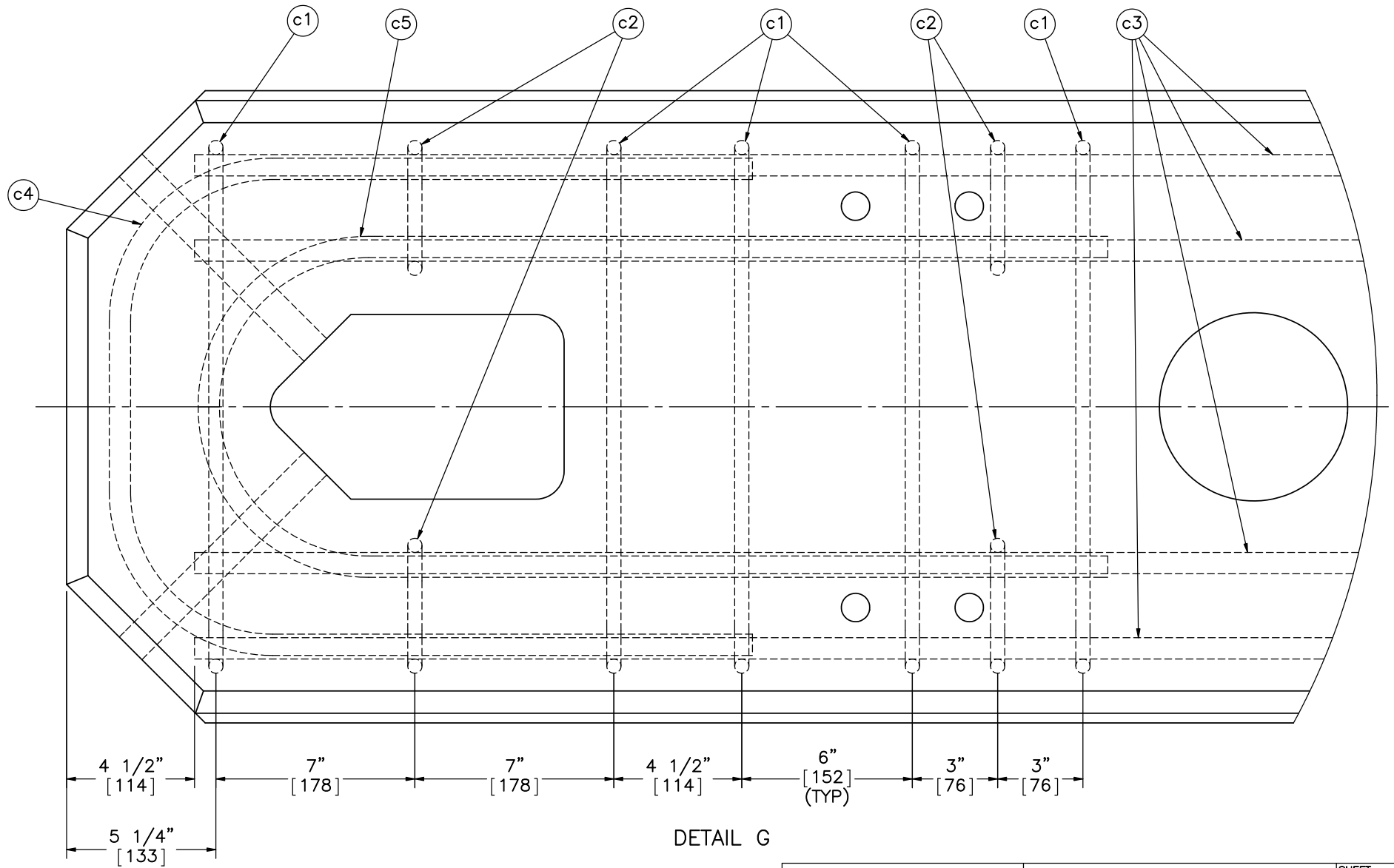
DRAWN BY:
SDB

REV. BY:
JDS/SKR/
KAL



SECTION F-F

	SAFER For Highway – Angle Joint (SFH-2)		SHEET: 9 of 23
	Concrete Rail – Rebar Assembly Details		DATE: 10/15/2014
Midwest Roadside Safety Facility	DWG. NAME: SFH-2_R1		DRAWN BY: SDB
	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-2)

Concrete Rail – Rebar
Assembly Details

DWG. NAME.
SFH-2_R1

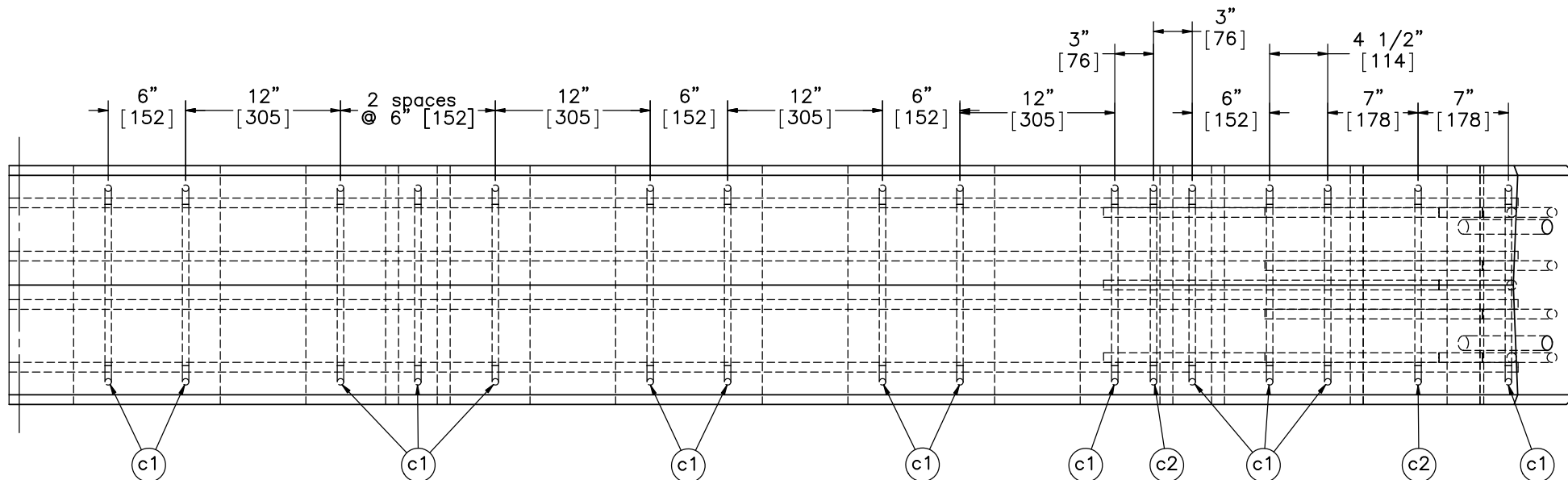
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SHEET:
10 of 23

