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Submittal Data Sheet

Submittal #: 2

Submission #: 1

Date: 4/21/2016

Project Name: Irasburg IM Deck (46)

Owner: Vermont Agency of Transportation

Engineer: VTrans

Contractor: J.P. Sicard, Inc.

Item Number: Special Provision 900.620 (Bridge Scupper)

Supplier: The Fort Miller Co., Inc.

Description of Item: Braced Traffic Barrier

Substitution: NO

Engineers Review Comments:

Submitted By: Brad Drake
Title: Project Manager
Company: JP Sicard, Inc.



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April 21, 2016

Seth Hisman
Resident Engineer
VTrans Construction Section
61 Valley View
Rutland, VT 05701

Seth,

Please find attached formal submittal package for the braced traffic barrier for the Irasburg IM Deck (46) project. The below summary of the submittal package identifies each document as it relates to the proposed barrier (Fort Miller Co., Inc. is supplier) and meets criteria set forth for this product:

- Page 4-5– VTrans Irasburg IM Deck (46) Plan Drawings, Sheet 17 of 49, Temporary Barrier – Braced Sheet 1; See General Note No. 2:
“Temporary Traffic Barrier-Braced details as shown in these plans are in compliance with the requirements per updated NCHRP report 350 for test No. 3-II, TL-3 crash tested by Midwest Roadside Safety: NY Box Beam Stiffening of unanchored TCB, March 2008.”
- Page 6-242 – Midwest Roadside Safety – Evaluation of Box Beam Stiffening of Unanchored Temporary Concrete Barriers (Displays passing evaluation for above compliance requirements.)
- Page 243-250 – Official FHWA Memorandum to NYSDOT approving/certifying NYS TCB with Box Beam Stiffener meets NCHRP 350 requirements and approved for use.
- Page 251 – NYSDOT Engineering Bulletin issuing Standard Sheet 619-01-Temporary Concrete Barrier and M619-72-Box Beam Stiffening of Temporary Concrete Barrier
- Page 252-254 – Official NYSDOT Standard 619-01 Issued for Box Beam Barrier System
- Page 255 – Fort Miller Traffic Barrier Design Drawing approved by NYDOT – See Note 8:
“All H-Key & Tube Details, Materials and Welding Requirements Shall Conform to NYSDOT Standard Sheet 619-01.”



