U.S. Department of Transportation
Federal Highway Administration

August 9, 2021

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

In Reply Refer To:
HSST-1/B-358

Gichuru Muchane
North Carolina Department of Transportation –
Structure Management Unit
1581 MSC,
Raleigh, NC 27699-1581
USA

Dear Mr. Muchane:

This letter is in response to your February 19, 2021 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-358 and is valid until a subsequent letter is issued by FHWA that expressly references this device.

Decision

The following device is eligible within the length-of-need, with details provided in the form which is attached as an integral part of this letter:

- NC Two-bar Metal Bridge Rail

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 AASHTO's 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: NC Two-bar Metal Bridge Rail
Type of system: Longitudinal Barrier
Test Level: TL3
Testing conducted by: Midwest Roadside Safety Facility
Date of request: February 19, 2021

FHWA concurs with the recommendation of the accredited crash testing laboratory on 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. Any modifications to this device should be submitted to the user (i.e., state DOT) as per their requirements.

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-358 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.

- This FHWA eligibility letter is not an expression of any Agency view, position, or determination of validity, scope, or ownership of any intellectual property rights to a specific device or design. Further, this letter does not impute any distribution or licensing rights to the requester. This FHWA eligibility letter determination is made based solely on the crash-testing information submitted by the requester. The FHWA reserves the right to review and revoke an earlier eligibility determination after receipt of subsequent information related to crash testing.

Sincerely,

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

Enclosures

Request for Federal Aid Reimbursement Eligibility of Highway Safety Hardware

Submitter	Date of Request:	February 19, 2021	◉ New ○ Resubmission
	Name:	Gichuru Muchane	
	Company:	North Carolina Department of Transportation - Structures Mgmt. Unit	
	Address:	1581 MSC, Raleigh NC 27699-1581	
	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	NC Two-bar Metal Bridge Rail	AASHTO MASH	TL3

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

Individual or Organization responsible for the product:

Contact Name:	Gichuru Muchane	Same as Submitter ☐
Company Name:	North Carolina Department of Transportation - Structures Mgmt. Unit	Same as Submitter ☒
Address:	1581 MSC, Raleigh NC 27699-1581	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 2-Bar Metal Bridge Rail is for use by NCDOT on State owned and maintained bridges. Neither the Department, nor the testing facility, hold any financial interests in the bridge rail. In addition, the construction details for the bridge rail are not proprietary.

PRODUCT DESCRIPTION

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

The bridge rail design tested was the NC two-bar metal bridge rail system that consisted of a 90-ft long concrete parapet with top-mounted aluminum posts and elliptical rails. The concrete parapet consisted of three 30-ft long segments with 1-in. wide gaps to replicate bridge expansion joints in between segments. The concrete parapet was 14-in. wide and 30-in. tall, except for the two tapered buttress ends at the upstream and downstream ends of the system. The rail system consisted of two elliptical aluminum rail segments that were attached to 16 vertical posts and base plate assemblies. Each post consisted of welded aluminum plates measuring 23½ in. tall and was mounted to a two-piece, cast aluminum base plate assembly, which was mounted to the top of the parapet through embedded bolts. Post nos. 6 through 13, where impact for Test 3-10 occurred, were spaced 72 in. apart. Post nos. 3 through 6, where impact for Test 3-11 occurred, were spaced 78 in. apart. Two elliptical rail segments were mounted on the front side of each aluminum post, through the rails' grooved back slots and clamp bars that were bolted to the posts. The mounting heights of the two aluminum rails were 10 in. and 22 in., respectively, measured vertically from the rail center to the top of the parapet.

The NCDOT two-bar bridge rail system is typically installed on various standard NC bridge deck systems. Based on feedback from NCDOT, the strengths of the barrier-to-deck connection and the stiffness of the bridge deck were deemed sufficient to install the parapet directly to the top surface of the concrete tarmac at the MwRSF Outdoor Test Site to represent typical installations on an NCDOT bridge deck. Vertical attachment of the concrete parapet to the concrete tarmac surface consisted of #5 rebar embedded 6 in. into the tarmac on the front and back sides of the system and spaced 12 in. apart on centers. The end buttresses were anchored to the concrete tarmac using #7 bars epoxied to the tarmac surface, also with an embedment depth of 6 in. to ensure full development of the bars.

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:	Cody Stolle	
Engineer Signature:	Cody Stolle Digitally signed by Cody Stolle DN: cn=Cody Stolle, o=University of Nebraska-Lincoln, ou=Midwest Roadside Safety Facility, email=cstolle2@unl.edu, c=US Date: 2019.11.22 14:19:28 -06'00'	
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
3-10 (1100C)	A 2010 Hyundai Accent (1100C vehicle) traveling at a speed of 63.2 mph impacted the bridge rail at an impact angle of 25.2°. The target critical impact point was at 54.6 in. upstream from post no. 11, which was selected based on MASH recommendations and finite element simulation results. The actual point of impact was at 51.1 in. upstream from post no. 11. Barrier damage was minimal and shown as contact marks on the lower rail, contact marks on the base plate of post no. 11, and contact marks and small concrete gouging across the front face of the parapet. The maximum lateral dynamic barrier deflection was 0.3 in. at post no. 15, as determined from high-speed digital video analysis. Minor splice movement was observed on the lower rail between post nos. 10 and 11: the traffic-side gap was 13/16 in. and the back-side gap was ¾ in. For the top rail between all posts, both front- and back-side gaps were ¾ in. Damage to the vehicle was moderate; the majority of damage occurred on the left-front corner and left side of the vehicle where impact occurred. There were no penetrations into the occupant compartment and none of the established MASH 2016 deformation limits were violated. The maximum occupant compartment deformation was 2.9 in. on the side front panel. It should be noted that windshield displacements were measured three days after testing. The maximum windshield displacement of 5.0 in. was artificially high due to settling that occurred in between testing and measurement. The measured displacement of 5.0 in. was not believed to be realistic, and was therefore not considered a violation of MASH 2016 safety performance criteria. Additionally, none of the MASH criteria for windshield contact, protrusion, or deformation were violated. The front-left window disengaged from the vehicle after contact with the dummy's head and the remaining window glass was undamaged. The 1100C vehicle was contained and redirected by the bridge rail without penetrating or overriding the barrier. The test vehicle remained upright during and after impact, with a maximum roll angle of 12.6° and a maximum pitch angle of 5.0°. The longitudinal and lateral OIVs were 24.5 ft/s and 30.8 ft/s, respectively. The longitudinal and lateral ORAs were 3.65 g and 12.8 g, respectively.	PASS

Required Test Number	Narrative Description	Evaluation Results
3-11 (2270P)	A 2015 Chevrolet Silverado quad cab (2270P vehicle) traveling at a speed of 61.9 mph impacted the bridge rail at an impact angle of 24.9°. The target critical impact point was at 61-15/16 in. upstream from post no. 6, which was selected based on MASH recommendations and finite element simulation results. The actual point of impact was at 61-7/8 in. upstream from post no. 6. Barrier damage was minimal and shown as contact marks on lower and upper rails, contact marks on upstream front flanges of post nos. 6, and 7, contact marks and small concrete gouging across the front face of the parapet, and minor concrete breakout on the upstream edge of the second parapet segment at the expansion joint. The maximum lateral dynamic barrier deflection was 0.8 in. on the upper rail between post nos. 5 and 6, as determined from high-speed digital video analysis. The splices between the first and second rail segments experienced minor elongation, measuring 7/8 in. on both the front- and back-side of the upper and lower rails. Damage to the vehicle was moderate; the majority of damage occurred on the left-front corner and left side of the vehicle where impact occurred. There were no penetrations into the occupant compartment and none of the established MASH 2016 deformation limits were violated. The maximum occupant compartment deformation was 1.6 in. on both the side front panel and the side door above seat. During the test, the driver-side window glass was ejected and shattered due to contact with the dummy's head. The test article did not cause the window glass to shatter. The 2270P vehicle was adequately contained and redirected by the bridge rail without penetrating or overriding the barrier. The test vehicle remained upright during and after impact, with a maximum roll angle of 9.3° and a maximum pitch angle of 3.0°. The longitudinal and lateral OIVs were 21.5 ft/s and 27.9 ft/s, respectively. The longitudinal and lateral ORAs were 5.09 g and 13.4 g, respectively.	PASS
3-20 (1100C)	Test no. 3-20 is not applicable for this type of system.	Non-Relevant Test, not conducted
3-21 (2270P)	Test no. 3-21 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:	Cody Stolle — Digitally signed by Cody Stolle DN: cn=Cody Stolle, o=University of Nebraska-Lincoln, ou=Midwest Roadside Safety Facility, email=cstolle2@unl.edu, c=US Date: 2019.11.22 14:19:43 -06'00'	
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*: Gichuru Muchane — Digitally signed by Gichuru Muchane Date: 2021.02.15 12:35:29 -05'00'

Submit Form

ATTACHMENTS

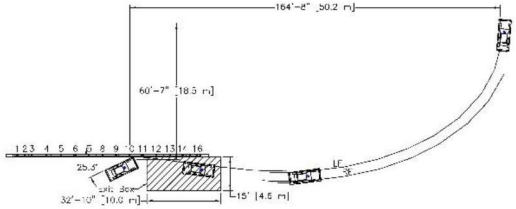
Attach to this form:

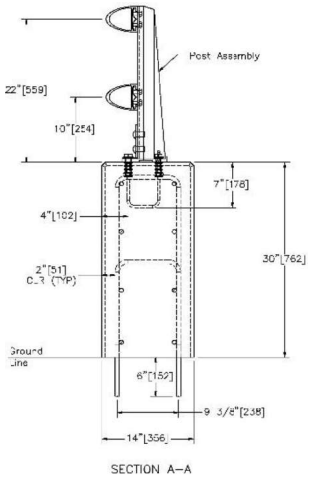
1) Additional disclosures of related financial interest as indicated above.
2) A copy of the full test report, video, and a Test Data Summary Sheet for each test conducted in support of this request.
3) A drawing or drawings of the device(s) that conform to the Task Force-13 Drawing Specifications [Hardware 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

0.000 sec 0.050 sec 0.100 sec 0.200 sec 0.300 sec



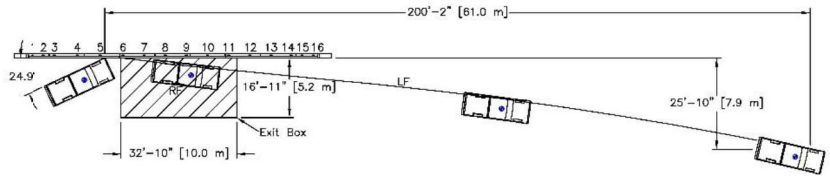


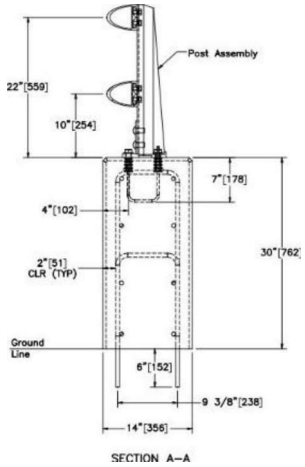
- Test Agency ..... MwRSF
- Test Number NCBR-1
- Date ..... May 13, 2019
- MASH 2016 Test Designation No. 3-10
- Test Article ..... NCDOT Two-Bar Metal Bridge Rail
- Total Length ..... 90 ft
- Key Component – Elliptical Aluminum Rail
  - Length ..... 30 ft
  - Width ..... 4 in.
  - Depth ..... 4¾ in.
- Key Component – Aluminum Post
  - Height ..... 23½ in.
  - Length ..... 5¾ in.
  - Width ..... 4¼ in.
  - Spacing ..... 72 in.
- Vehicle Make / Model ..... 2010 Hyundai Accent
  - Curb ..... 2,505 lb
  - Test Inertial ..... 2,425 lb
  - Gross Static ..... 2,585 lb
- Impact Conditions
  - Speed ..... 63.2 mph
  - Angle ..... 25.2 deg.
  - Impact Location ..... 51.1 in. upstream from post no. 11
- Impact Severity ..... 59.0 kip-ft > 51 kip-ft limit from MASH 2016
- Exit Conditions
  - Speed ..... 42.8 mph
  - Angle ..... 8.5 deg.
- Exit Box Criterion ..... Pass
- Vehicle Stability ..... Satisfactory
- Vehicle Stopping Distance ..... 164 ft – 8 in. downstream, 60 ft – 7 in. laterally behind
- Vehicle Damage ..... Moderate
  - VDS [10] 11-LFQ-4
  - CDC [11] 11-LFEW-3
  - Maximum Interior Deformation ..... 2.9 in.
- Test Article Damage ..... Minimal
- Maximum Test Article Deflections
  - Permanent Set ..... -0.2 in.
  - Dynamic ..... 0.3 in.
  - Working Width ..... 14.0 in.
- Transducer Data

Evaluation Criteria		Transducer		MASH 2016 Limit
		SLICE-1 (primary)	SLICE-2	
OIV ft/s	Longitudinal	-24.46	-24.49	±40
	Lateral	30.78	28.60	±40
ORA g's	Longitudinal	-3.65	-2.86	±20.49
	Lateral	10.20	12.79	±20.49
MAX ANGULAR DISP. deg.	Roll	-12.6	-8.2	±75
	Pitch	-4.0	-5.0	±75
	Yaw	39.9	39.3	not required
THIV – ft/s		38.74	35.75	not required
PHD – g's		10.39	12.99	not required
ASI		2.51	2.34	not required