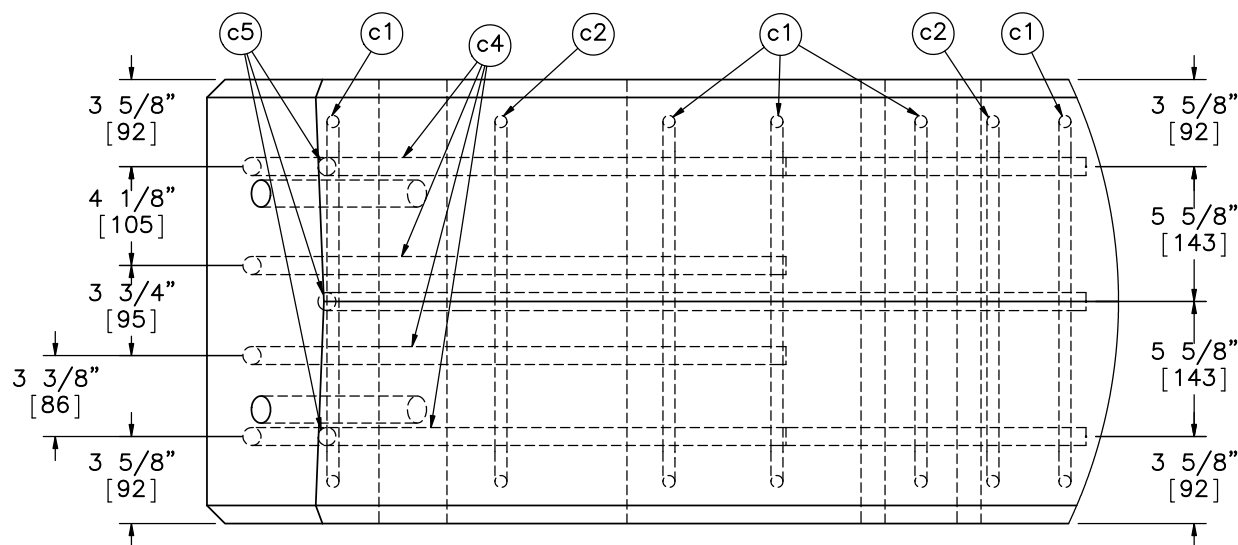
DATE:
10/15/2014

DRAWN BY:
SDB

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.



Midwest Roadside
Safety Facility

SAFER For Highway -
Angle Joint (SFH-2)

Concrete Rail - Rebar
Assembly Details

DWG. NAME:
SFH-2_R1

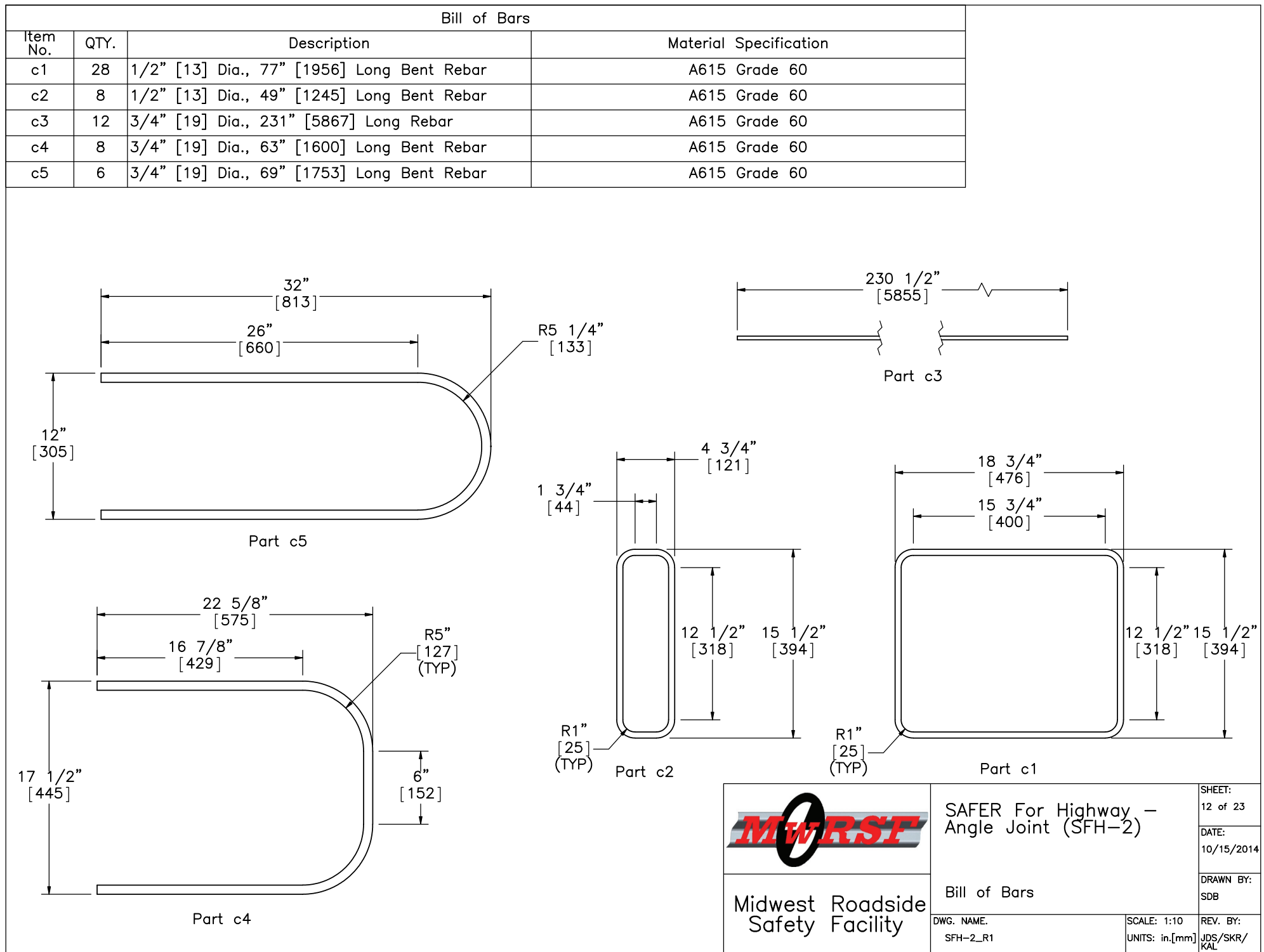
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UNITS: in./mm