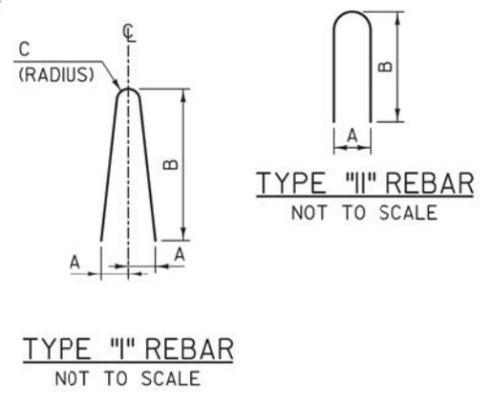
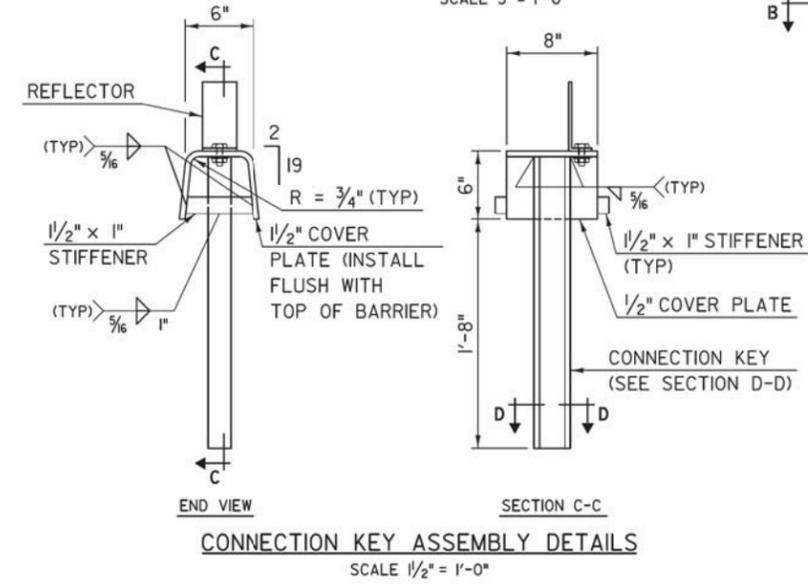
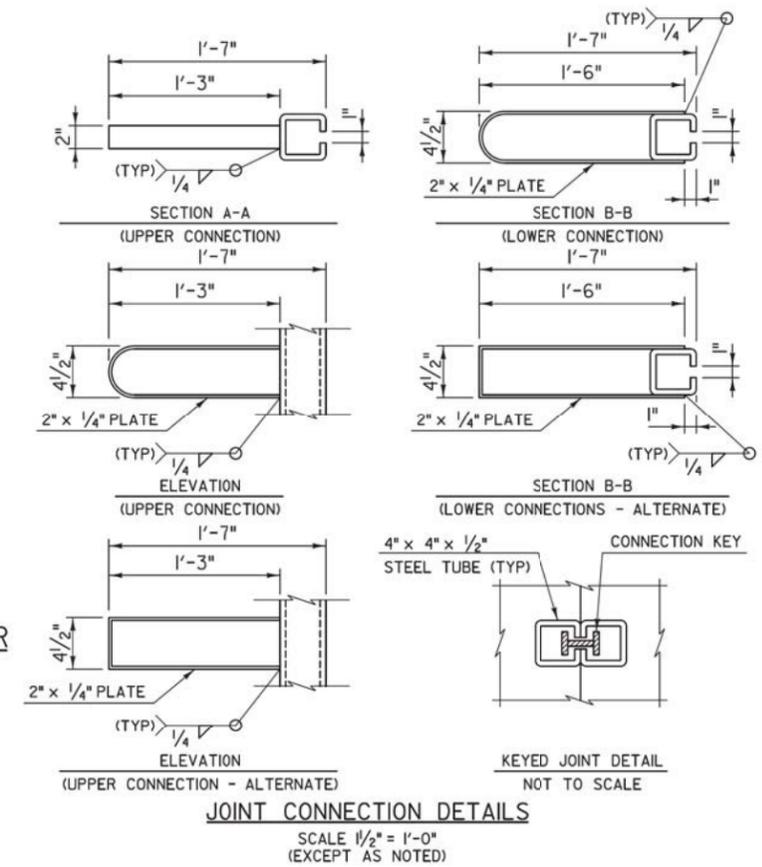
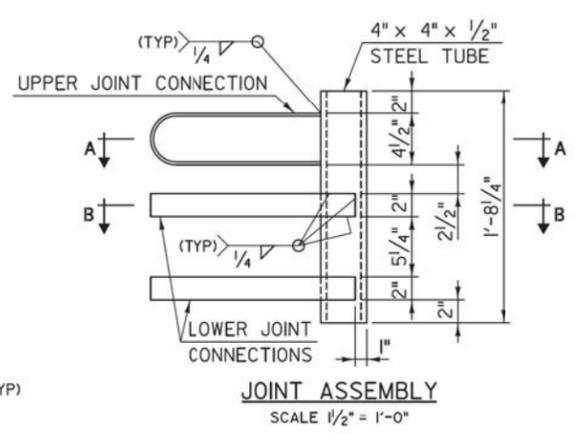
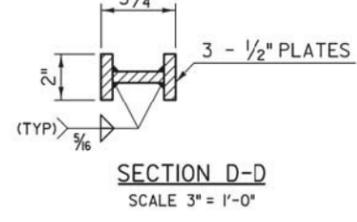
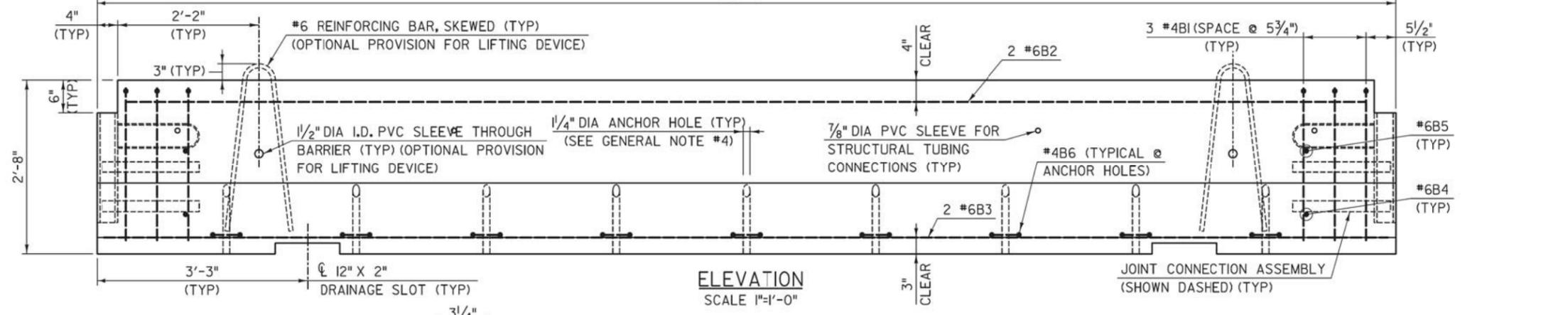
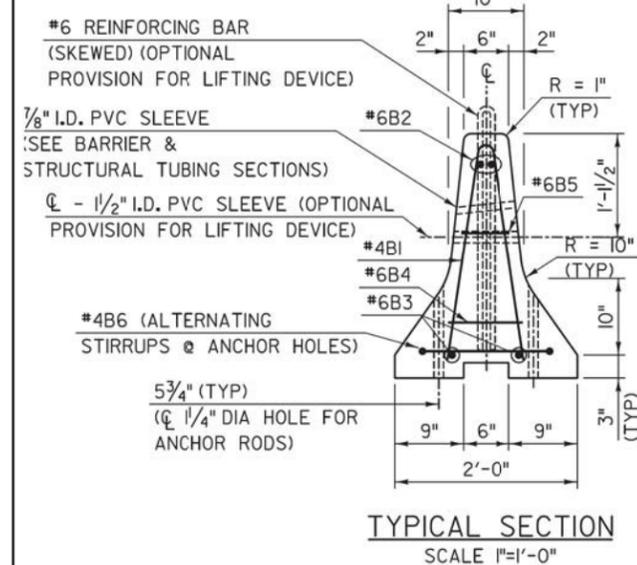
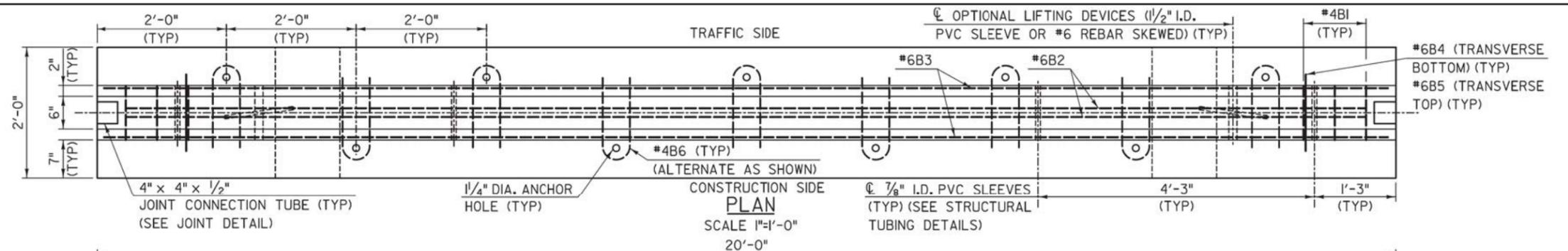
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Please let me know if you have any questions or require any additional information.