Figure 65. Summary of Test Results and Sequential Photographs, Test No. NCBR-1

0.000 sec 0.050 sec 0.100 sec 0.200 sec 0.300 sec





- Test Agency ..... MwRSF
- Test Number NCBR-2
- Date ..... June 11, 2019
- MASH 2016 Test Designation No. 3-11
- Test Article ..... NCDOT Two-Bar Metal Bridge Rail
- Total Length ..... 90 ft
- Key Component – Elliptical Aluminum Rail
  - Length ..... 26 ft – ½ in.
  - Width ..... 4 in.
  - Depth ..... 4¾ in.
- Key Component – Aluminum Post
  - Height ..... 23½ in.
  - Length ..... 5¾ in.
  - Width ..... 4¼ in.
  - Spacing ..... 78 in.
- Vehicle Make / Model ..... 2015 Chevrolet Silverado
  - Curb ..... 5,015 lb
  - Test Inertial ..... 5,018 lb
  - Gross Static ..... 5,183 lb
- Impact Conditions
  - Speed ..... 61.9 mph
  - Angle ..... 24.9 deg.
  - Impact Location ..... $61\frac{7}{8}$ in. upstream from post no. 6
- Impact Severity ..... 113.5 kip-ft > 106 kip-ft limit from MASH 2016
- Exit Conditions
  - Speed ..... 46.6 mph
  - Angle ..... 8.8 deg.
- Exit Box Criterion ..... Pass
- Vehicle Stability ..... Satisfactory
- Vehicle Stopping Distance ..... 200 ft – 2 in. downstream, 25 ft – 10 in. laterally in front
- Vehicle Damage ..... Moderate
  - VDS [10] 11-LFQ-4
  - CDC [11] 11-LFEW-3
  - Maximum Interior Deformation ..... 1.6 in.
- Test Article Damage ..... Minimal
- Maximum Test Article Deflections
  - Permanent Set ..... 0.7 in.
  - Dynamic ..... 0.8 in.
  - Working Width ..... 15.5 in.
- Transducer Data

Evaluation Criteria		Transducer		MASH 2016 Limit
		SLICE-1 (primary)	SLICE-2	
OIV ft/s	Longitudinal	-21.49	-20.66	±40
	Lateral	27.89	26.20	±40
ORA g's	Longitudinal	-5.09	-5.06	±20.49
	Lateral	10.78	13.36	±20.49
MAX ANGULAR DISP. deg.	Roll	-9.3	-6.1	±75
	Pitch	3.0	2.4	±75
	Yaw	32.1	31.5	not required
THIV – ft/s		36.42	34.48	not required
PHD – g's		11.26	13.74	not required
ASI		1.91	1.84	not required

Figure 87. Summary of Test Results and Sequential Photographs, Test No. NCBR-2

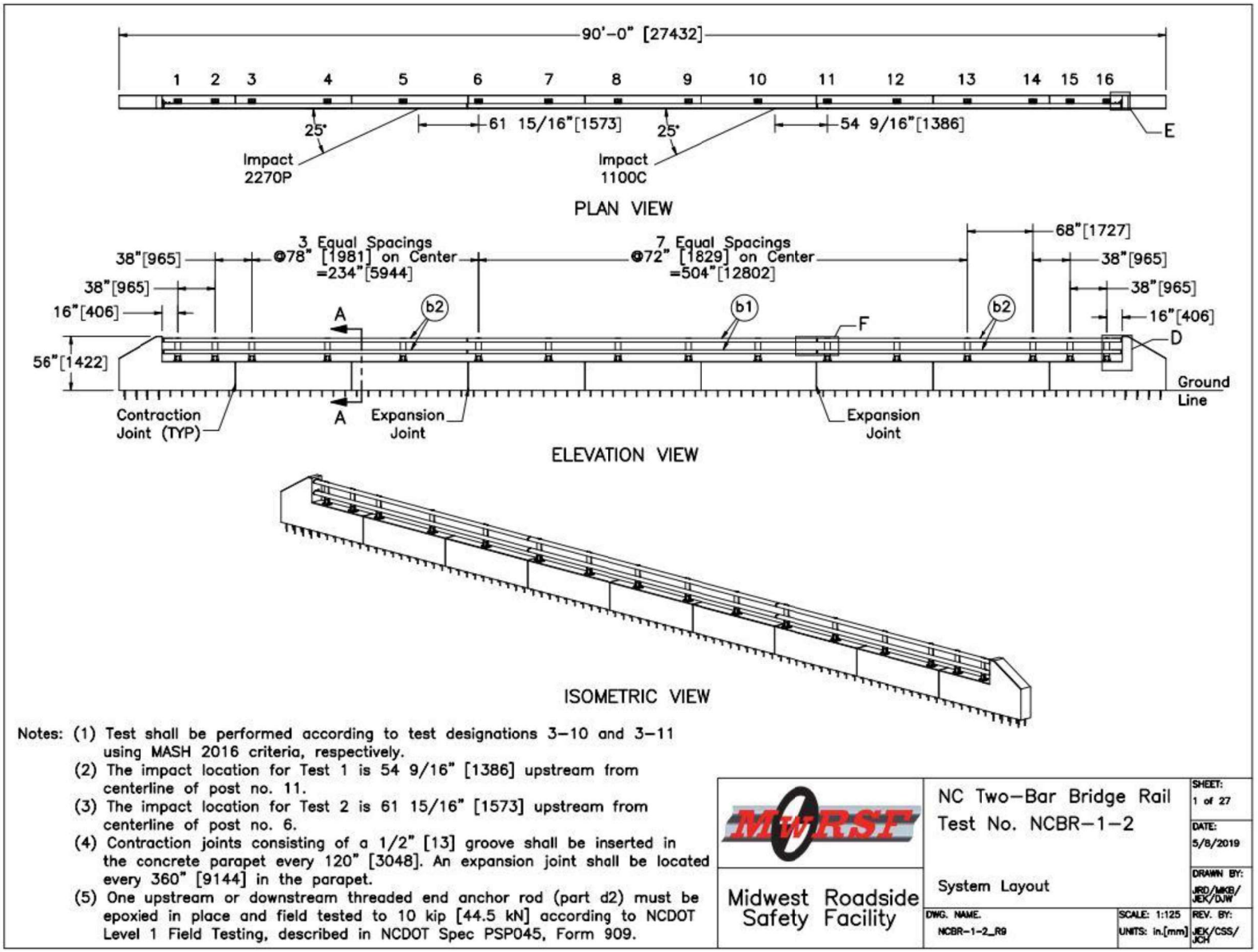


Figure 2. System Layout, Test Nos. NCBR-1 and NCBR-2

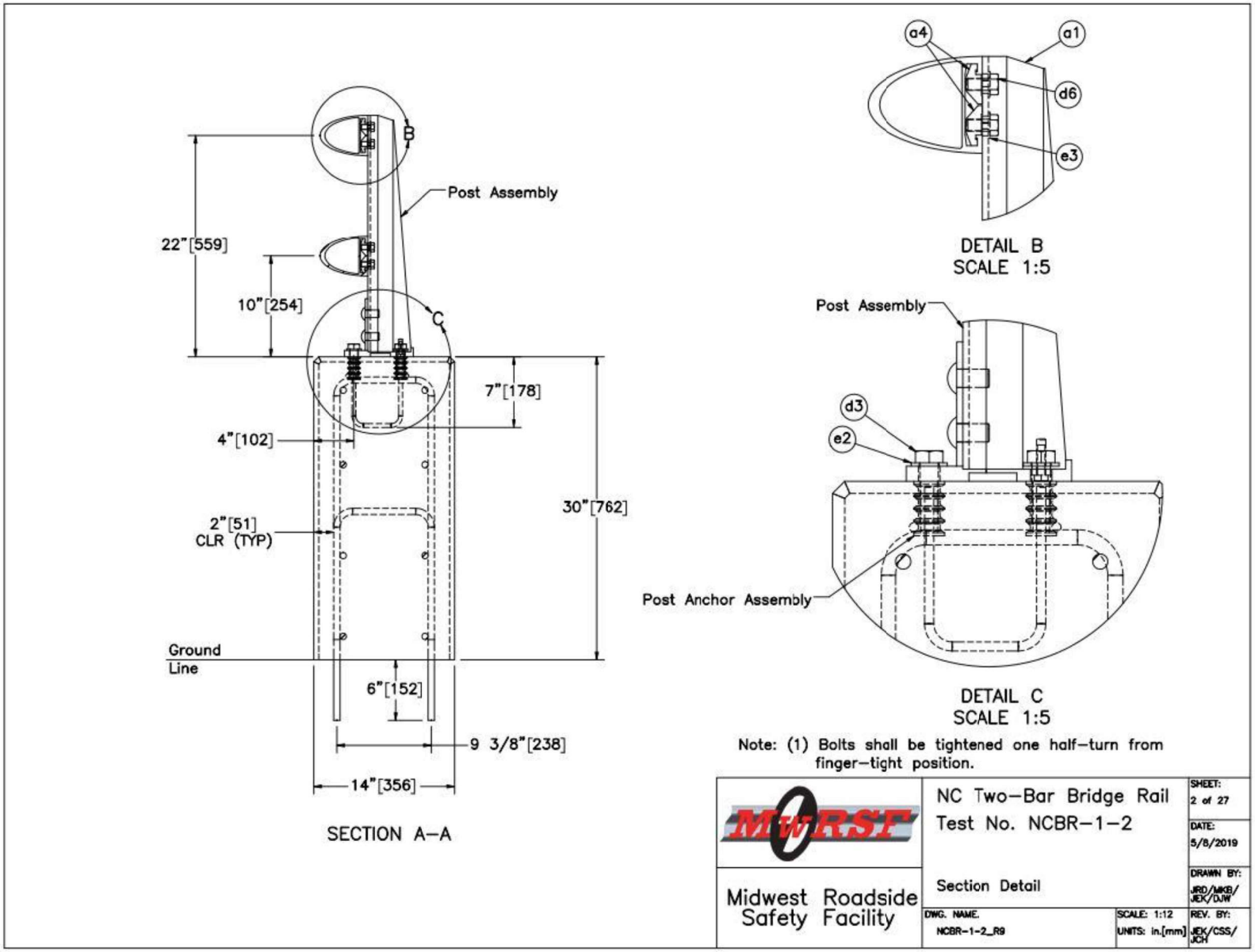


Figure 3. Section Detail, Test Nos. NCBR-1 and NCBR-2

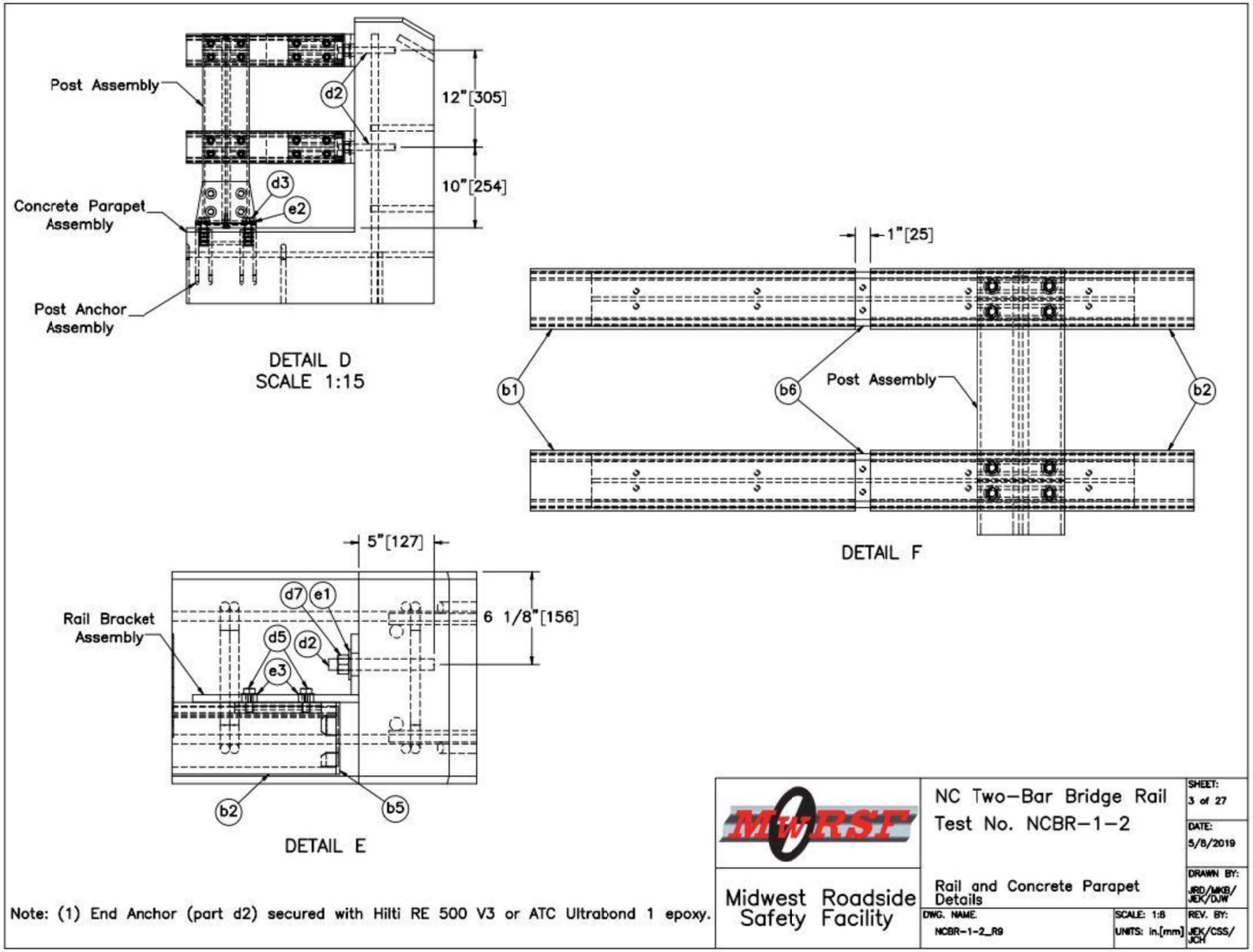
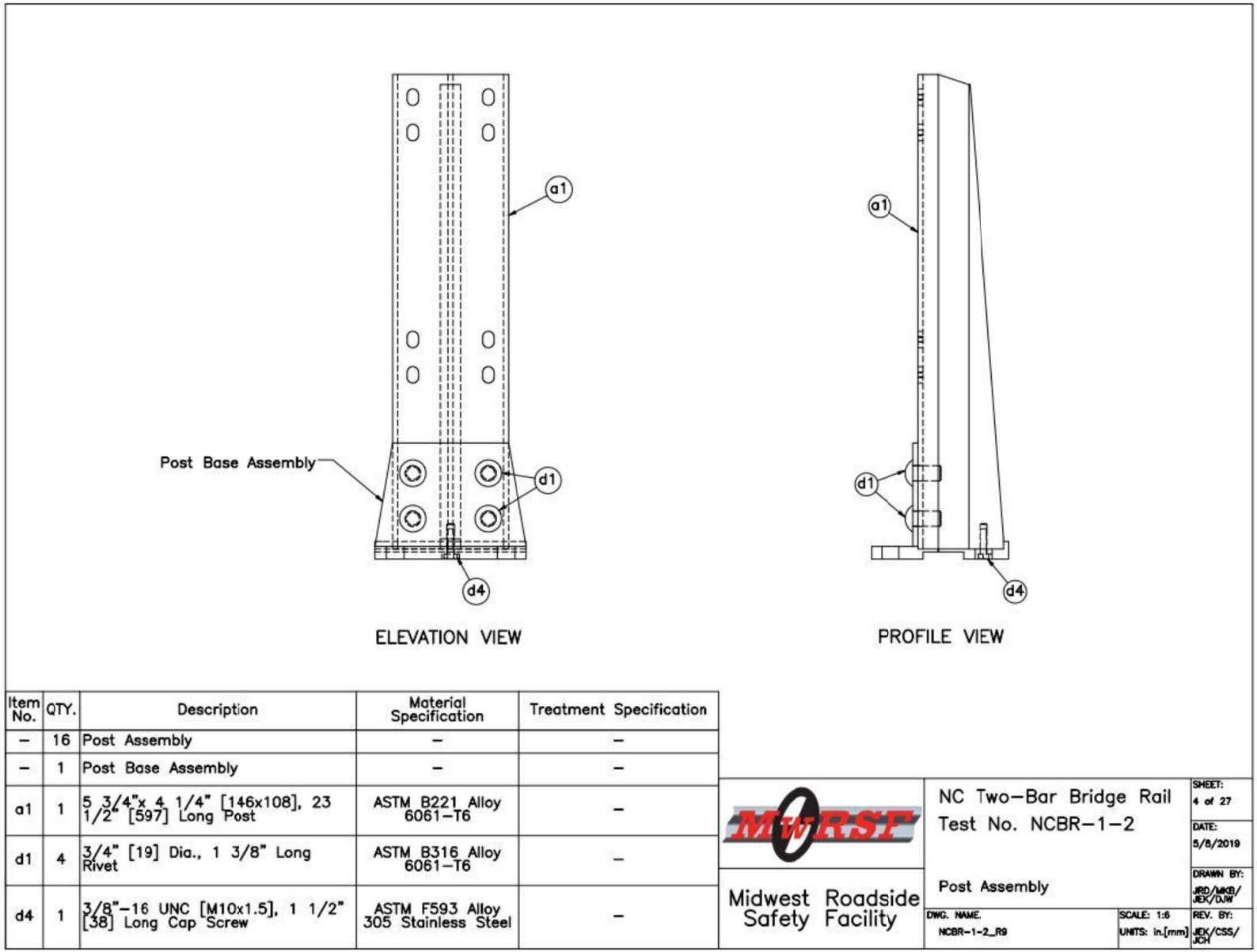