SHEET:
11 of 23

DATE:
10/15/2014

DRAWN BY:
SDB

REV. BY:
JDS/SKR/
KAL



Midwest Roadside
Safety Facility

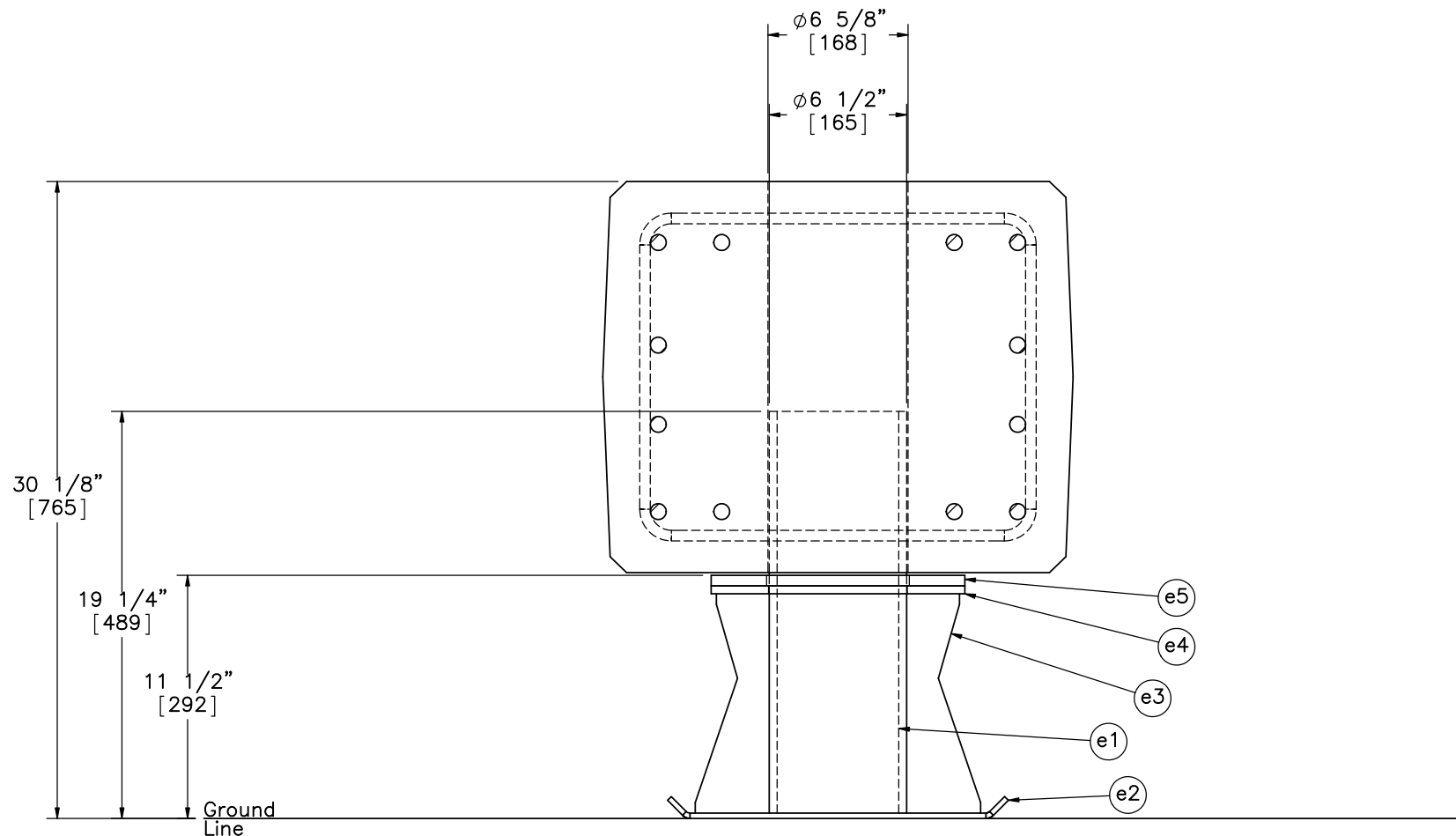
SAFER For Highway –
Angle Joint (SFH-2)

Bill of Bars

DWG. NAME.
SFH-2_R1

SCALE: 1:10
UNITS: in.[mm]

SHEET:
12 of 23
DATE:
10/15/2014
DRAWN BY:
SDB
REV. BY:
JDS/SKR/
KAL



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-2)

Skid Details

DWG. NAME.
SFH-2_R1

SCALE: 1:8
UNITS: in.[mm]

SHEET:
13 of 23
DATE:
10/15/2014
DRAWN BY:
SDB
REV. BY:
JDS/SKR/
KAL

SAFER For Highway –
Angle Joint (SFH-2)

Skid Assembly Details

DWG. NAME.	SFH-2_R1
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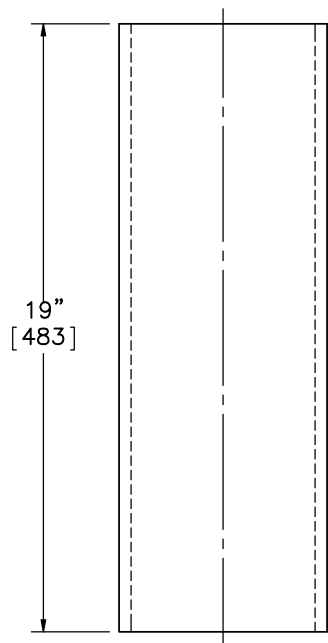
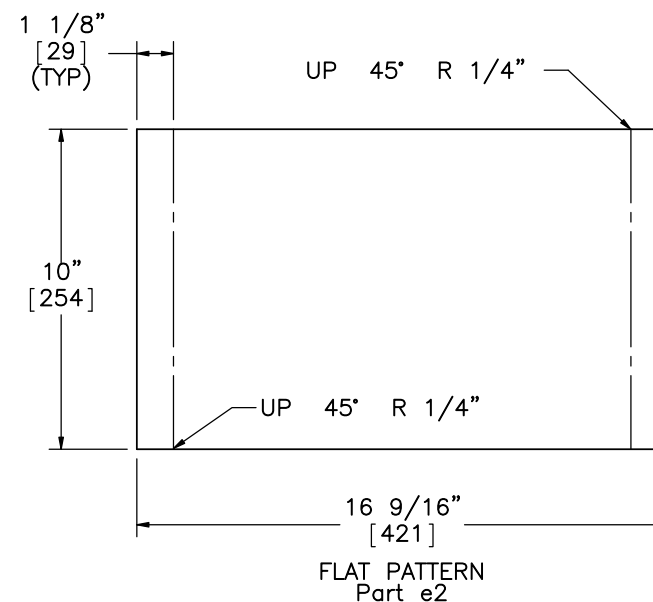
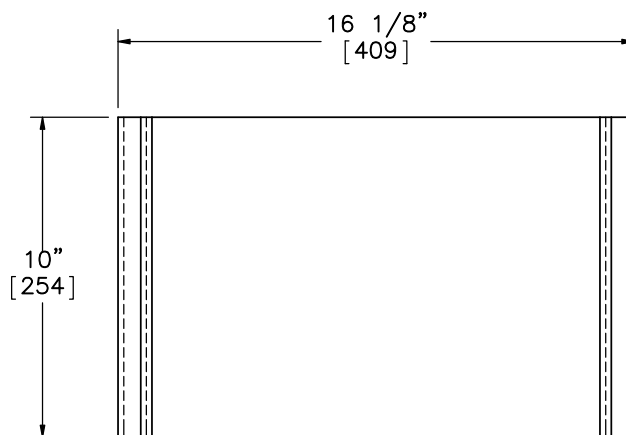
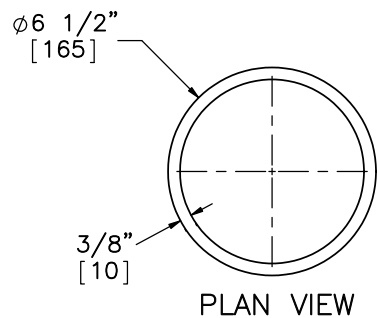
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UNITS: in.[mm]

SHEET:
14 of 23

DATE:	10/15/2014
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DRAWN BY:
SDB

	REV. BY:
m]	JDS/SKR/ KAI



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.