Thank you,

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REINFORCING SCHEDULE (PER 20' BARRIER UNIT)								
MARK	SIZE	LENGTH	# PIECES	TYPE	A	B	C	LOCATION
B1	#4	4'-10"	6	I	5"	2'-4"	1"	STIRRUPS
B2	#6	19'-1"	2	---				LONGITUDINAL (TOP)
B3	#6	19'-9"	2	---				LONGITUDINAL (BOTTOM)
B4	#6	1'-2"	2	---				TRANSVERSE (BOTTOM)
B5	#6	6"	2	---				TRANSVERSE (TOP)
B6	#4	2'-9"	9	II	5"	1'-3"		STIRRUPS

- GENERAL NOTES**
- TEMPORARY TRAFFIC BARRIER-BRACED SHALL BE FURNISHED BY THE CONTRACTOR AND PAYMENT SHALL BE INCLUDED IN PAY ITEM 900.645 SPECIAL PROVISION (TRAFFIC CONTROL, ALL INCLUSIVE). CONCRETE BARRIER AND ALL ATTACHMENTS SHALL BE FABRICATED IN ACCORDANCE WITH SECTION 62. ALL BARRIER UNITS FOR BRACED SYSTEMS SHALL BE 20' LONG.
 - TEMPORARY TRAFFIC BARRIER-BRACED DETAILS, AS SHOWN IN THESE PLANS, ARE IN COMPLIANCE WITH REQUIREMENTS PER UPDATED NCHRP REPORT 350 FOR TEST NO. 3-II, TL-3 CRASH TESTED BY MIDWEST ROADSIDE SAFETY; NY BOX BEAM STIFFENING OF UNANCHORED TCB, MARCH 2008. THE BARRIER SYSTEM TESTED WITH A 27.6" DYNAMIC DEFLECTION AND ALLOWS FOR PLACEMENT AT A MINIMUM 12" DISTANCE BETWEEN BARRIERS AND EDGE OF BRIDGE DECK.
 - A MINIMUM OF TWO BARRIER UNITS WITH BRACED JOINTS ARE REQUIRED TO BE PLACED BEYOND BOTH ENDS OF THE BRIDGE WORK AREA FOR SPEEDS GREATER THAN 45 MPH. FOR SPEEDS ≤ 45 MPH, A MINIMUM OF ONE BRACED BARRIER IS REQUIRED TO BE FULLY SET BEYOND EACH END OF BRIDGE WORK AREA.
 - THE LAST CONCRETE BARRIER UNIT, AT EACH END OF BARRIER LAYOUT, SHALL BE ANCHORED A MINIMUM 18" BELOW THE ROADWAY SURFACE. REQUIRED 1" DIA. ANCHOR RODS (A36 STEEL) SHALL BE INSTALLED WITH 5 ANCHORS ON THE TRAFFIC SIDE OF BARRIER AND 4 ON THE CONSTRUCTION SIDE. IF THE END(S) OF THE BRACED CONCRETE BARRIER SYSTEM EXTENDS 50' OR MORE BEYOND LIMITS OF BRIDGE WORK THE LAST BARRIER UNIT DOES NOT REQUIRE ANCHORAGE.
 - TEMPORARY TRAFFIC BARRIER - BRACED MAY BE INSTALLED WITH A 230' MINIMUM RADIUS. GAPS CREATED BETWEEN STRUCTURAL TUBES AND CONCRETE BARRIER, DURING A RADIAL LAYOUT, SHALL BE SHIMMED WITH 8"x8"x1/2" PLATES & FENDER WASHERS TO FIRMLY ATTACH STRUCTURAL TUBING TO BARRIER.
 - THE CONTRACTOR SHALL FURNISH AND INSTALL APPROVED RETROREFLECTIVE DELINEATORS AT 25-FOOT INTERVALS ALONG TOP AND/OR ONE FOOT DOWN THE SIDE OF PORTABLE CONCRETE BARRIER. PAYMENT SHALL BE INCLUDED IN ITEM 900.645 "SPECIAL PROVISION (TRAFFIC CONTROL, ALL INCLUSIVE)". THE COLOR OF DELINEATORS SHALL, IN ALL INSTANCES, CONFORM TO THE COLOR OF EDGE LINE MARKINGS. DELINEATORS SUPPLEMENT, BUT DO NOT REPLACE, THE NEED FOR RETROREFLECTIVE SOLID EDGE LINE MARKINGS.