Figure 4. Rail and Concrete Parapet Details, Test Nos. NCBR-1 and NCBR-2



Item No.	QTY.	Description	Material Specification	Treatment Specification
–	16	Post Assembly	–	–
–	1	Post Base Assembly	–	–
a1	1	5 3/4"x 4 1/4" [146x108], 23 1/2" [597] Long Post	ASTM B221 Alloy 6061–T6	–
d1	4	3/4" [19] Dia., 1 3/8" Long Rivet	ASTM B316 Alloy 6061–T6	–
d4	1	3/8"–16 UNC [M10x1.5], 1 1/2" [38] Long Cap Screw	ASTM F593 Alloy 305 Stainless Steel	–

MwRSF

Midwest Roadside Safety Facility

NC Two–Bar Bridge Rail
Test No. NCBR–1–2

Post Assembly

SHEET: 4 of 27
DATE: 5/8/2019
DRAWN BY: JRD/MKB/JEK/DJW
REV. BY: JEK/CSS/JCH
DWG. NAME. NCBR-1-2_R9
SCALE: 1:6
UNITS: in.[mm]

Figure 5. Post Assembly, Test Nos. NCBR-1 and NCBR-2

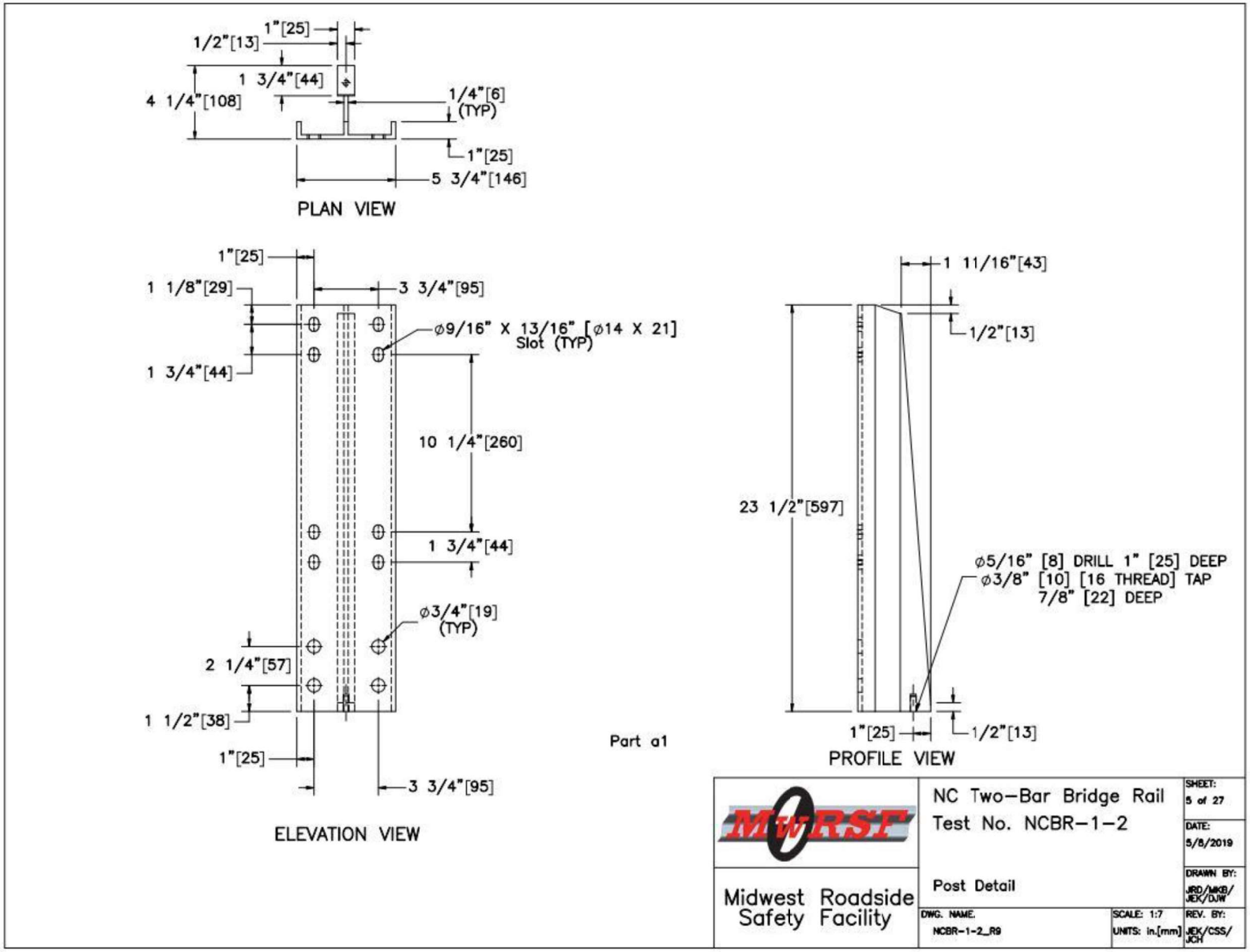


Figure 6. Post Detail, Test Nos. NCBR-1 and NCBR-2

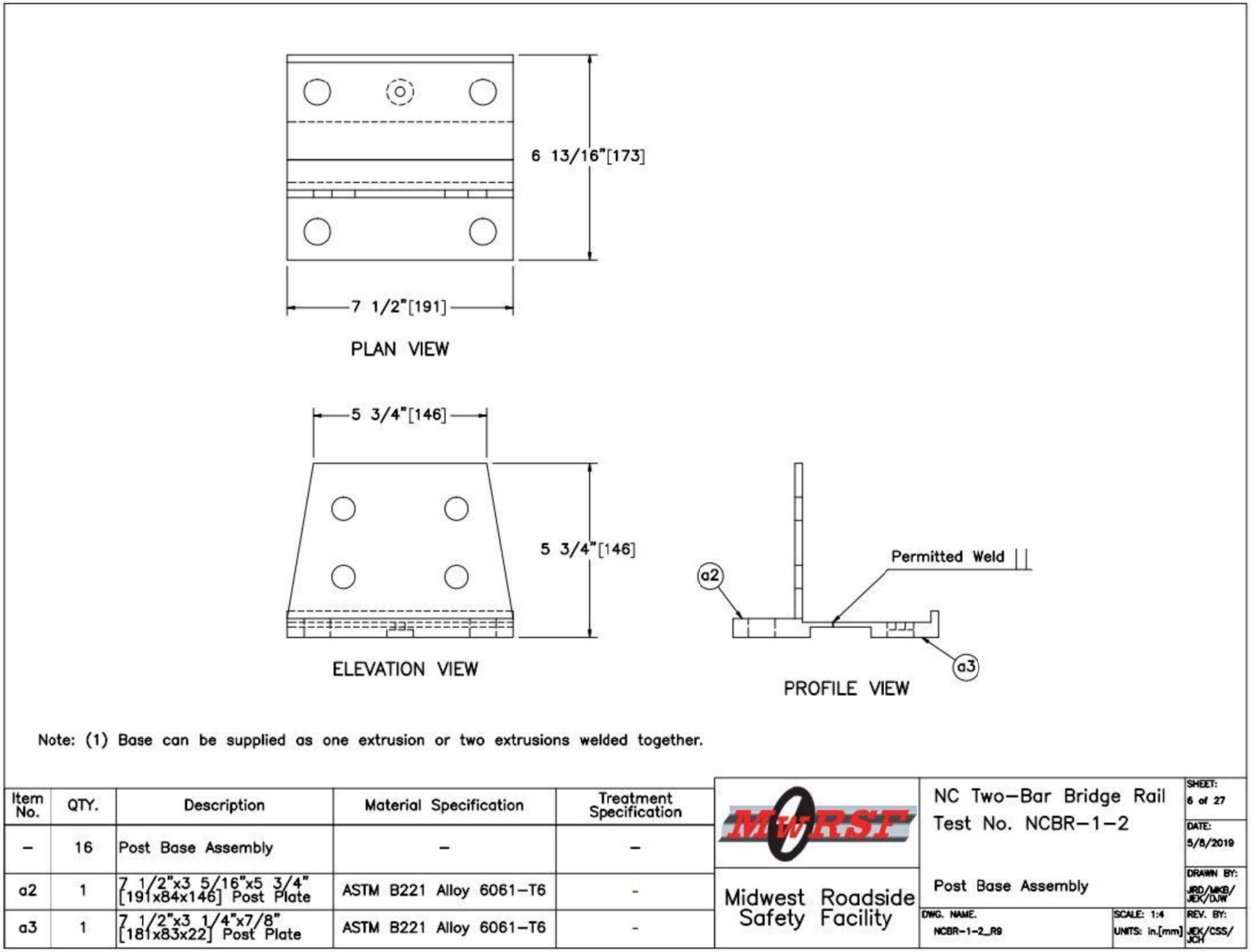


Figure 7. Post Base Assembly, Test Nos. NCBR-1 and NCBR-2

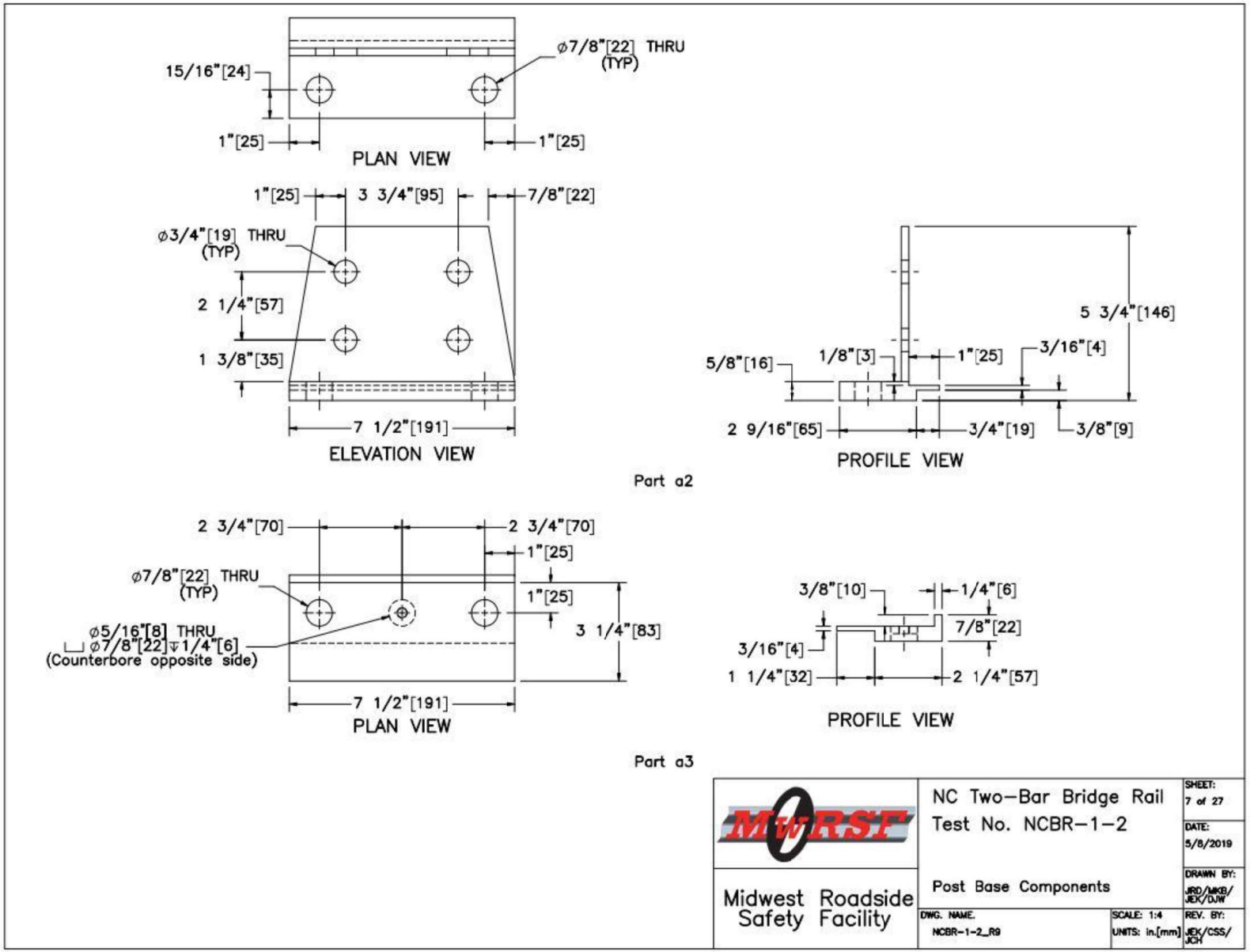


Figure 8. Post Base Components, Test Nos. NCBR-1 and NCBR-2

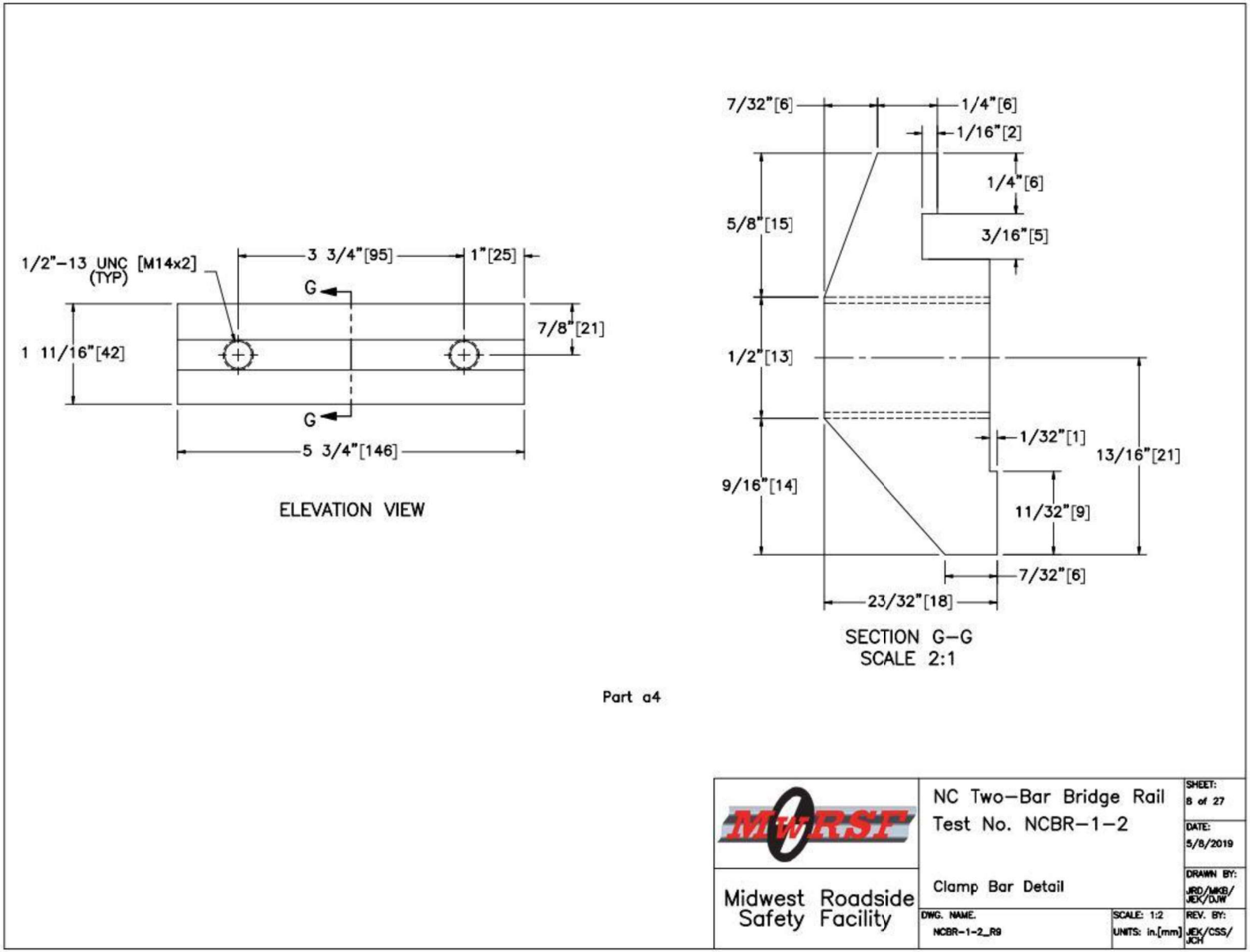


Figure 9. Clamp Bar Detail, Test Nos. NCBR-1 and NCBR-2

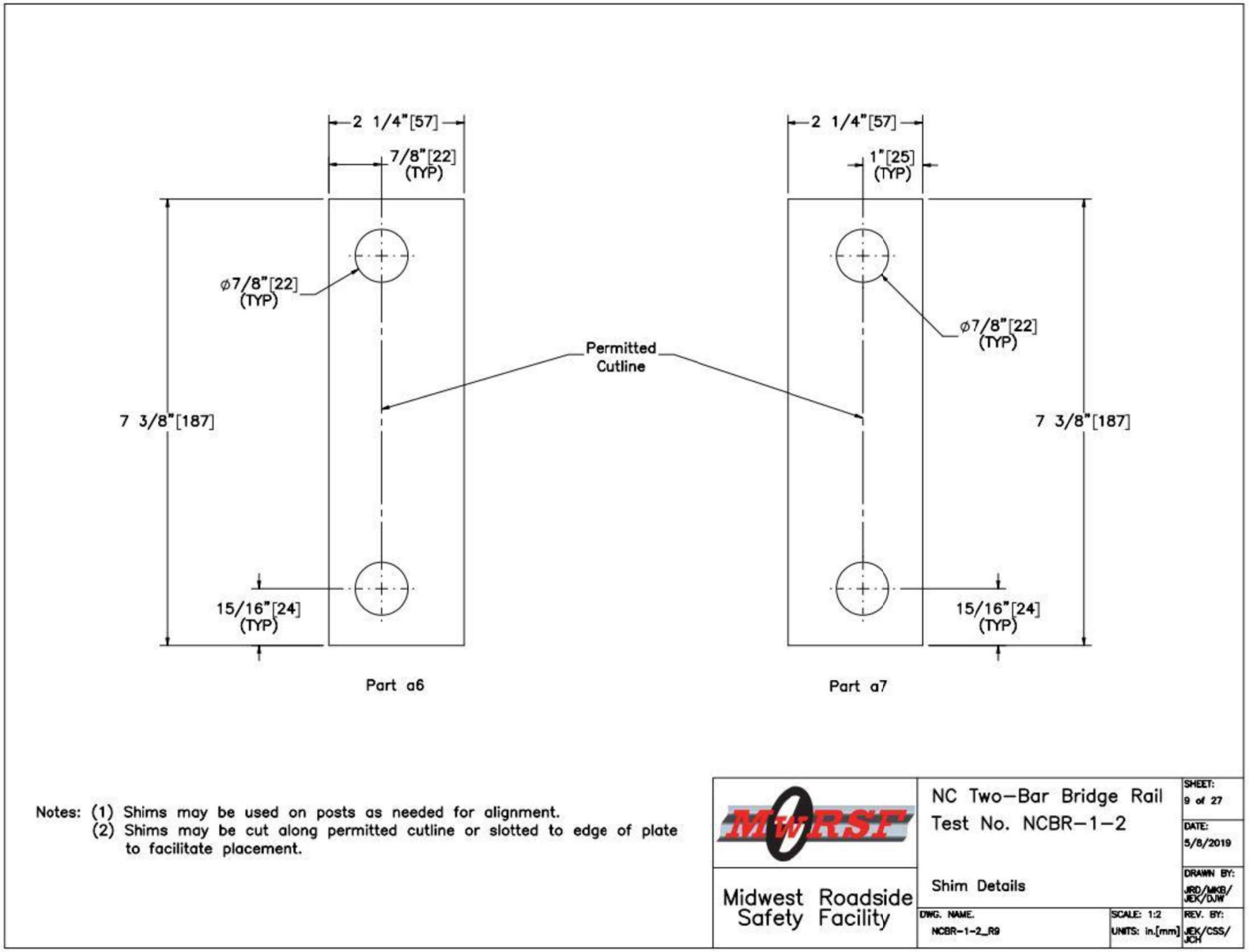


Figure 10. Shim Details, Test Nos. NCBR-1 and NCBR-2

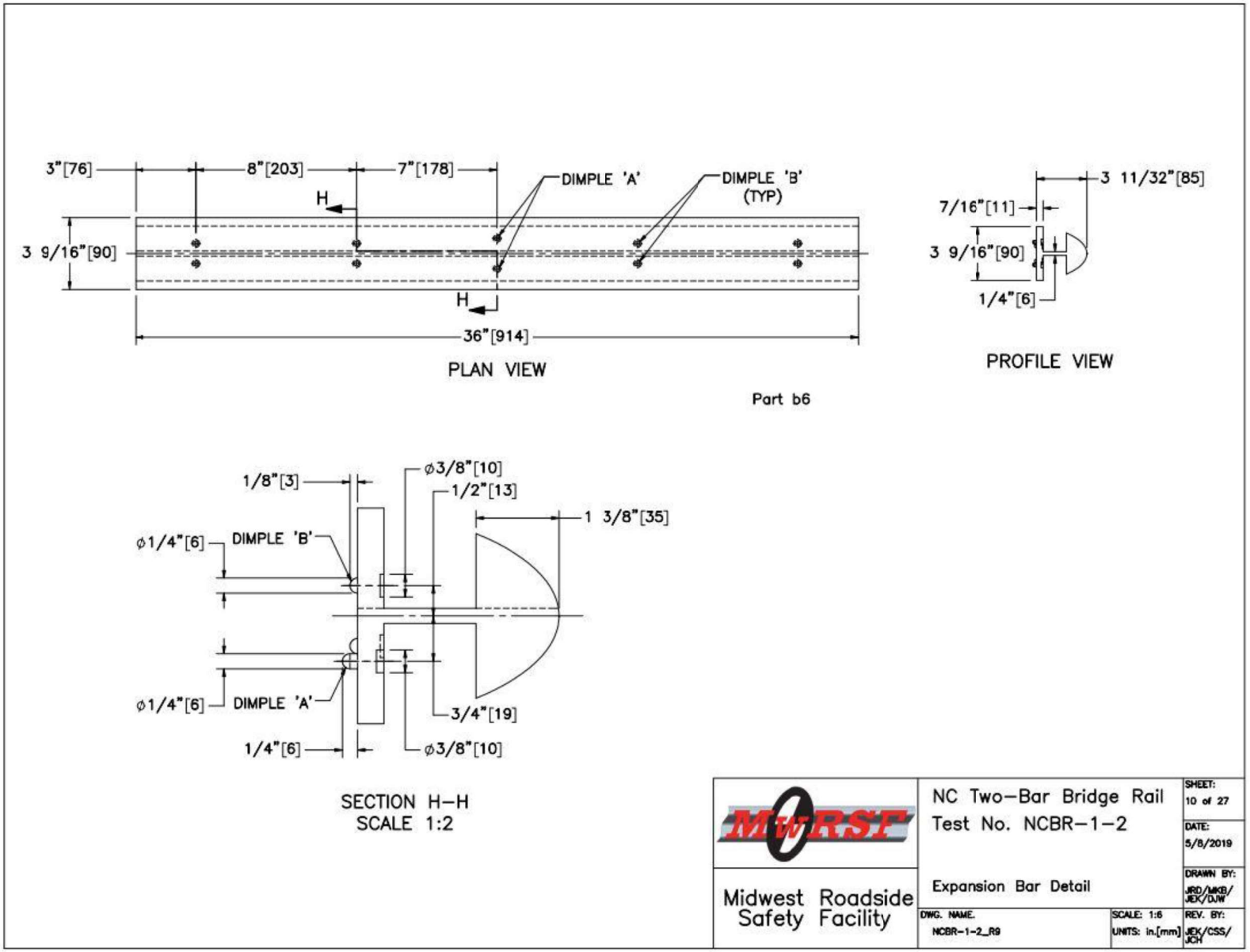


Figure 11. Expansion Bar Detail, Test Nos. NCBR-1 and NCBR-2

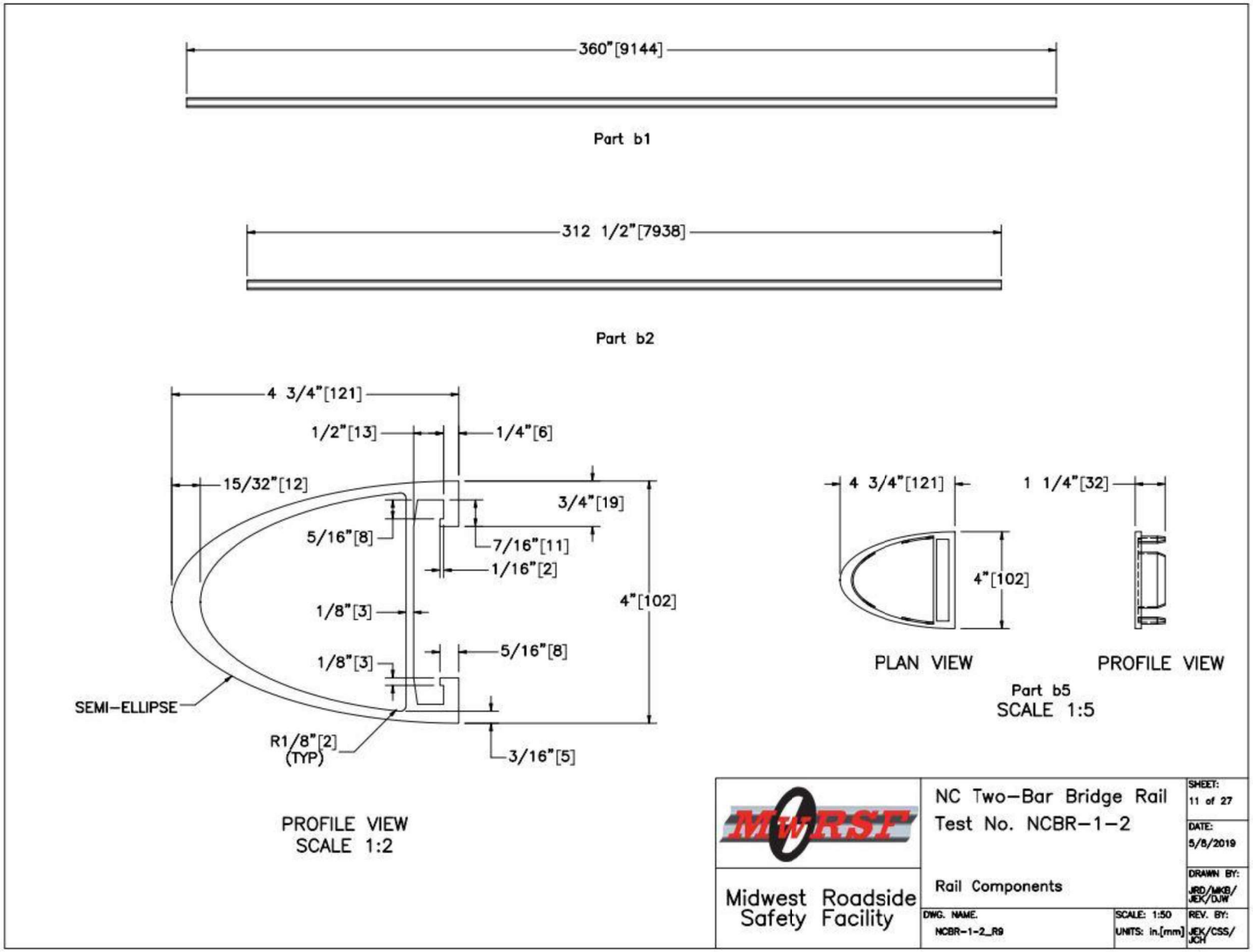