Midwest Roadside
Safety Facility

SAFER For Highway –
Angle Joint (SFH-2)

Skid Component Details

DWG. NAME.
SFH-2_R1

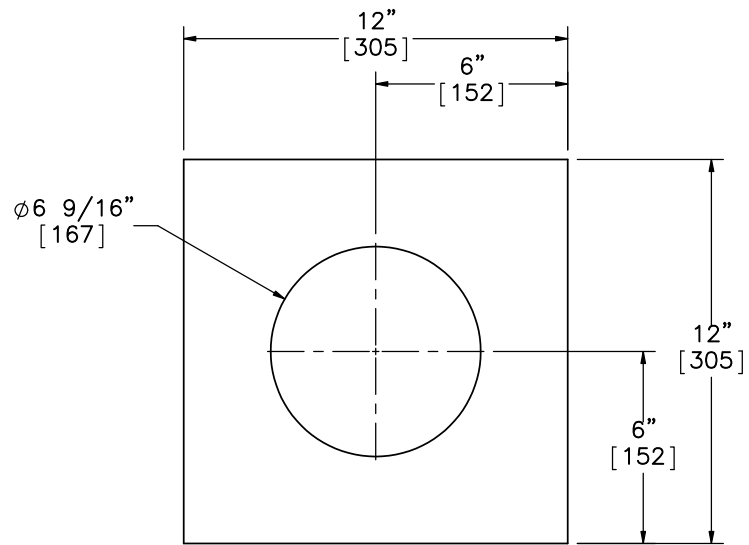
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SHEET:
15 of 23

DATE:
10/15/2014

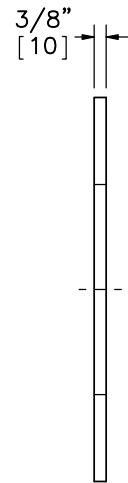
DRAWN BY:
SDB

REV. BY:
JDS/SKR/
KAL

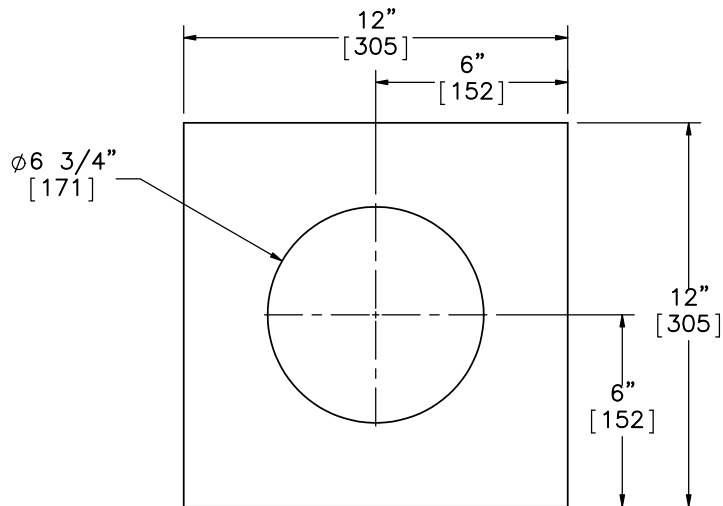


PLAN VIEW

Part e4

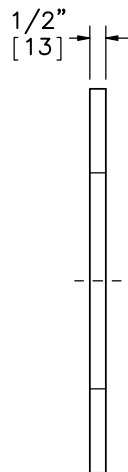


PROFILE VIEW

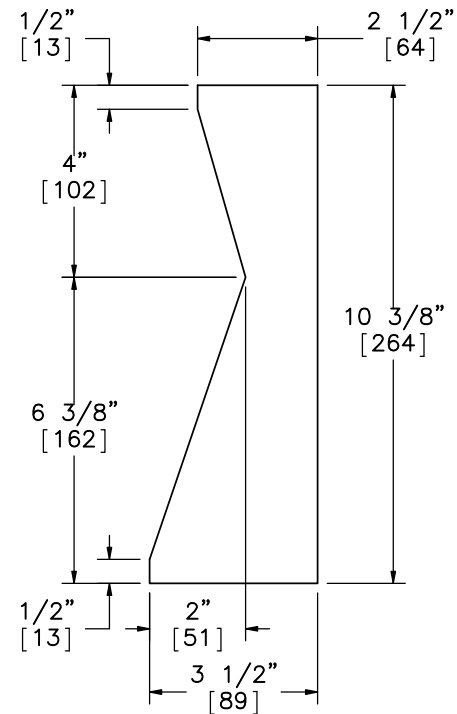


PLAN VIEW

Part e5

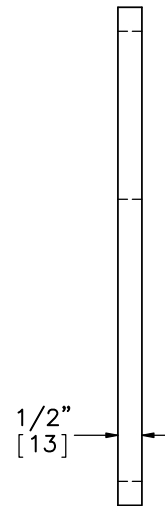


PROFILE VIEW



ELEVATION VIEW

Part e3
SCALE 1:4



PROFILE VIEW



Midwest Roadside
Safety Facility

SAFER For Highway –
Angle Joint (SFH-2)

Skid Top Plate Details

DWG. NAME.
SFH-2_R1

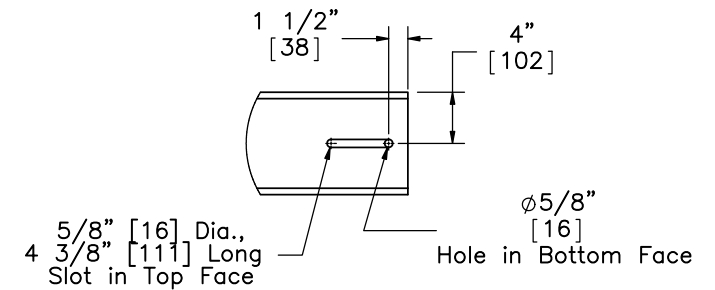
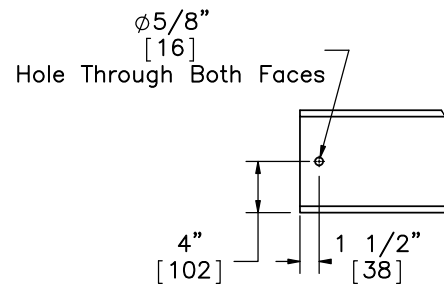
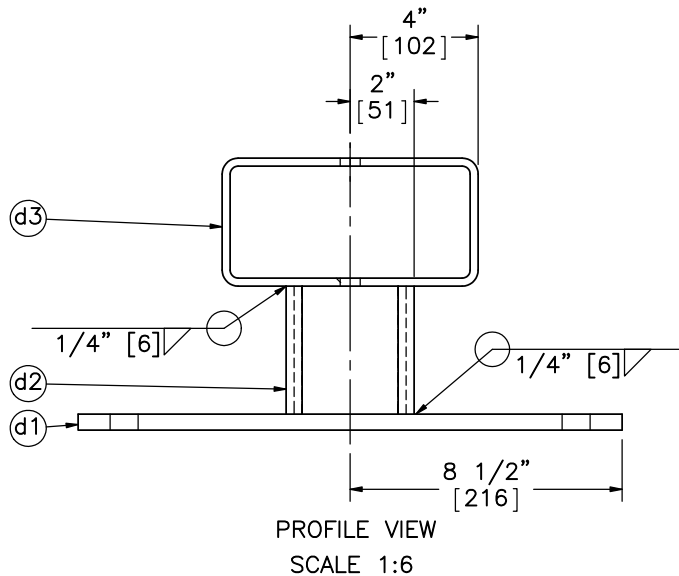
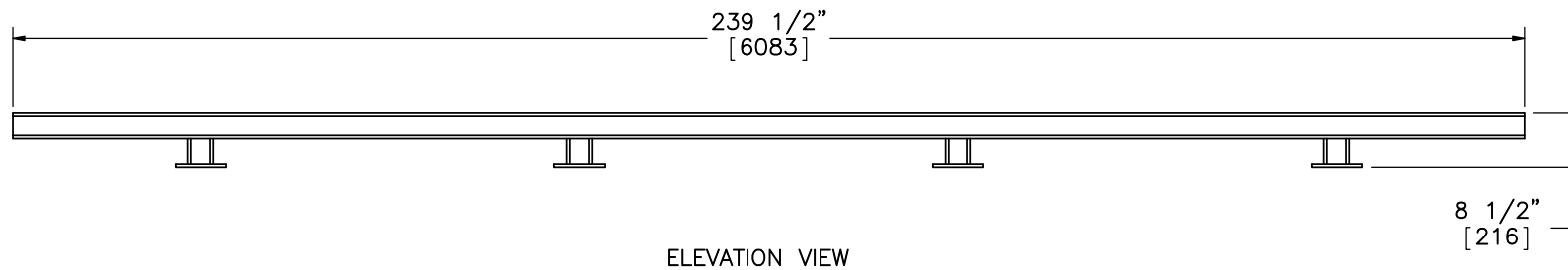
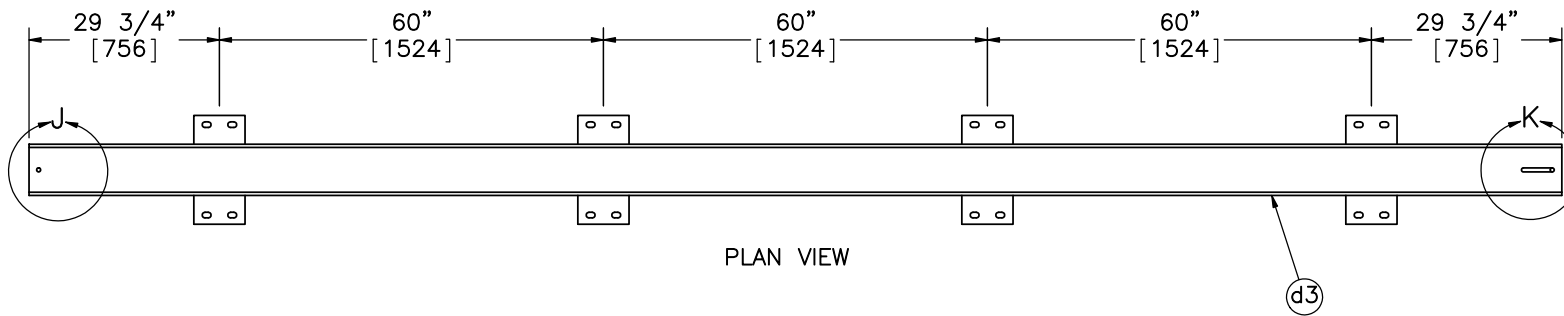
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SHEET:
16 of 23