- MATERIAL NOTES**
- BARRIERS SHALL BE LIGHT COLORED CLASS AA CONCRETE, WITH MINIMUM COMPRESSIVE STRENGTH OF 4000 psi, AND SHALL HAVE A SMOOTH UNIFORM SURFACE FREE OF DEFECTS AND IRREGULARITIES. CASTING DATE SHALL BE SHOWN ON BARRIER. ALL EXPOSED EDGES OF CONCRETE SHALL BE CHAMFERED 3/4", UNLESS OTHERWISE NOTED.
 - ALL REINFORCING STEEL SHALL BE AASHTO M31 (ASTM A615) GRADE 60. ALL REINFORCEMENT SHALL HAVE 1/2" MINIMUM CLEAR COVER, UNLESS OTHERWISE NOTED.
 - STRUCTURAL STEEL, EXCEPT THE STEEL TUBES, SHALL BE AASHTO M270 GRADE 50. ALL STEEL SHALL BE FABRICATED IN ACCORDANCE WITH SECTION 506.
 - STEEL TUBES, 6x6x3/8 & 4x4x1/2, SHALL BE ASTM A 500 GRADE B OR C. THE 6x6x3/8 TUBES SHALL BE 12' LONG AND GALVANIZED IN ACCORDANCE WITH SUBSECTION 726.08.
 - A MINIMUM OF 2 RECESSED LIFTING DEVICES, EACH WITH THE CAPACITY TO LIFT A MASS OF 6 TONS (MINIMUM), SHALL BE INSTALLED TO EACH BARRIER UNIT. TWENTY FOOT LONG CONCRETE BARRIER UNITS ARE APPROXIMATELY 400 LBS./FT.
 - DELINEATORS SHALL BE ATTACHED TO BARRIER USING AN APPROVED ADHESIVE MATERIAL OR AS SHOWN ON THIS SHEET.

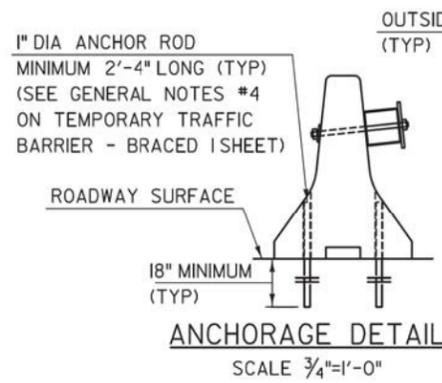
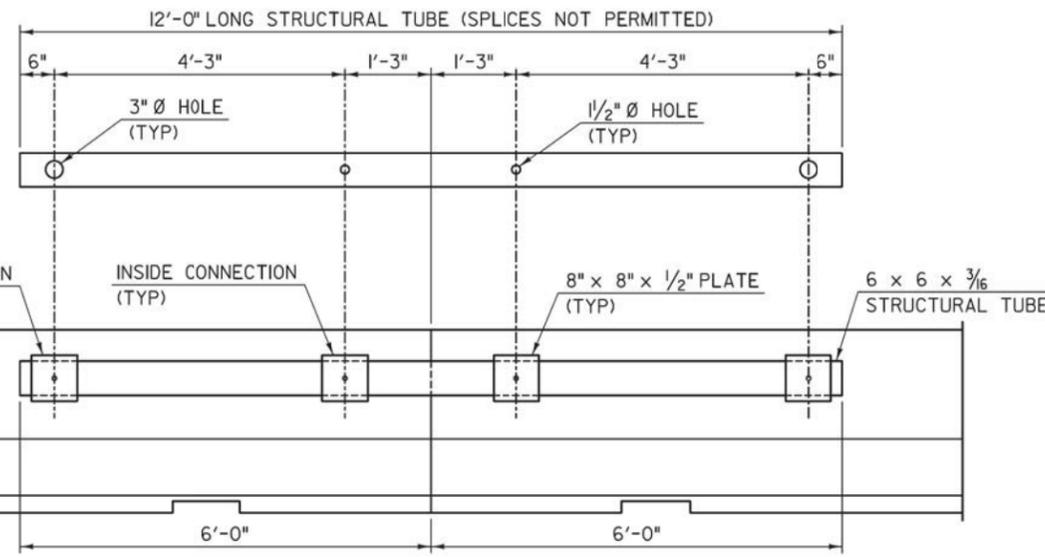
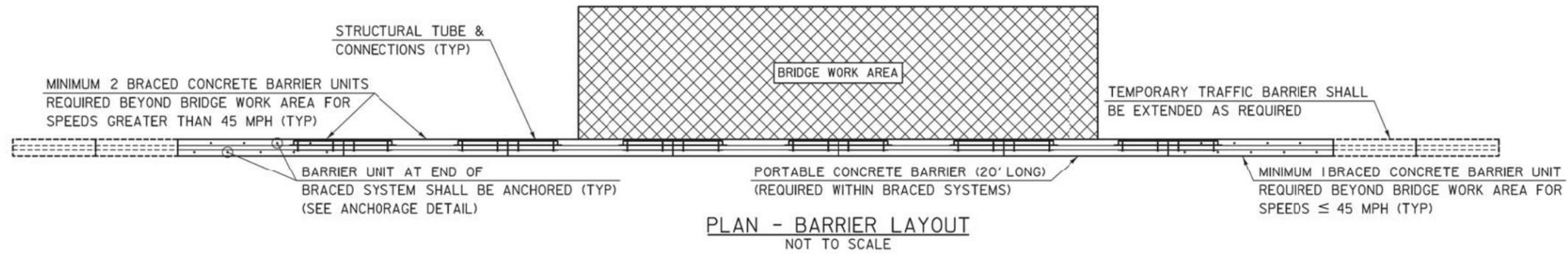
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 PROJECT NUMBER: IM DECK(46)

FILE NAME: z15all6barrier-107N.dgn
 PROJECT LEADER: J. BYATT
 DESIGNED BY: S. BEAUMONT
 TEMPORARY TRAFFIC BARRIER - BRACED SHEET 1