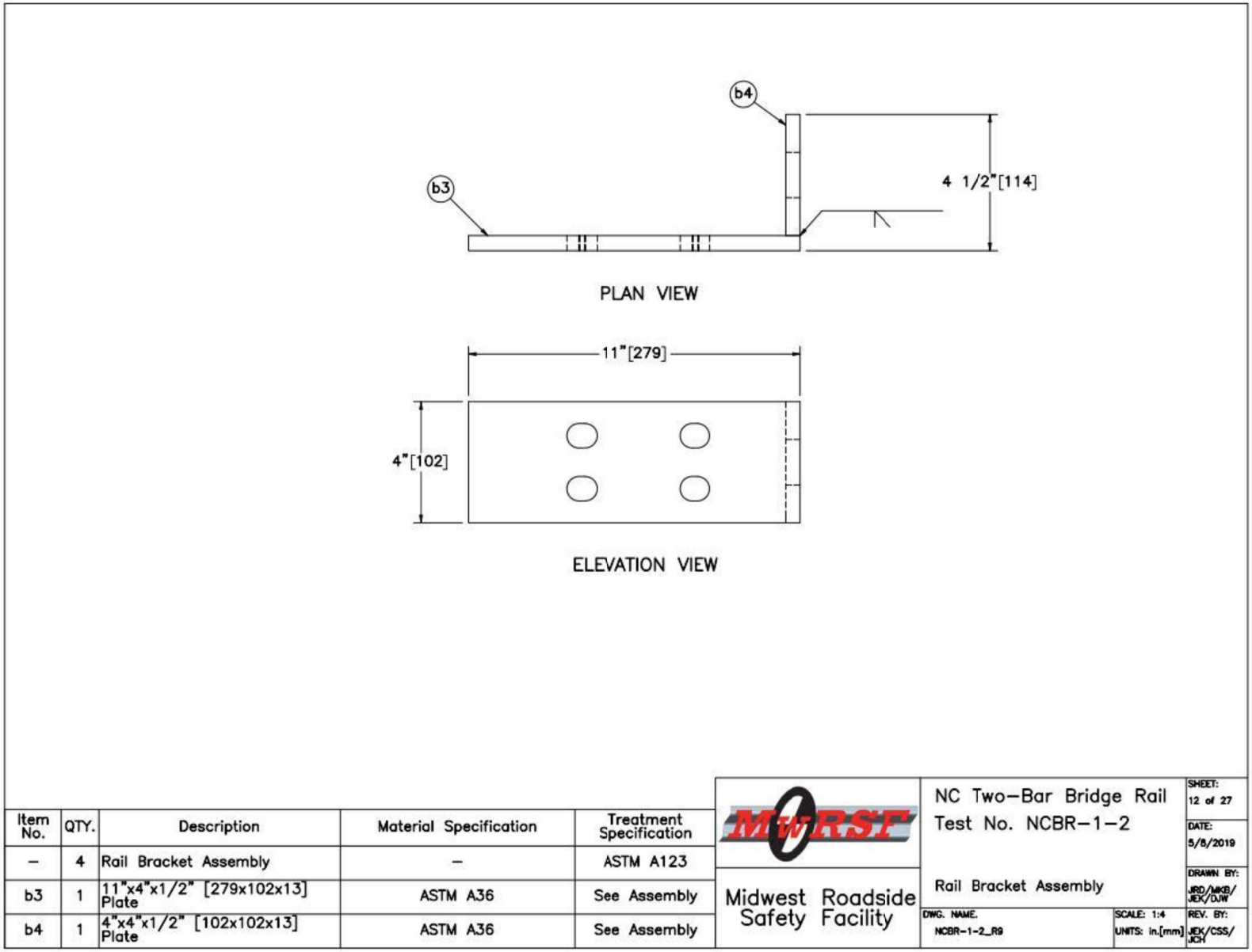


Figure 12. Rail Components, Test Nos. NCBR-1 and NCBR-2



Item No.	QTY.	Description	Material Specification	Treatment Specification
–	4	Rail Bracket Assembly	–	ASTM A123
b3	1	11"x4"x1/2" [279x102x13] Plate	ASTM A36	See Assembly
b4	1	4"x4"x1/2" [102x102x13] Plate	ASTM A36	See Assembly

Midwest Roadside Safety Facility

NC Two–Bar Bridge Rail
Test No. NCBR–1–2

Rail Bracket Assembly

DWG. NAME. NCBR–1–2_R9
SCALE: 1:4
UNITS: in.[mm]
SHEET: 12 of 27
DATE: 5/8/2019
DRAWN BY: JRD/MKB/JEK/DJW
REV. BY: JEK/CSS/JCH

Figure 13. Rail Bracket Assembly, Test Nos. NCBR-1 and NCBR-2

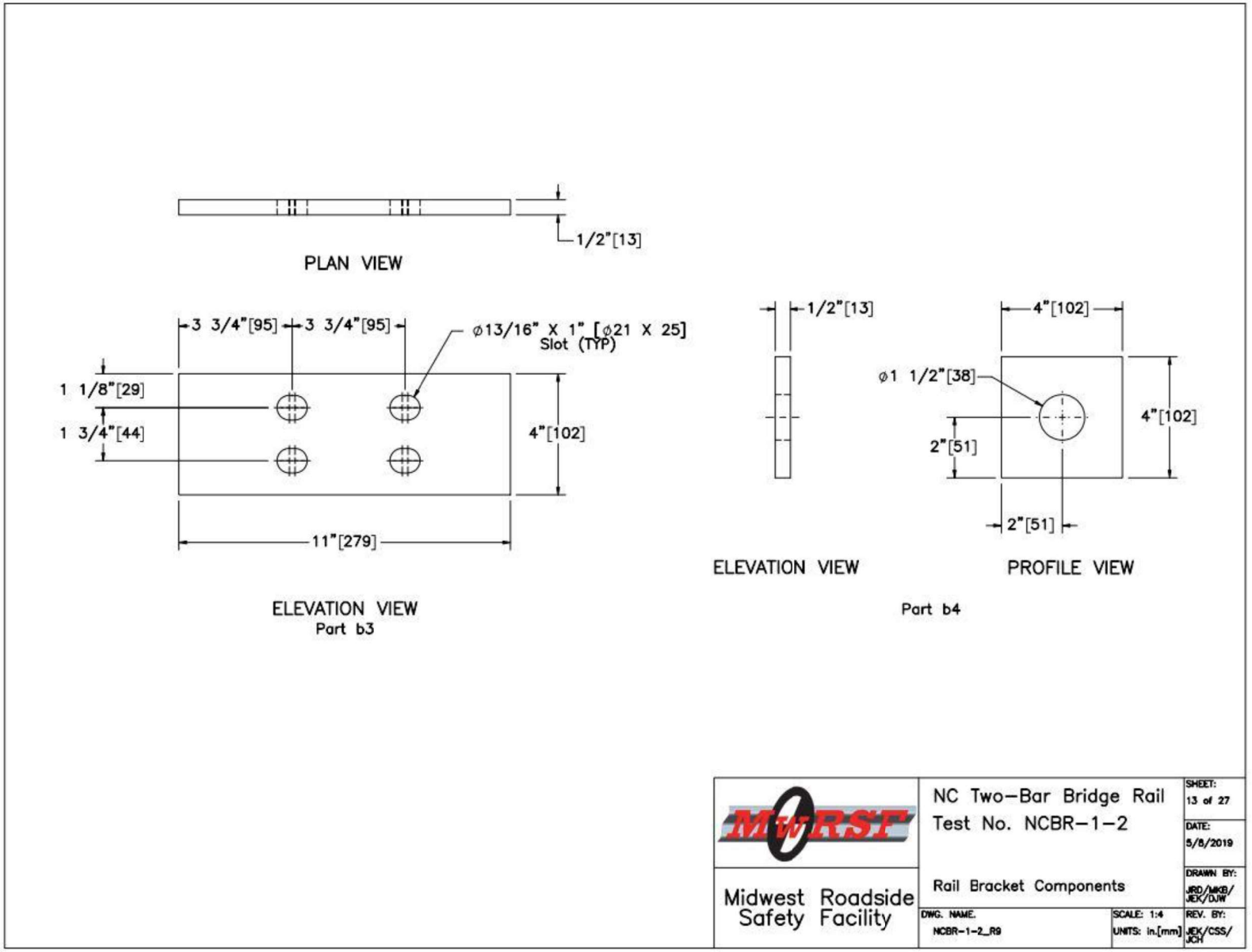
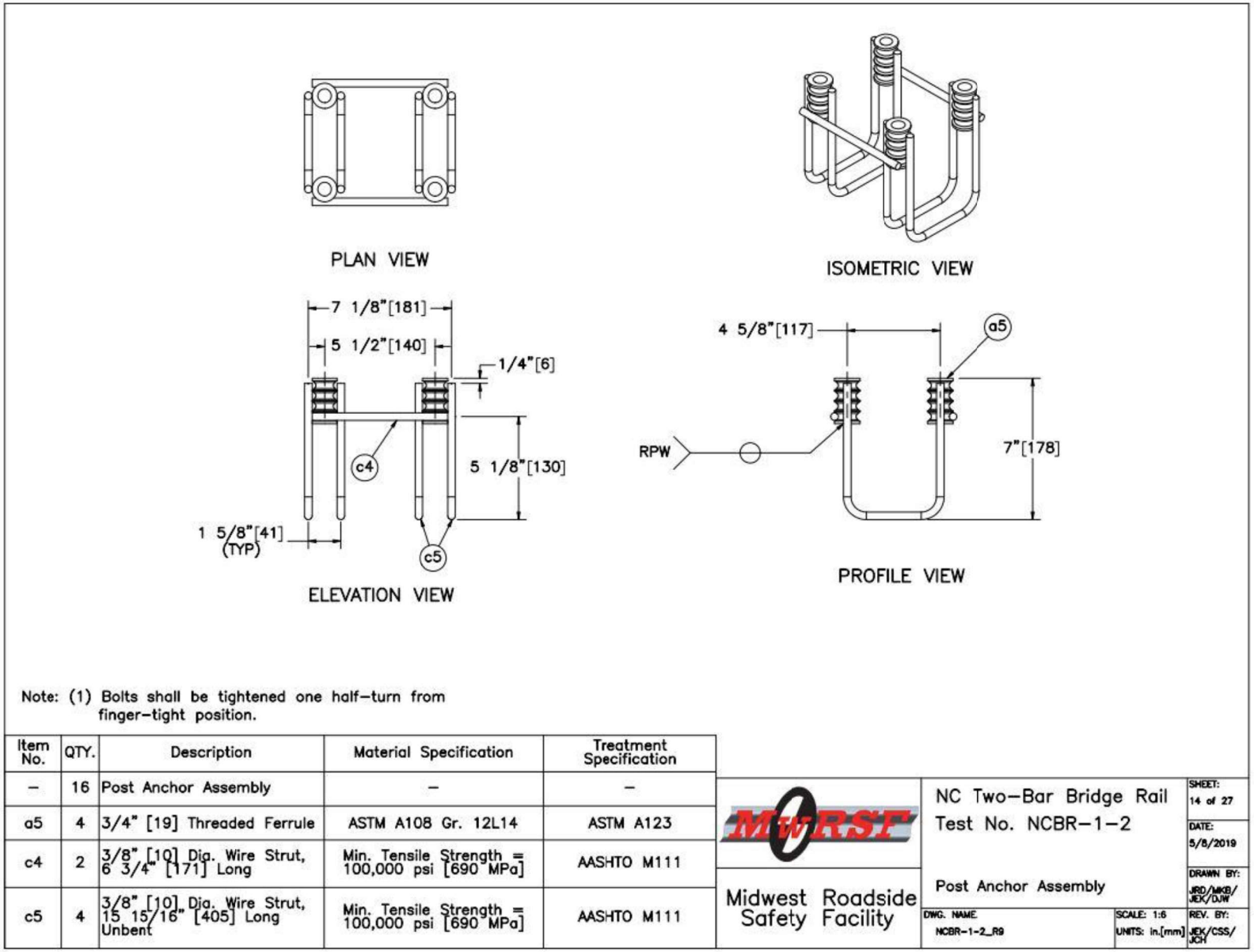