DATE:
10/15/2014

DRAWN BY:
SDB

REV. BY:
JDS/SKR/
KAL



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



Midwest Roadside
Safety Facility

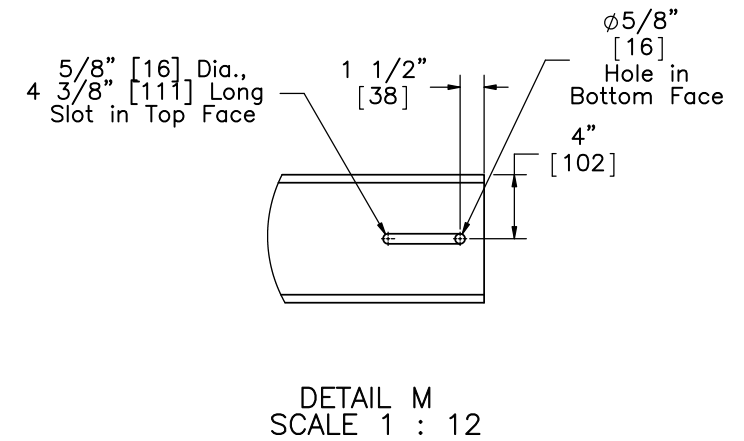
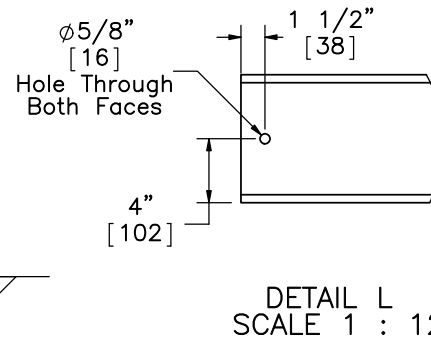
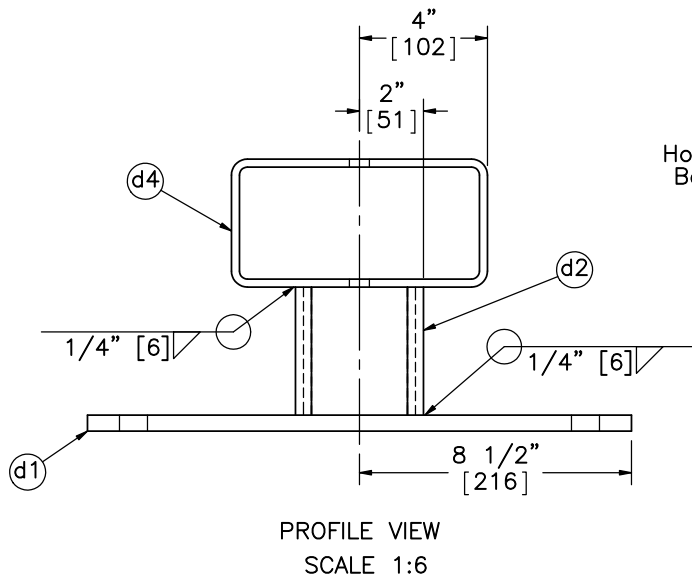
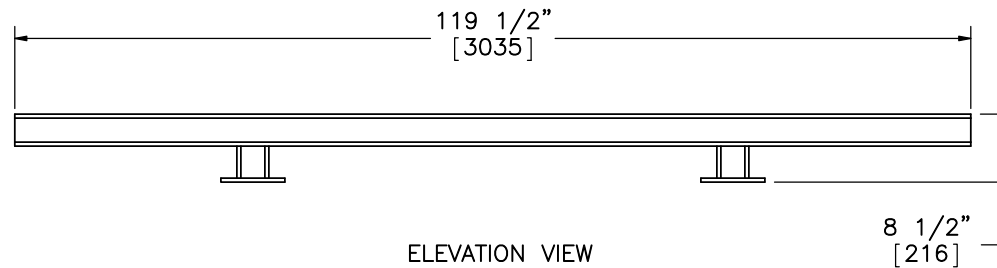
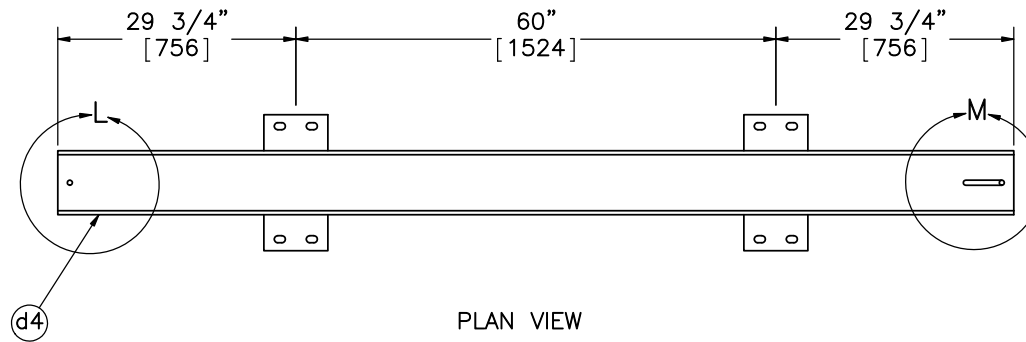
SAFER For Highway –
Angle Joint (SFH-2)