PLOT DATE: 2/5/2016
 DRAWN BY: M. SMITH
 CHECKED BY: J. BYATT
 SHEET 17 OF 49

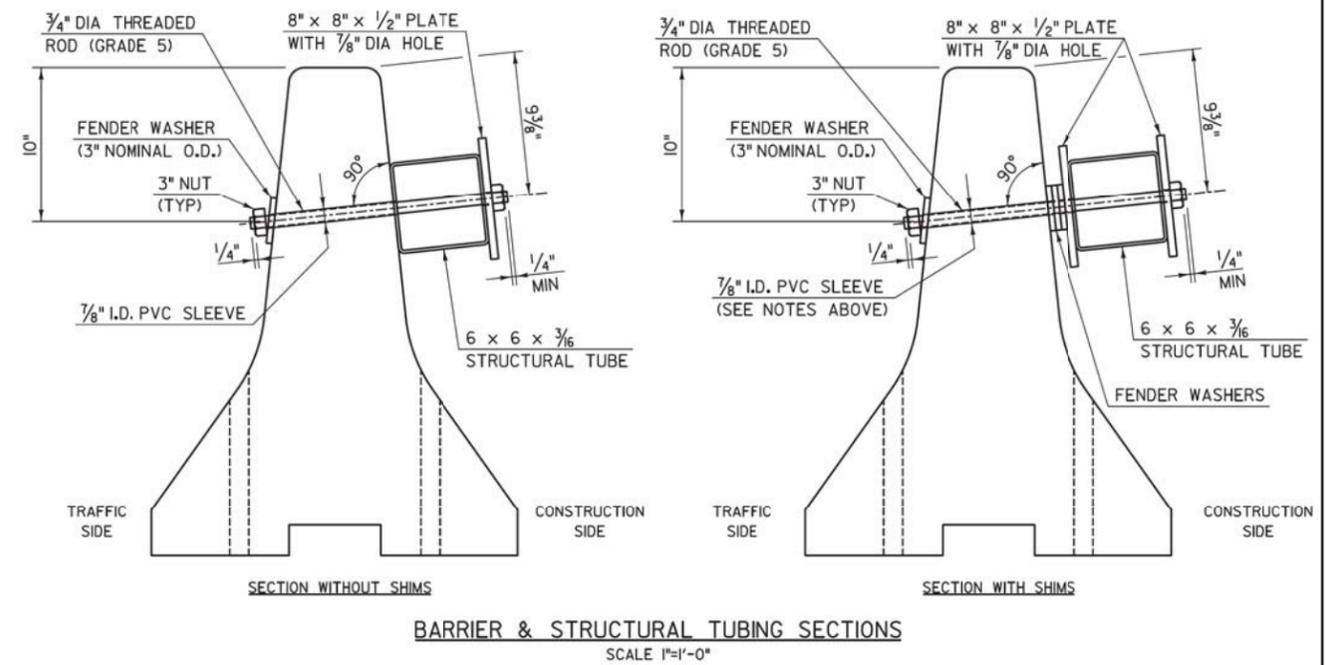
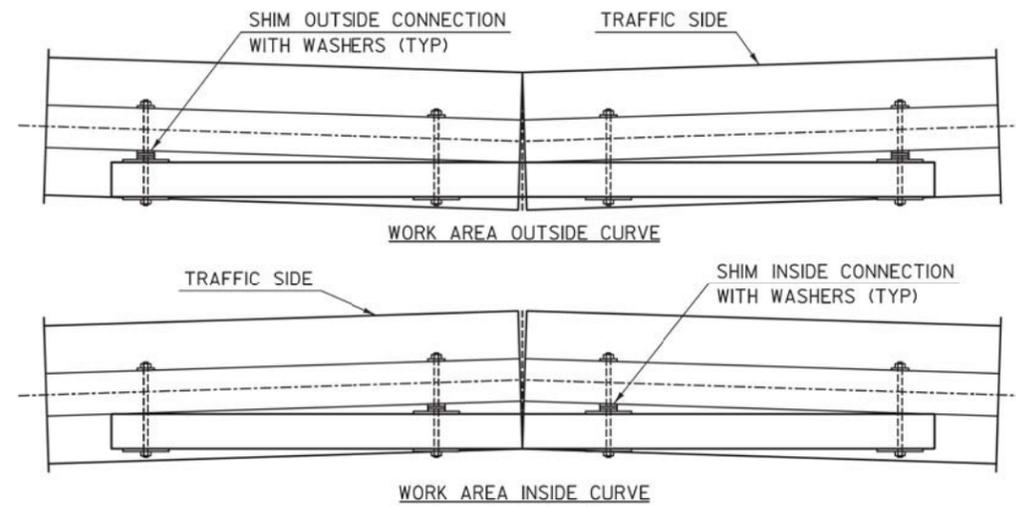


MODEL: Sheet 01
CLD 15-0223



PVC SLEEVE OPENINGS SHALL BE MODIFIED/DRILLED AS REQUIRED TO PROPERLY ALIGN STRUCTURAL TUBE BRACING UNITS FOR CURVED ALIGNMENTS

THE PRESENCE OF NORMAL HOLES WHICH HAVE BEEN MODIFIED/DRILLED WILL NOT AFFECT THE REUSE OF CONCRETE BARRIER UNITS



CLD 15-0223 MODEL: Sheet02



PROJECT NAME: IRASBURG
PROJECT NUMBER: IM DECK(46)

FILE NAME: z15all6barrier-107N.dgn
PROJECT LEADER: J. BYATT
DESIGNED BY: S. BEAUMONT
TEMPORARY TRAFFIC BARRIER - BRACED SHEET 2