Figure 14. Rail Bracket Components, Test Nos. NCBR-1 and NCBR-2



Item No.	QTY.	Description	Material Specification	Treatment Specification
–	16	Post Anchor Assembly	–	–
a5	4	3/4" [19] Threaded Ferrule	ASTM A108 Gr. 12L14	ASTM A123
c4	2	3/8" [10] Dia. Wire Strut, 6 3/4" [171] Long	Min. Tensile Strength = 100,000 psi [690 MPa]	AASHTO M111
c5	4	3/8" [10] Dia. Wire Strut, 15 15/16" [405] Long Unbent	Min. Tensile Strength = 100,000 psi [690 MPa]	AASHTO M111

Midwest Roadside Safety Facility

NC Two-Bar Bridge Rail
Test No. NCBR-1-2

Post Anchor Assembly

SHEET: 14 of 27
DATE: 5/8/2019
DRAWN BY: JRD/MKB/JEK/DJW
REV. BY: JEK/CSS/JCH
DWG. NAME: NCBR-1-2_R9
SCALE: 1:6
UNITS: in.[mm]

Figure 15. Post Anchor Assembly, Test Nos. NCBR-1 and NCBR-2

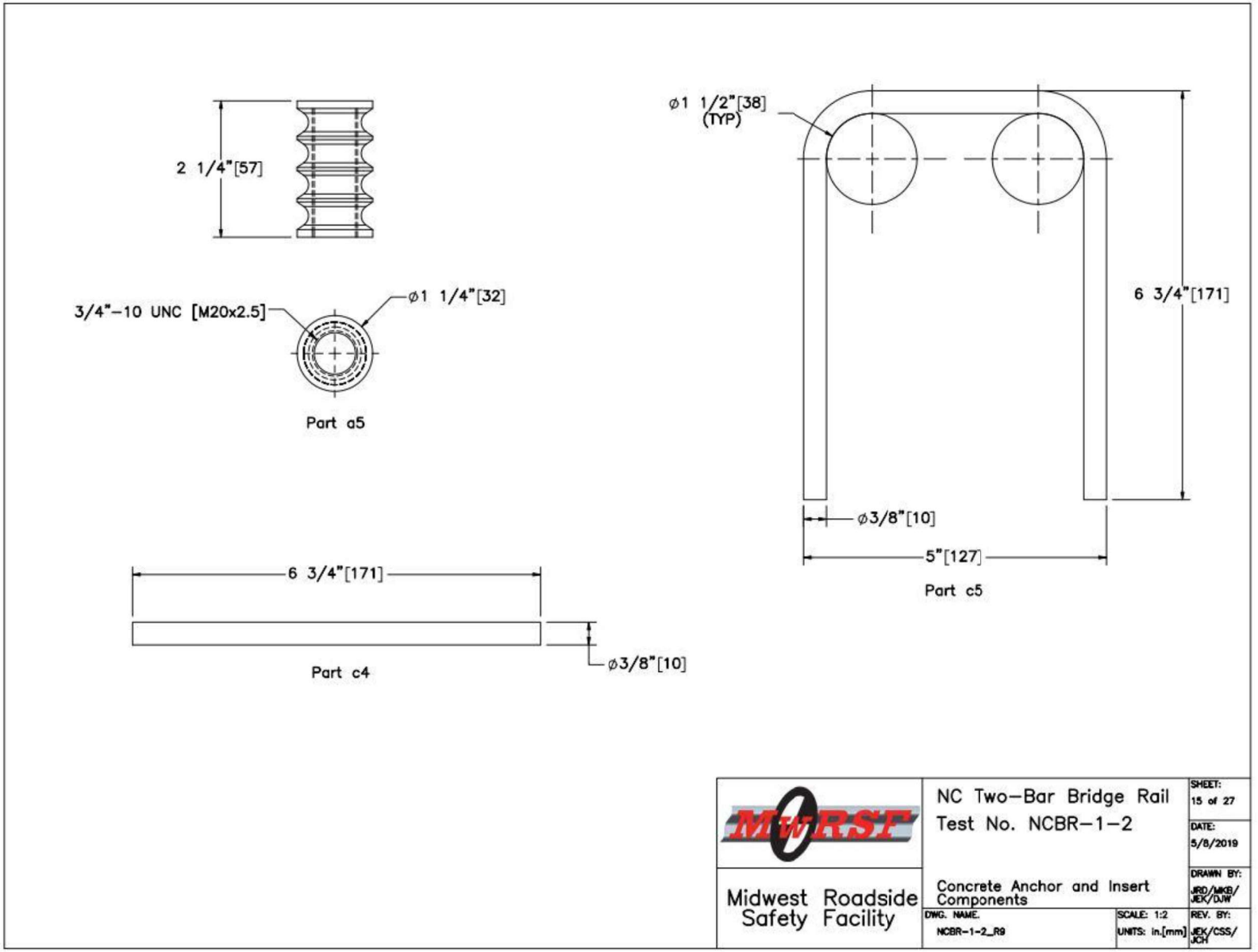
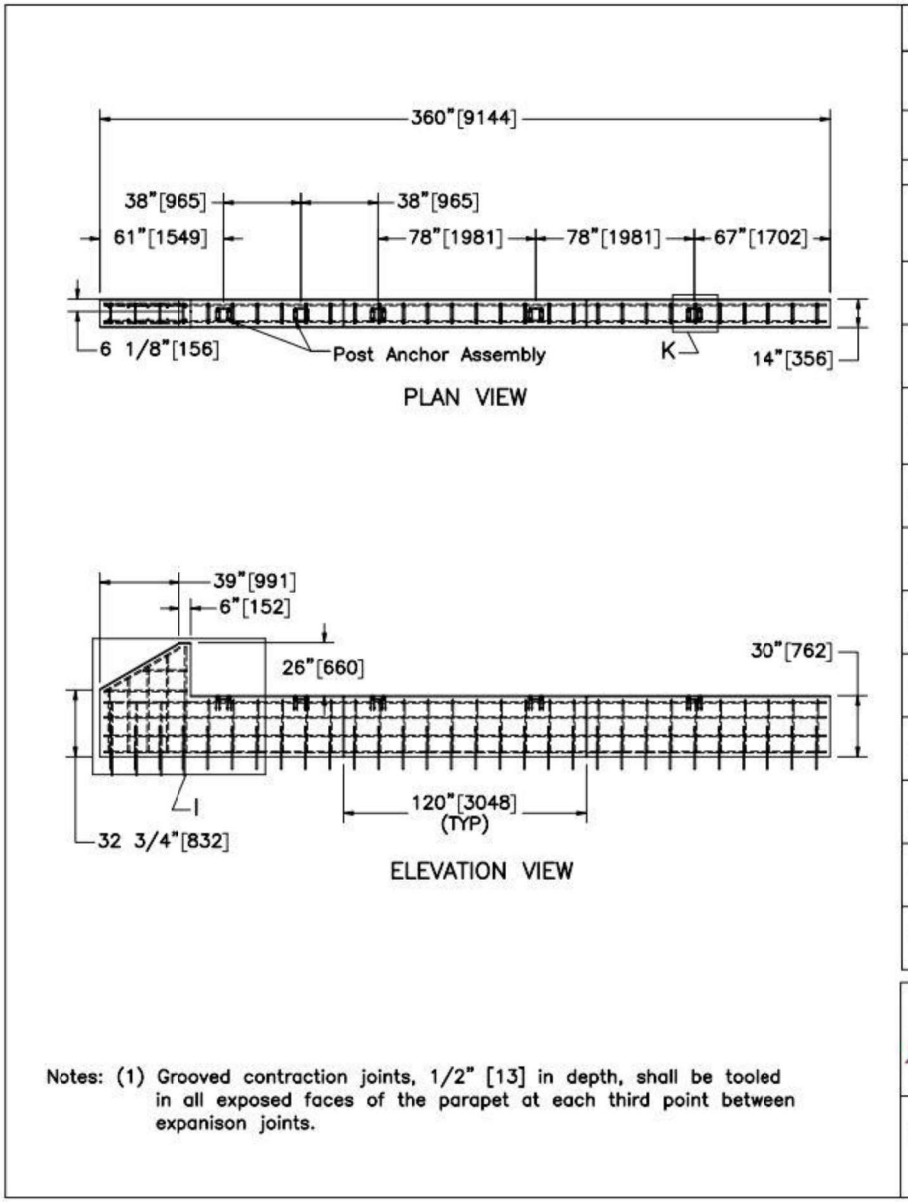


Figure 16. Concrete Anchor and Insert Components, Test Nos. NCBR-1 and NCBR-2



Item No.	QTY.	Description	Material Specification	Treatment Specification
–	1	Upstream Parapet Assembly	–	–
–	5	Post Anchor Assembly		
c1	1	Concrete	–	–
c6	26	#5 [16] Bar, 59 1/2" [1,511] Long Unbent	ASTM A615 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
c8	8	#5 [16] Bar, 356" [9,042] Long	ASTM A615 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
c9	8	#5 [16] Bar, 36" [914] Long	ASTM A615 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
c10	30	#5 [16] Bar, 49 1/2" [1,257] Long Unbent	ASTM A615 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
c11	2	#6 [19] Bar, 22" [559] Long	ASTM A615 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
c12	2	#6 [19] Bar, 40" [1,016] Long	ASTM A615 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
c13	2	#6 [19] Bar, 43 1/4" [1,099] Long	ASTM A615 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
c14	2	#7 [22] Bar, 31" [787] Long	ASTM A615 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
c15	2	#7 [22] Bar, 36 1/2" [927] Long	ASTM A615 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
c16	2	#7 [22] Bar, 42" [1,067] Long	ASTM A615 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
c17	2	#7 [22] Bar, 47 1/2" [1,207] Long	ASTM A615 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
c18	2	#7 [22] Bar, 52" [1,321] Long	ASTM A615 Gr. 60	Epoxy–Coated (ASTM A775 or A934)

Notes: (1) Grooved contraction joints, 1/2" [13] in depth, shall be tooled in all exposed faces of the parapet at each third point between expanison joints.

MwRSF	NC Two–Bar Bridge Rail Test No. NCBR–1–2	SHEET: 16 of 27
		DATE: 5/8/2019
Midwest Roadside Safety Facility	Upstream Concrete Parapet Assembly	DRAWN BY: JRD/MKB/ JEK/DJW
	DWG. NAME. NCBR–1–2_R9 SCALE: 1:75 UNITS: in.[mm]	REV. BY: JEK/CSS/ JCH