Steel Rail Assembly

DWG. NAME.
SFH-2_R1

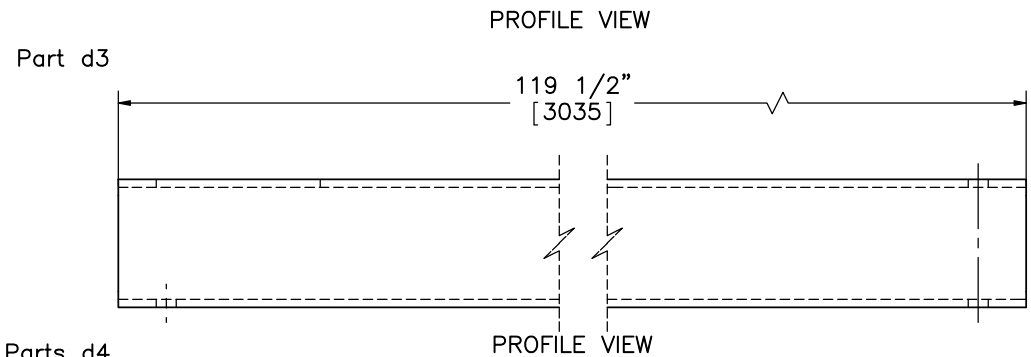
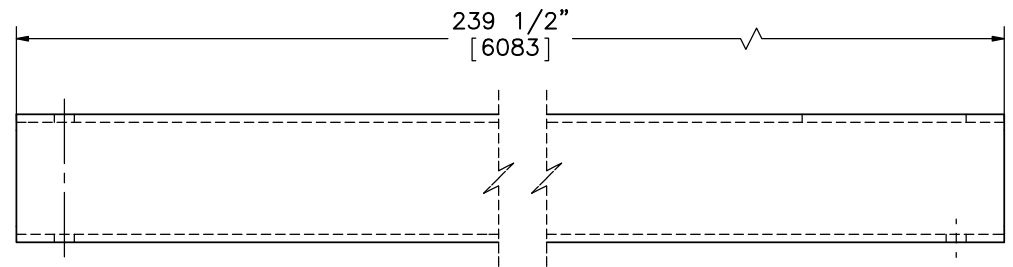
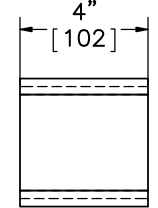
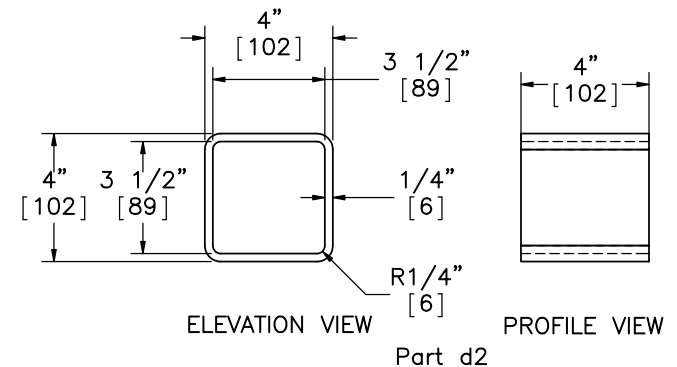
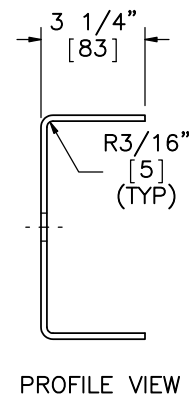
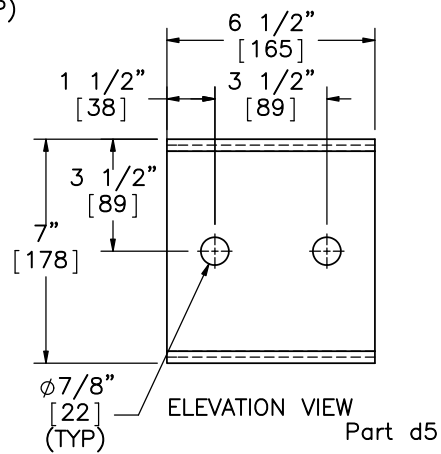
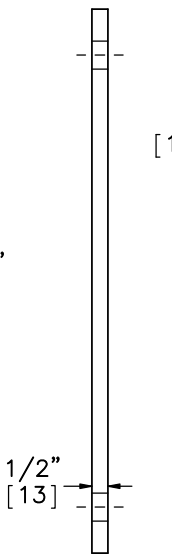
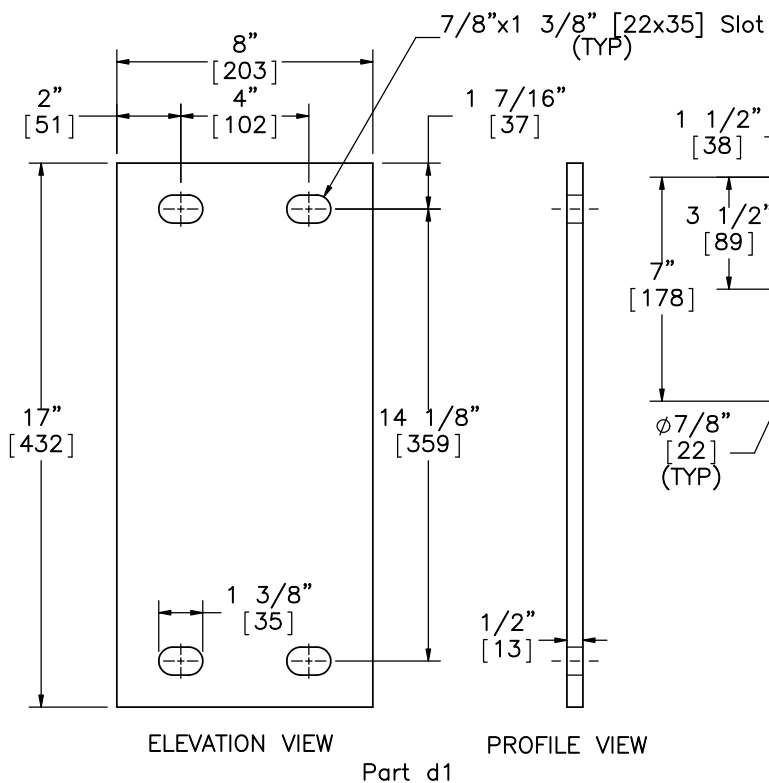
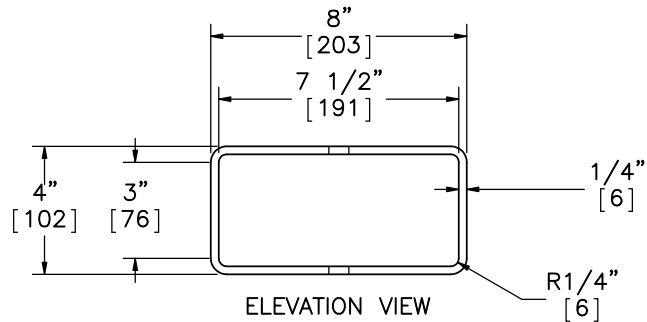
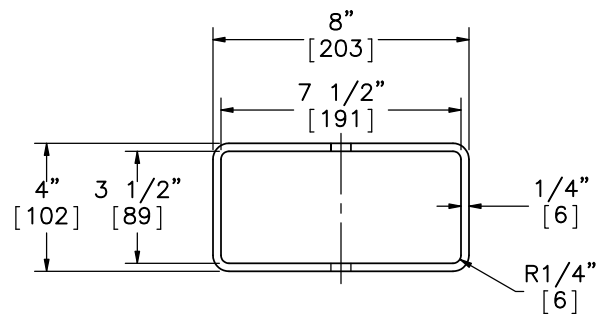
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SHEET:
17 of 23
DATE:
10/15/2014
DRAWN BY:
SDB
REV. BY:
JDS/SKR/
KAL

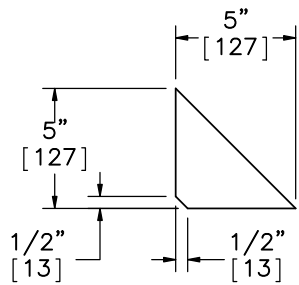


NOTE: (1) Dimensions are symmetric across the center line.
(2) Slot dimensions are measured to far exterior points.