PLOT DATE: 2/5/2016
DRAWN BY: M. SMITH
CHECKED BY: J. BYATT
SHEET 18 OF 49

EVALUATION OF BOX BEAM STIFFENING OF UNANCHORED TEMPORARY CONCRETE BARRIERS

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Submitted to

NEW YORK STATE DEPARTMENT OF TRANSPORTATION

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Albany, New York 12232

MwRSF Research Report No. TRP-03-202-08

March 14, 2008

Technical Report Documentation Page

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12. Sponsoring Organization Name and Address New York State Department of Transportation 50 Wolf Road, 6 th Floor Albany, New York 12232		13. Type of Report and Period Covered Final Report 2007-2008	
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15. Supplementary Notes Prepared in cooperation with U.S. Department of Transportation, Federal Highway Administration			
16. Abstract (Limit: 200 words)			
<p>Temporary concrete barrier (TCB) systems that are not pinned into the pavement can be displaced during an impact and can result in workers being crushed between the barrier and objects within the workspace. Alternatively, the barrier could be moved far enough to fall off of the paved surface and onto workers in an excavation, below a bridge, or onto traffic under the bridge. The process for drilling holes in a bridge deck to anchor temporary concrete barriers is time-consuming, costly, and may ultimately result in damage to the bridge. Thus, a means for reducing the deflection of the barrier system is necessary and without the use of anchoring the barrier sections to the underlying pavements with pins, rods, or bolts.</p> <p>The primary objective of this study was to evaluate the potential for reducing barrier deflections through the use of box beam stiffening on New York State's TCBs. The secondary objective of the study was to evaluate stiffened and unstiffened versions of New York State's temporary concrete barrier system according to the Test Level 3 (TL-3) criteria set forth in the currently proposed Update to NCHRP Report No. 350. The research study included three full-scale vehicle crash tests with Dodge Quad Cab pickup trucks. The first system utilized 152-mm x 152-mm x 4.8-mm (6-in. x 6-in. x 0.1875-in.) box beam sections placed across three joints. The second system consisted of an unstiffened version of the temporary concrete barrier system. The final system utilized 152-mm x 203-mm x 6.4-mm (6-in. x 8-in. x 0.25-in.) box beam sections placed across six joints with the back side of the barriers placed 305 mm (12 in.) away from the bridge deck edge. Following the successful redirection of all three pickup trucks, the safety performance of the unstiffened and the two stiffened designs were determined to be acceptable according the TL-3 evaluation criteria specified in the currently proposed Update to NCHRP Report No. 350. Furthermore, the stiffened versions of the temporary concrete barrier system can be safely installed with a 305 mm (12 in.) gap between the bridge deck edge and the back side of the barriers.</p>			
17. Document Analysis/Descriptors Highway Safety, Roadside Appurtenances, Longitudinal Barriers, Temporary Barriers, Concrete Barriers, Box Beam Stiffener, Crash Test, Compliance Test, NCHRP 350 Update		18. Availability Statement No restrictions. Document available from: National Technical Information Services, Springfield, Virginia 22161	
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DISCLAIMER STATEMENT

The contents of this report reflect the views of the authors who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views nor policies of the New York State Department of Transportation, the United States Department of Transportation, nor the Federal Highway Administration. This report does not constitute a standard, specification, regulation, product endorsement, nor an endorsement of manufacturers.

ACKNOWLEDGMENTS

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(1) the New York State Department of Transportation for sponsoring the project; and (2) MwRSF personnel for constructing the barriers and conducting the crash tests.

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1 INTRODUCTION

1.1 Problem Statement

Temporary concrete barrier (TCB) systems that are not pinned into the pavement can be displaced during an impact. The displacement could result in workers being crushed between the barrier and objects within the workspace. Alternatively, the barrier could be moved laterally such as to fall off of the paved surface and onto workers in an excavation, below a bridge, or onto traffic under the bridge. While it is possible to drill holes into a bridge deck in order to anchor the TCB system, the process is time-consuming, costly, and ultimately may result in damage to the bridge. Thus, there is a need for a means of reducing the deflection of the TCB system that does not require an attachment to the pavement.

Previous crash testing of the New York State Department of Transportation (NYSDOT) TCB system, in both pinned and unpinned configurations, has shown acceptable performance. The previous crash testing had been conducted according to the National Cooperative Highway Research Program (NCHRP) Report No. 350 safety performance criteria (1). However, an unpinned, stiffened version of the TCB has not been crash tested. In order to stiffen the system, a proposed solution was to fasten box beam sections across barrier joints and to anchor both ends of the barrier system. Although the bolt heads used to fasten the box beams to the barrier sections may have a slight effect on the vehicle's response, they should not be a cause for concern. These box beam stiffening sections were believed to be capable of reducing lateral deflections and preventing separation of the barriers when deflected and suspended over the edge of a bridge deck.

1.2 Research Objective

The objective of this research project was to evaluate the safety performance of stiffened NYSDOT temporary concrete barrier systems and compare it to the performance observed for non-

stiffened TCBs. As part of the testing program, Midwest Roadside Safety Facility (MwRSF) researchers suggested that the stiffened TCB be placed adjacent to the free edge of a bridge deck in order to evaluate a real-world scenario as well as to provide convincing evidence of the system's effectiveness. NYSDOT officials agreed to this modified test layout as part of the final crash test. NYSDOT officials were confident that the barrier systems would meet all impact safety standards. However, the NYSDOT desired that the temporary concrete barrier systems be evaluated according to the new Test Level 3 (TL-3) safety performance criteria set forth in the currently proposed Update to NCHRP Report No. 350 (2).