Figure 17. Upstream Concrete Parapet Assembly, Test Nos. NCBR-1 and NCBR-2

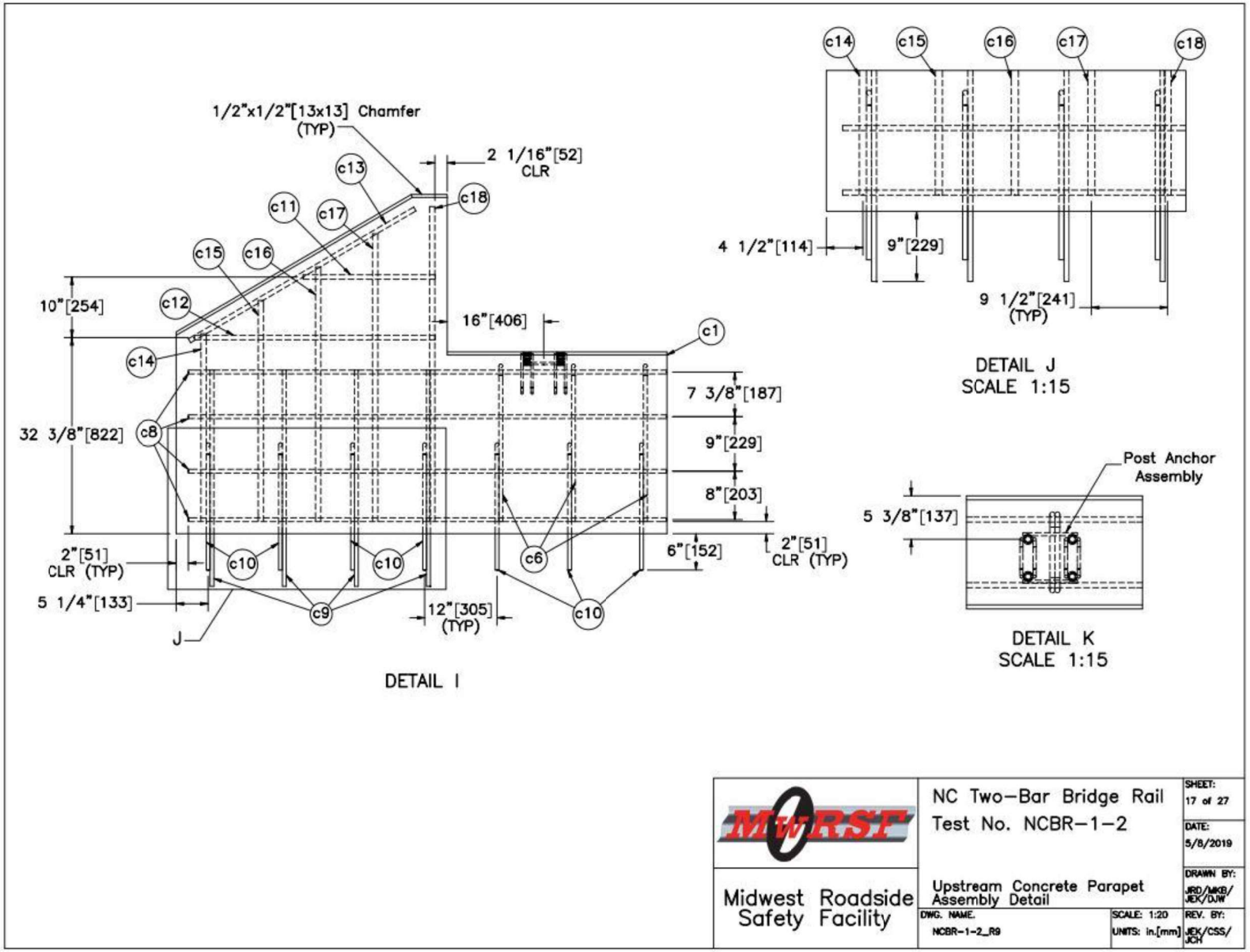
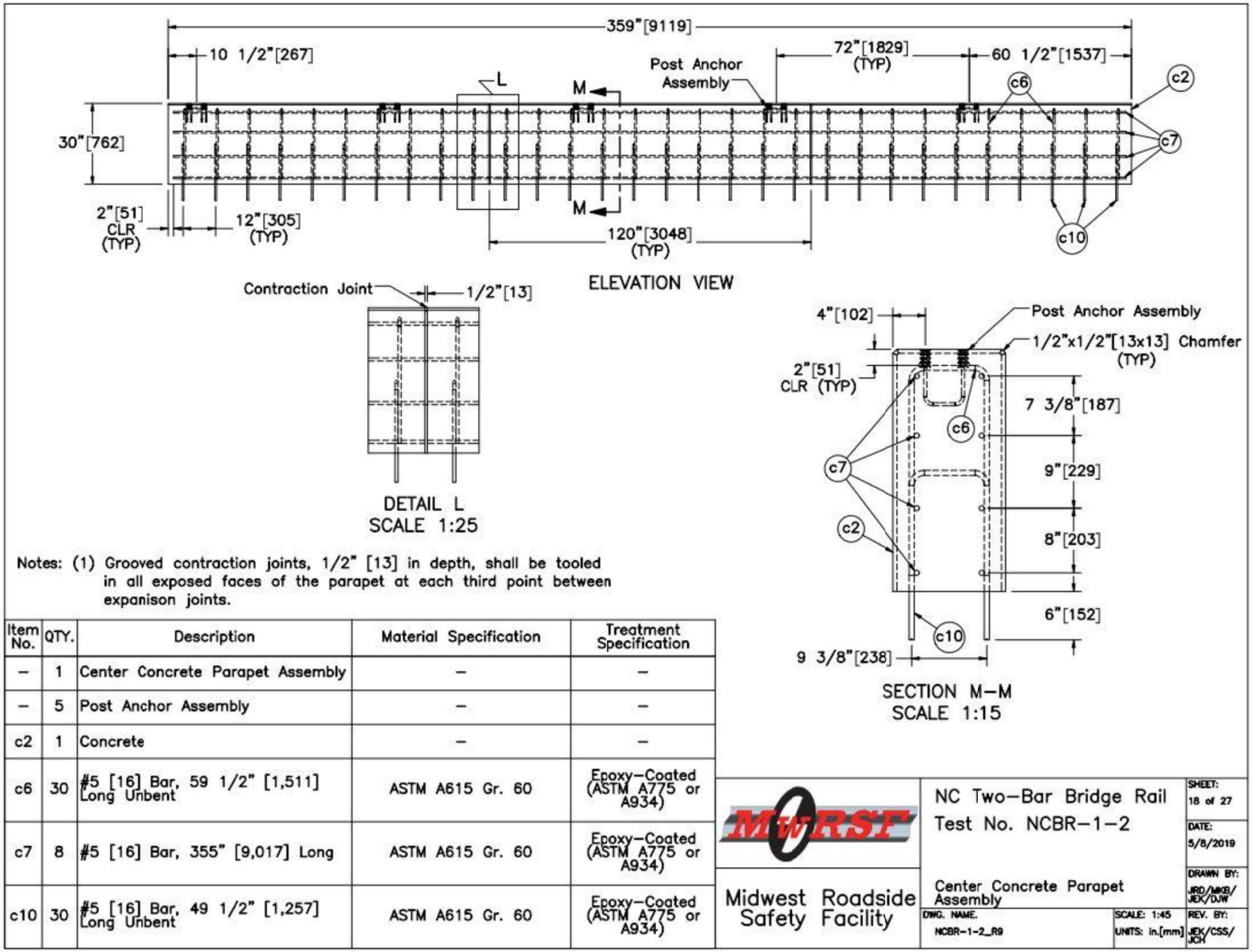
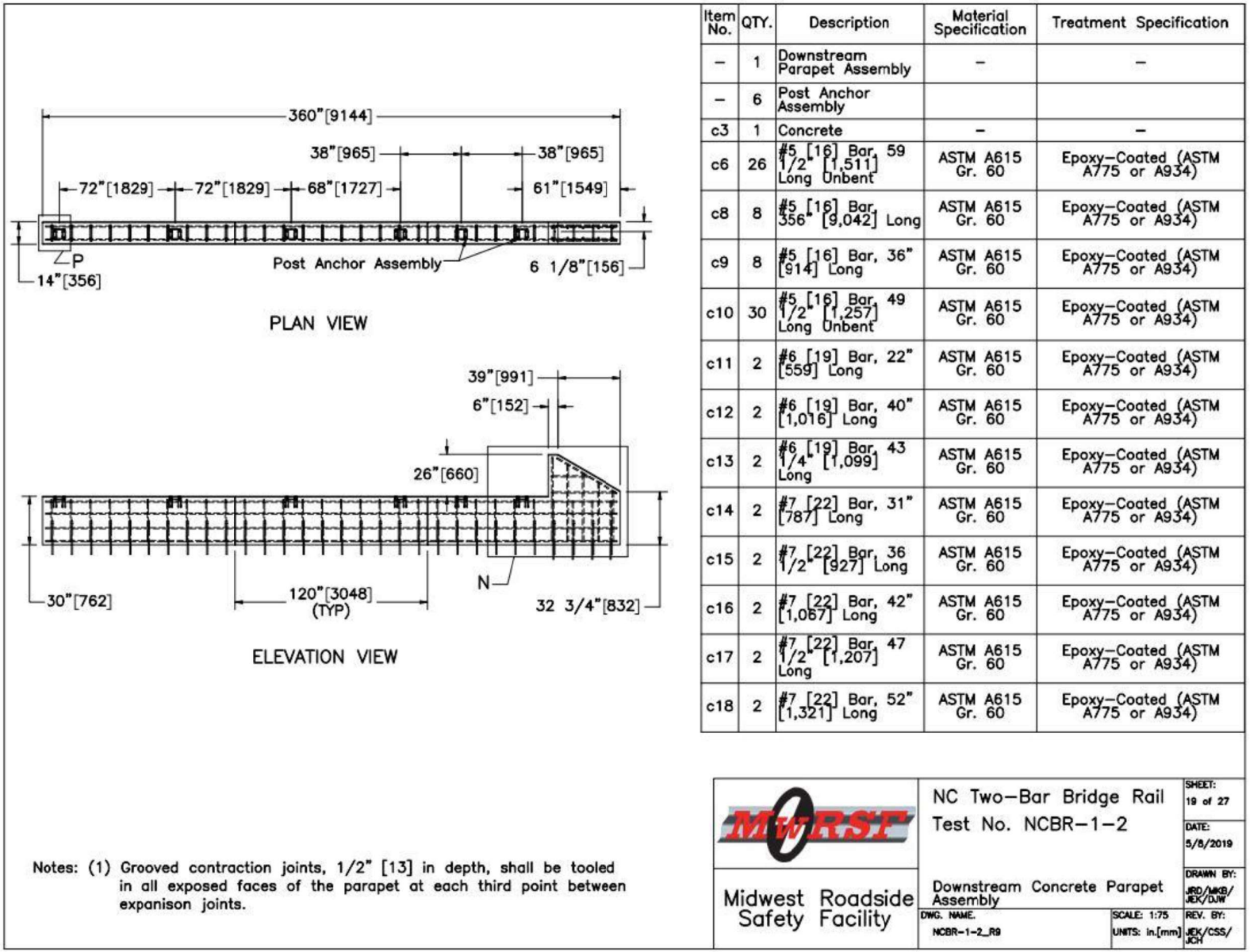


Figure 18. Upstream Concrete Parapet Assembly Detail, Test Nos. NCBR-1 and NCBR-2



Item No.	QTY.	Description	Material Specification	Treatment Specification
–	1	Center Concrete Parapet Assembly	–	–
–	5	Post Anchor Assembly	–	–
c2	1	Concrete	–	–
c6	30	#5 [16] Bar, 59 1/2" [1,511] Long Unbent	ASTM A615 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
c7	8	#5 [16] Bar, 355" [9,017] Long	ASTM A615 Gr. 60	Epoxy–Coated (ASTM A775 or A934)
c10	30	#5 [16] Bar, 49 1/2" [1,257] Long Unbent	ASTM A615 Gr. 60	Epoxy–Coated (ASTM A775 or A934)

Figure 19. Center Concrete Parapet Assembly, Test Nos. NCBR-1 and NCBR-2



Item No.	QTY.	Description	Material Specification	Treatment Specification
–	1	Downstream Parapet Assembly	–	–
–	6	Post Anchor Assembly		
c3	1	Concrete	–	–
c6	26	#5 [16] Bar, 59 1/2" [1,511] Long Unbent	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c8	8	#5 [16] Bar, 356" [9,042] Long	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c9	8	#5 [16] Bar, 36" [914] Long	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c10	30	#5 [16] Bar, 49 1/2" [1,257] Long Unbent	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c11	2	#6 [19] Bar, 22" [559] Long	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c12	2	#6 [19] Bar, 40" [1,016] Long	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c13	2	#6 [19] Bar, 43 1/4" [1,099] Long	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c14	2	#7 [22] Bar, 31" [787] Long	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c15	2	#7 [22] Bar, 36 1/2" [927] Long	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c16	2	#7 [22] Bar, 42" [1,067] Long	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c17	2	#7 [22] Bar, 47 1/2" [1,207] Long	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c18	2	#7 [22] Bar, 52" [1,321] Long	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)