	SAFER For Highway – Angle Joint (SFH-2)		SHEET: 18 of 23
	Steel End Tubing Assembly		DATE: 10/15/2014
Midwest Roadside Safety Facility	DWG. NAME: SFH-2_R1		DRAWN BY: SDB
	SCALE: 1:24 UNITS: in./mm		REV. BY: JDS/SKR/KAL

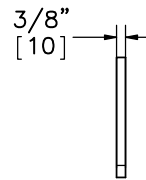


	SAFER For Highway – Angle Joint (SFH-2)		SHEET: 19 of 23
	Steel Rail Components		DATE: 10/15/2014
Midwest Roadside Safety Facility	DWG. NAME: SFH-2_R1	SCALE: 1:6 UNITS: in.[mm]	DRAWN BY: SDB REV. BY:

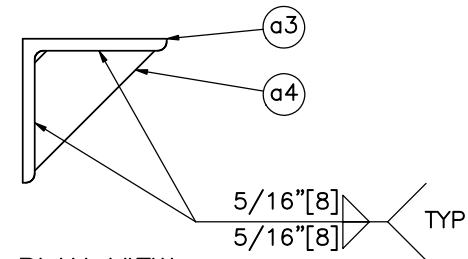


ELEVATION VIEW

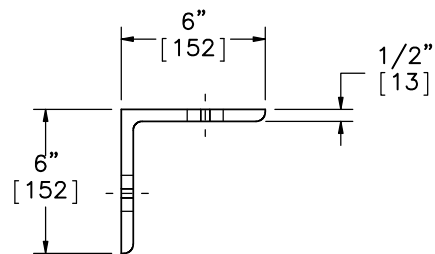
Part a4



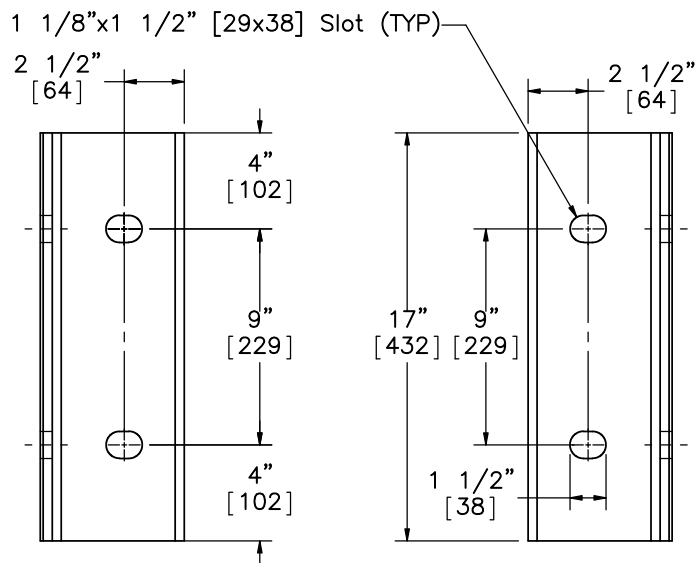
PROFILE VIEW



PLAN VIEW



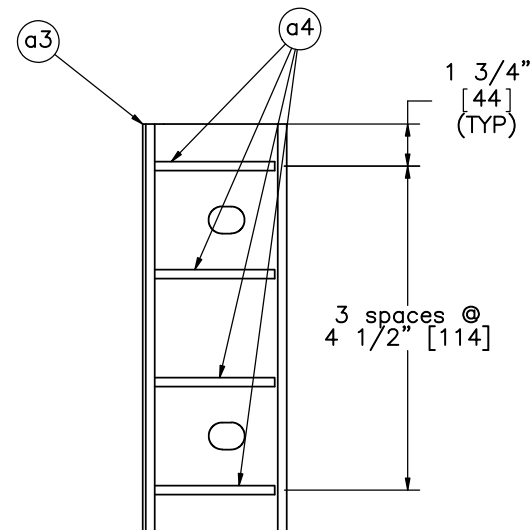
PLAN VIEW



ELEVATION VIEW

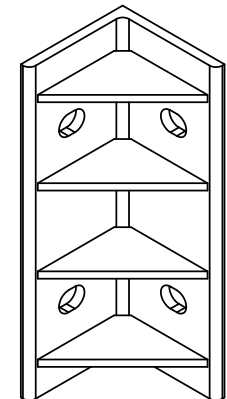
Part a3

PROFILE VIEW



ELEVATION VIEW

- Notes: (1) Slot dimensions measured from exterior points.
(2) Dimensions shown are to center of slot.



ISOMETRIC VIEW



Midwest Roadside
Safety Facility

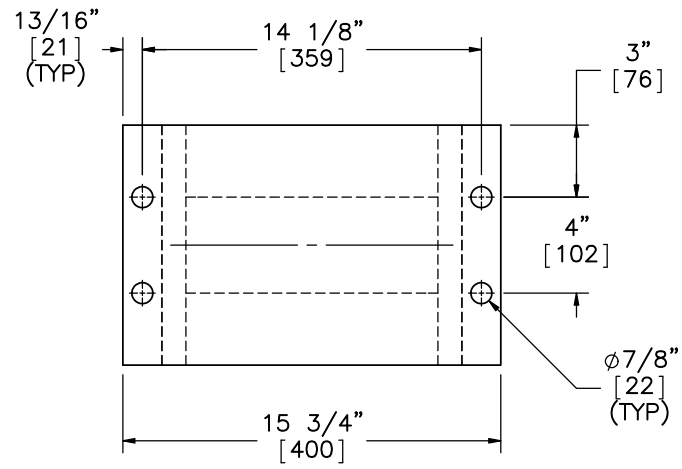
SAFER For Highway –
Angle Joint (SFH-2)

Angle Joint Details

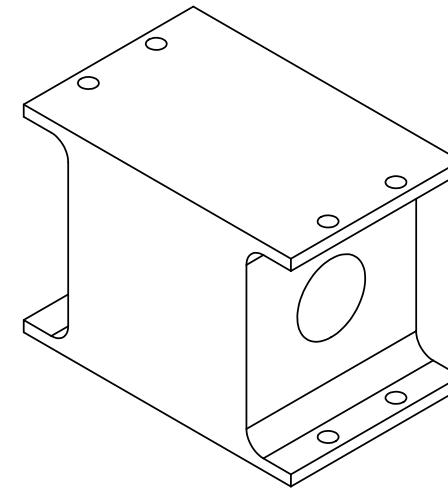
DWG. NAME.
SFH-2_R1

SCALE: 1:8
UNITS: in.[mm]

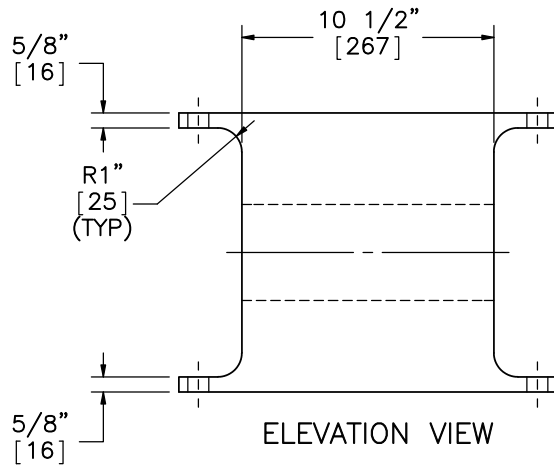
SHEET:
20 of 23
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DRAWN BY:
SDB
REV. BY:
JDS/SKR/
KAL