1.3 Scope

The research objective was achieved through the completion of several tasks. First, full-scale vehicle crash tests were performed on the box beam stiffened and unstiffened versions of the temporary concrete barrier system. The crash tests utilized ½ ton pickup trucks, each weighing approximately 2,270 kg (5,004 lbs) as recommended by the currently proposed Update to NCHRP Report No. 350 (2). The target impact conditions for the tests were an impact speed of 100.0 km/h (62.1 mph) and an impact angle of 25 degrees. Next, the test results were analyzed, evaluated, and documented. Finally, conclusions and recommendations were made that pertain to the safety performance of the box beam stiffened and unstiffened variations of the temporary concrete barrier system.

2 LITERATURE REVIEW

Previous testing on the NYSDOT TCB system was conducted by the Texas Transportation Institute (TTI) (3-4). Crash testing of the TCB system was evaluated according to the criteria provided in NCHRP Report No. 350 (1).

In 1999, TTI tested the unpinned version of the NYSDOT TCB (3). In test no. 473220-7, a 2,075-kg (4,575-lb) pickup truck impacted the ten barrier system 1.2 m (3 ft - 11 in.) upstream of the connection between barrier segment nos. 3 and 4 at a speed of 98.0 km/h (60.9 mph) and at an angle of 26.3 degrees. During the impact, three of the barrier joints failed, causing the barrier at the point of impact to overturn. Subsequently, the vehicle overrode the barrier and rolled over. Thus, the test was determined to be unacceptable according to the NCHRP Report No. 350 requirements, since the vehicle did not remain upright after collision with the system. The joint failure was subsequently attributed to substandard welding in the connection joints.

In 2001, TTI retested the properly fabricated unpinned NYSDOT TCB system (4). It should be noted that the end barrier sections were unpinned as well. During test no. 473220-14, a 2,076-kg (4,577-lb) pickup truck impacted the ten barrier system 1.38 m (4 ft - 6 in.) upstream of the joint between barrier segment nos. 3 and 4 at a speed of 100.8 km/h (62.6 mph) and at an angle of 25.6 degrees. During the impact, the vehicle was redirected smoothly, and the test was determined to be acceptable according to the NCHRP Report No. 350 requirements. The barrier system experienced 1,270 mm (50 in.) of dynamic deflection and 1,270 mm (50 in.) of permanent set deflection. During the test, the upstream end was pulled 148 mm (5.8 in.) longitudinally downstream, while the downstream end was displaced 5 mm (0.2 in.) longitudinally upstream, or toward the impact point. The noted lateral barrier deflections would be correlated to the unpinned section ends.

It was NYSDOT's concern over this large barrier deflection that caused the state agency to contract with MwRSF to conduct the barrier stiffening research covered by this report.

3 TEST REQUIREMENTS AND EVALUATION CRITERIA

3.1 Test Requirements

Historically, longitudinal barriers, such as temporary concrete barriers, have been required to satisfy impact safety standards in order to be accepted by the Federal Highway Administration (FHWA) for use on National Highway System (NHS) construction projects or as a replacement for existing designs not meeting current safety standards. In recent years, these safety standards have consisted of the guidelines and procedures published in NCHRP Report No. 350 (1). However, NCHRP Project 22-14(2) generated revised testing procedures and guidelines for use in the evaluation of roadside safety appurtenances and have been presented in the draft report entitled, *Recommended Procedures for the Safety Performance Evaluation of Highway Features* (2). Therefore, according to TL-3 of the currently proposed Update to NCHRP Report No. 350, longitudinal barrier systems must be subjected to two full-scale vehicle crash tests. The two full-scale crash tests are as follows:

1. Test Designation 3-10 consisting of an 1,100-kg (2,425-lb) passenger car impacting the barrier system at a nominal speed and angle of 100.0 km/h (62.1 mph) and 25 degrees, respectively.
2. Test Designation 3-11 consisting of a 2,270-kg (5,004-lb) pickup truck impacting the barrier system at a nominal speed and angle of 100.0 km/h (62.1 mph) and 25 degrees, respectively.

A rigid, F-shape bridge rail was successfully impacted by a small car weighing 893 kg (1,800 lbs) at 96.7 km/h (60.1 mph) and 21.4 degrees according to the American Association of State Highway and Transportation Officials (AASHTO) *Guide Specifications for Bridge Railings* (5-6). In the same manner, rigid New Jersey safety shape barriers struck by small cars have also been shown to meet safety performance standards (7-8). In addition, a New Jersey safety shape barrier was impacted by a passenger car weighing 1,170 kg (2,579 lbs) at 97.9 km/h (60.8 mph) and 26.1

degrees according to the TL-3 standards set forth in the currently proposed Update to NCHRP Report No. 350 (9). Furthermore, temporary New Jersey safety shape concrete median barriers have experienced only slight barrier deflections when impacted by small cars and behave similar to rigid barriers (10). As such, the 1,100-kg (2,425-lb) passenger car test was deemed unnecessary for this project. The test conditions for TL-3 longitudinal barriers are summarized in Table 1.

For this crash testing program, the NYSDOT's primary objective was to evaluate the potential for reducing barrier deflections through the use of box beam stiffening on an approved TCB design.