Figure 20. Downstream Concrete Parapet Assembly, Test Nos. NCBR-1 and NCBR-2

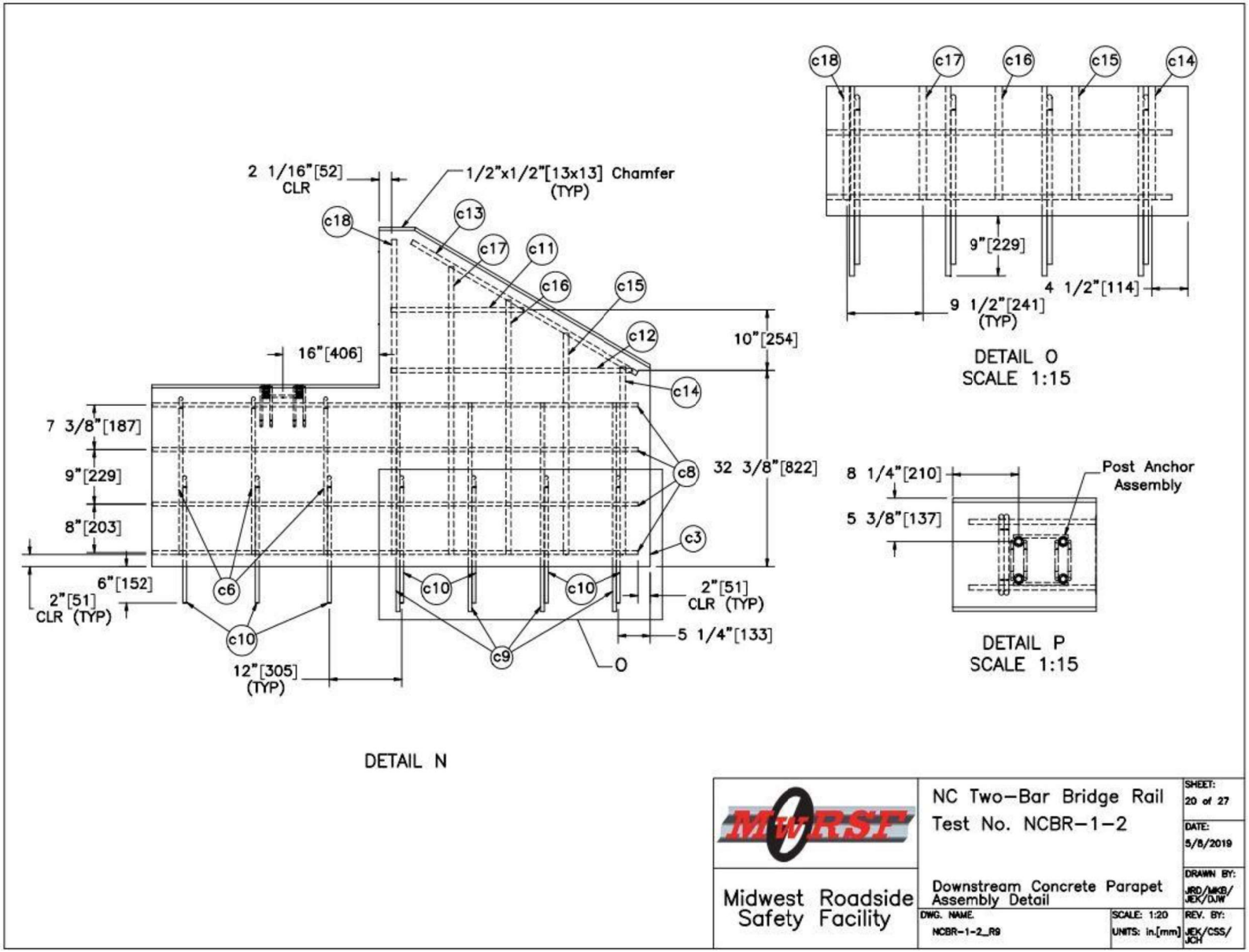
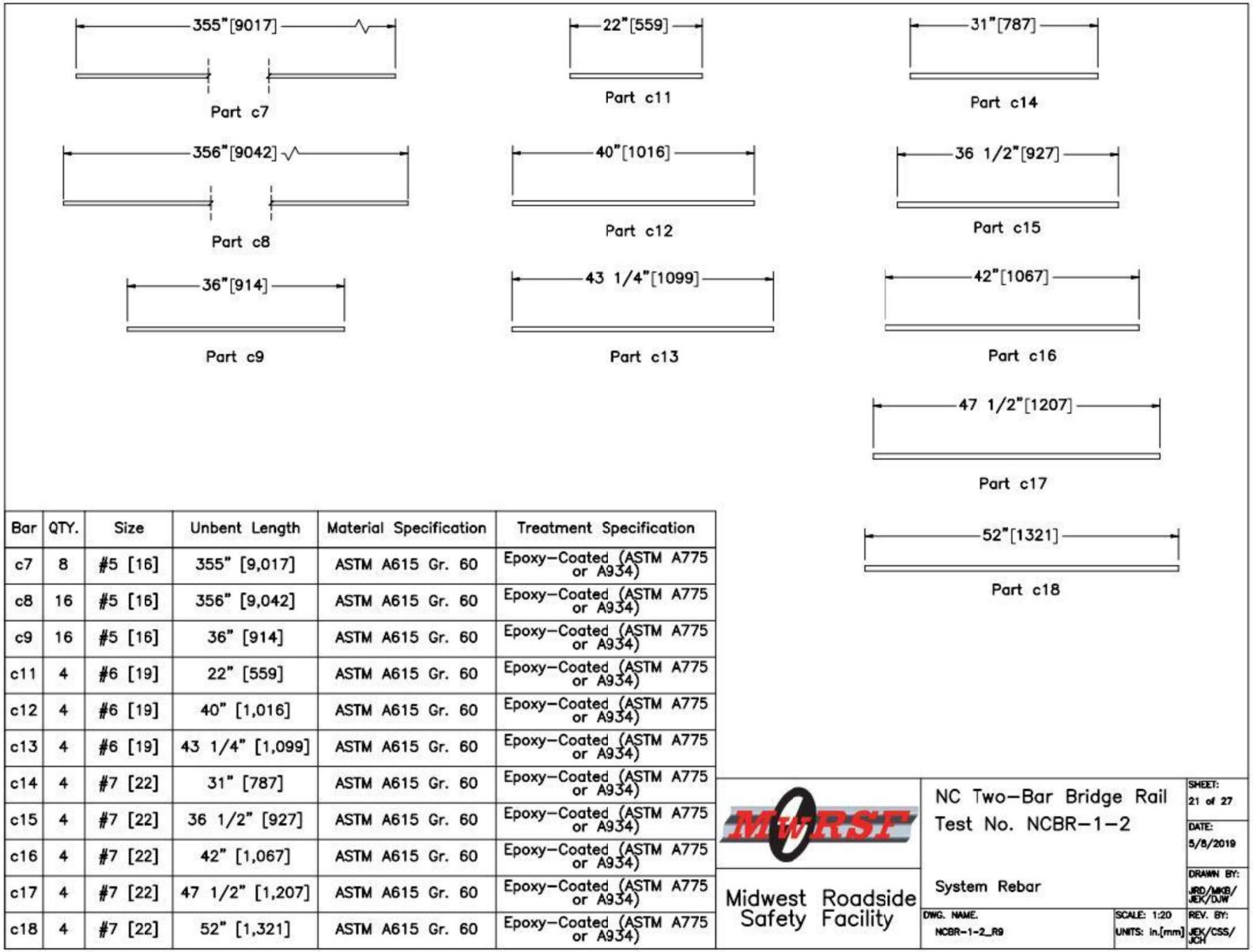


Figure 21. Downstream Concrete Parapet Assembly, Test Nos. NCBR-1 and NCBR-2



Bar	QTY.	Size	Unbent Length	Material Specification	Treatment Specification
c7	8	#5 [16]	355" [9,017]	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c8	16	#5 [16]	356" [9,042]	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c9	16	#5 [16]	36" [914]	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c11	4	#6 [19]	22" [559]	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c12	4	#6 [19]	40" [1,016]	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c13	4	#6 [19]	43 1/4" [1,099]	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c14	4	#7 [22]	31" [787]	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c15	4	#7 [22]	36 1/2" [927]	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c16	4	#7 [22]	42" [1,067]	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c17	4	#7 [22]	47 1/2" [1,207]	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c18	4	#7 [22]	52" [1,321]	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)

MwRSF

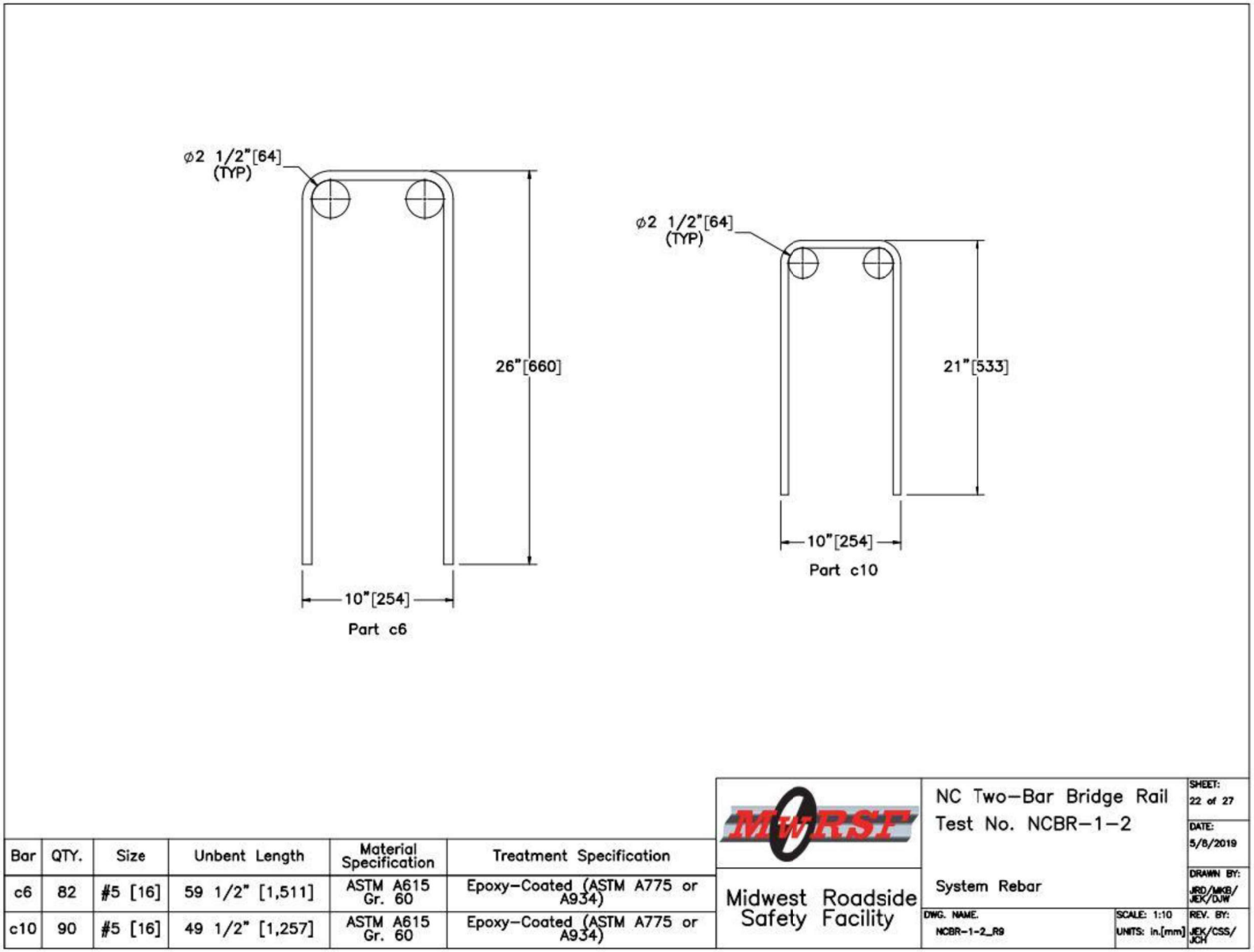
Midwest Roadside Safety Facility

NC Two-Bar Bridge Rail
Test No. NCBR-1-2

System Rebar

SHEET: 21 of 27
DATE: 5/8/2019
DRAWN BY: JRD/MKB/JEK/DJW
REV. BY: JEK/CSS/JCH
DWG. NAME: NCBR-1-2_R9
SCALE: 1:20
UNITS: in.[mm]

Figure 22. System Rebar, Test Nos. NCBR-1 and NCBR-2



Bar	QTY.	Size	Unbent Length	Material Specification	Treatment Specification
c6	82	#5 [16]	59 1/2" [1,511]	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)
c10	90	#5 [16]	49 1/2" [1,257]	ASTM A615 Gr. 60	Epoxy-Coated (ASTM A775 or A934)

Figure 23. System Rebar, Test Nos. NCBR-1 and NCBR-2

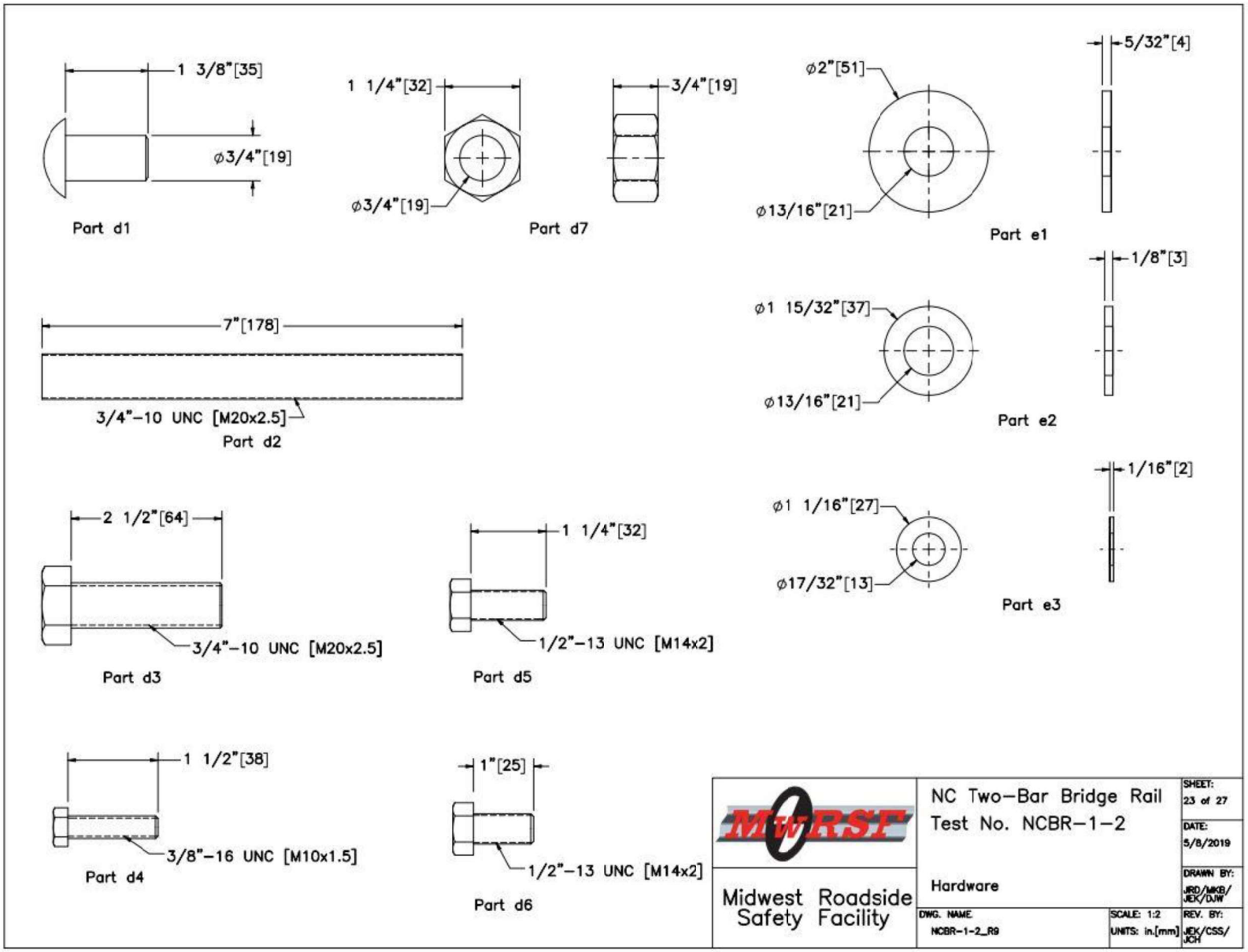


Figure 24. Hardware, Test Nos. NCBR-1 and NCBR-2