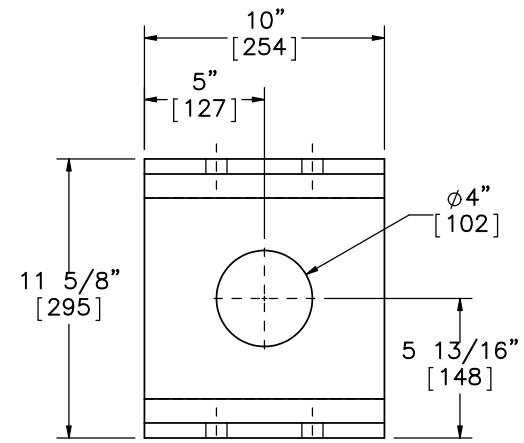
PLAN VIEW



ISOMETRIC VIEW



ELEVATION VIEW



PROFILE VIEW

Part a2



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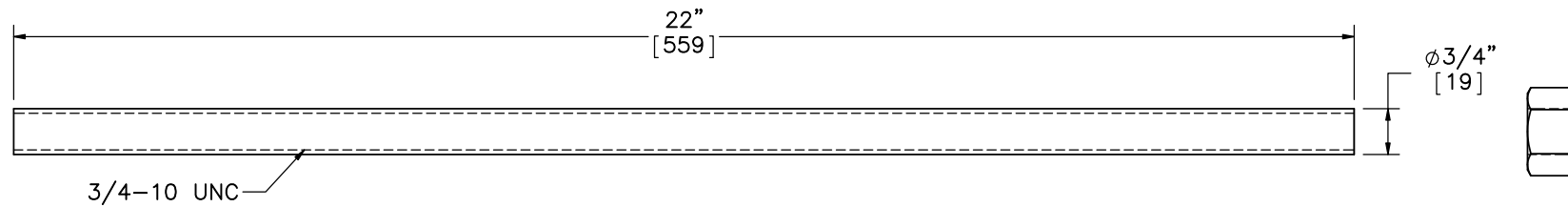
SAFER For Highway –
Angle Joint (SFH-2)

Rubber Post Details

DWG. NAME.
SFH-2_R1

SCALE: 1:8
UNITS: in.[mm]

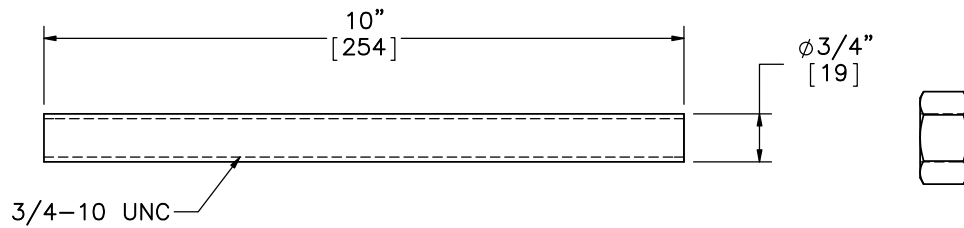
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ELEVATION VIEW
Part b1



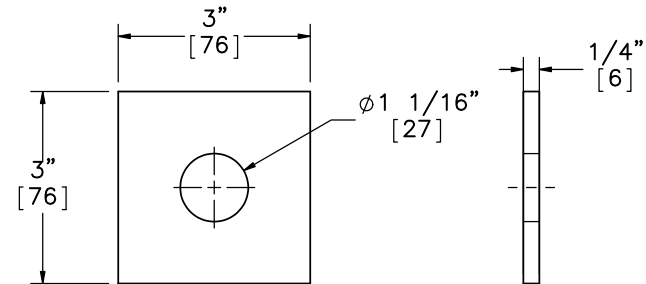
ELEVATION VIEW
Part b3



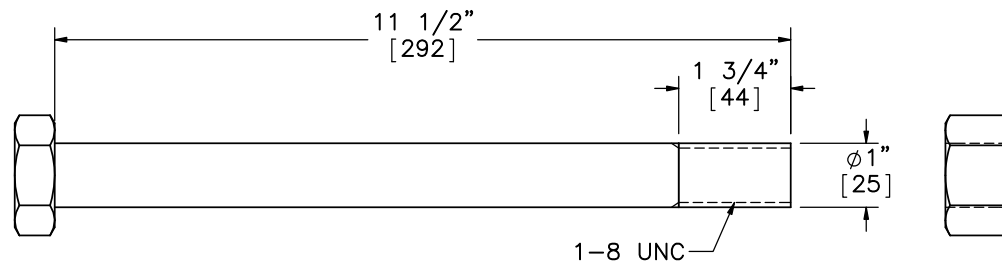
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Part b2



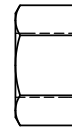
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Part b3



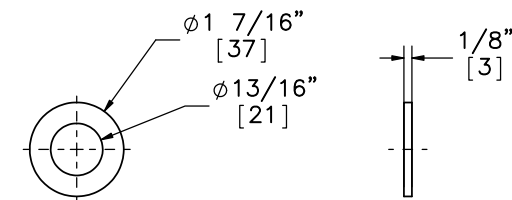
ELEVATION VIEW PROFILE VIEW
Part b6



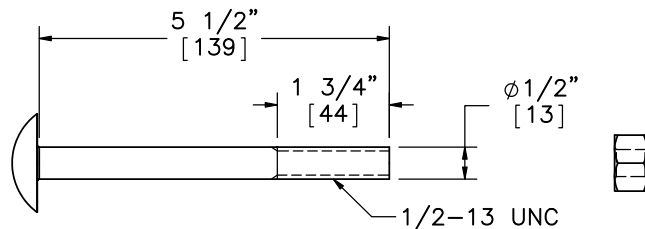
ELEVATION VIEW
Part b5



ELEVATION VIEW
Part b7



ELEVATION VIEW PROFILE VIEW
Part b4



ELEVATION VIEW
Part d6



ELEVATION VIEW
Part d8



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SAFER For Highway -
Angle Joint (SFH-2)

Fastener Details

DWG. NAME.
SFH-2_R1

SCALE: 1:3
UNITS: in.[mm]

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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, 22" [559] Long Threaded Rod	ASTM A193 Grade B7 Galvanized	—
b2	192	3/4" [19] Dia. UNC, 10" [254] Long Threaded Rod	ASTM A193 Grade B7 Galvanized	—
b3	576	3/4" [19] Dia. UNC Heavy Hex Nut	ASTM A194 Grade 2H Galv.	—
b4	576	3/4" [19] Dia. Flat Washer	ASTM F436 Galv.	FWC20b
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	ASTM A563 DH 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	—



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SAFER For Highway –
Angle Joint (SFH-2)

Bill of Materials

DWG. NAME.
SFH-2_R1

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REV.	DATE OF ISSUE	Page	NATURE OF CHANGES	REVISED BY
R0	7/18/2014	–	Derrived fom "SFH_AJ_R7" with altered impact location. 1100C and 43 5/16" US from the US face of the 1st post DS of 7–8 joint.	SDB
R1	10/15/2014	–	Rebar corrected to "as built."	SDB
		5	Load Cells corrected to "as tested"	
		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	Part d6 thread note corrected.	