3.2 Evaluation Criteria

According to the currently proposed Update to NCHRP Report No. 350, the evaluation criteria for full-scale vehicle crash testing are based on three appraisal areas: (1) structural adequacy; (2) occupant risk; and (3) vehicle trajectory after collision. Criteria for structural adequacy are intended to evaluate the ability of the barrier to contain, redirect, or allow controlled vehicle penetration in a predictable manner. Occupant risk evaluates the degree of hazard to occupants in the impacting vehicle. Vehicle trajectory after collision is a measure of the potential for the post-impact trajectory of the vehicle to cause subsequent multi-vehicle accidents. This criterion also indicates the potential safety hazard for the occupants of other vehicles or the occupants of the impacting vehicle when subjected to secondary collisions with other fixed objects. These three evaluation criteria are summarized in Table 2 and defined in greater detail in the currently proposed Update to NCHRP Report No. 350 (2). The full-scale vehicle crash tests were conducted and reported in accordance with the procedures provided in the currently proposed Update to NCHRP Report No. 350.

In addition to the standard occupant risk measures, the Post-Impact Head Deceleration

(PHD) and Theoretical Head Impact Velocity (THIV) were also determined and reported on the test summary sheets. Additional discussion on PHD and THIV is provided in reference (2).

Table 1. Update to NCHRP Report No. 350 Test Level 3 Crash Test Conditions

Test Article	Test Designation	Test Vehicle	Impact Conditions			Evaluation Criteria ¹
			Speed		Angle (degrees)	
			(km/h)	(mph)		
Longitudinal Barrier	3-10	1100C	100	62.1	25	A,D,F,H,I,M
	3-11	2270P	100	62.1	25	A,D,F,H,I,M

¹ Evaluation criteria explained in Table 2.

Table 2. Update to NCHRP Report No. 350 Evaluation Criteria for Crash Tests

Structural Adequacy	A. Test article should contain and redirect the vehicle or bring the vehicle to a controlled stop; the vehicle should not penetrate, underride, or override the installation although controlled lateral deflection of the test article is acceptable.
Occupant Risk	D. Detached elements, fragments or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present an undue hazard to other traffic, pedestrians, or personnel in a work zone. Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.3 and Appendix E of the currently proposed Update to NCRHP Report No. 350.
	F. The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.
	H. Longitudinal and lateral occupant impact velocities should fall below the preferred value of 9.1 m/s (30.0 ft/s), or at least below the maximum allowable value of 12.2 m/s (40.0 ft/s).
	I. Longitudinal and lateral occupant ridedown accelerations should fall below the preferred value of 15.0 g's, or at least below the maximum allowable value of 20.49 g's.
Vehicle Trajectory	M. After impact, the vehicle shall exit the barrier within the exit box.

4 TEST CONDITIONS

4.1 Test Facility

The testing facility is located at the Lincoln Air Park on the northwest side of the Lincoln Municipal Airport and is approximately 8.0 km (5 mi.) northwest of the University of Nebraska-Lincoln.

4.2 Vehicle Tow and Guidance System

A reverse cable tow system with a 1:2 mechanical advantage was used to propel the test vehicle. The distance traveled and the speed of the tow vehicle were one-half that of the test vehicle. The test vehicle was released from the tow cable before impact with the barrier system. A digital speedometer on the tow vehicle increases the accuracy of the test vehicle impact speed.

A vehicle guidance system developed by Hinch ([11](#)) was used to steer the test vehicle. A guide-flag, attached to the front-left wheel and the guide cable, was sheared off before impact with the barrier system. The 9.5-mm (0.375-in.) diameter guide cable was tensioned to approximately 15.6 kN (3,500 lbf), and supported laterally and vertically every 30.48 m (100 ft) by hinged stanchions. The hinged stanchions stood upright while holding up the guide cable, but as the vehicle was towed down the line, the guide-flag struck and knocked each stanchion to the ground. For tests NYTCB-1, NYTCB-2, and NYTCB-3, the vehicle guidance system was 335 m (1,100 ft) long.

4.3 Test Vehicles

For test NYTCB-1, a 2002 Dodge Ram 1500 Quad Cab pickup truck was used as the test vehicle. The test inertial and gross static weights were 2,275 kg (5,016 lbs). The test vehicle is shown in Figure 1, and vehicle dimensions are shown in Figure 2.

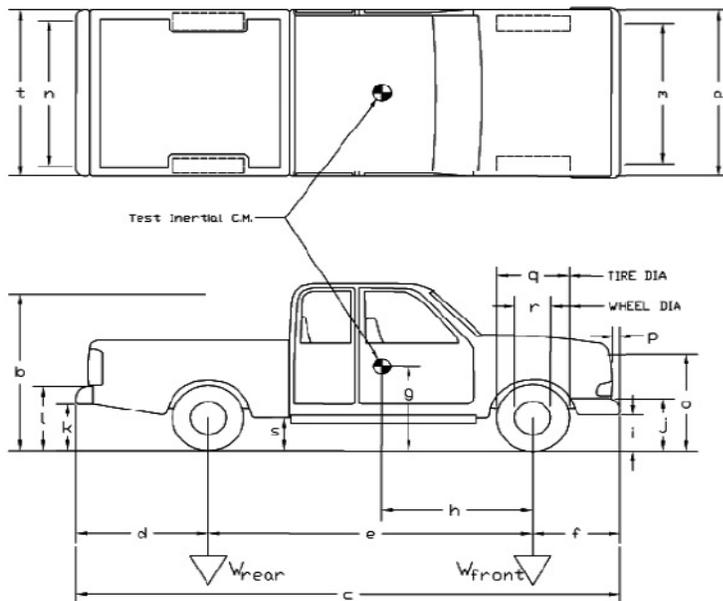
For test NYTCB-2, a 2002 Dodge Ram 1500 Quad Cab pickup truck was used as the test



Figure 1. Test Vehicle, Test NYTCB-1

Date: 7/24/2007 Test Number: NYTCB-1 Model: Ram 1500 Q.C.
 Make: Dodge Vehicle I.D.#: 3B7HA18N32G103871
 Tire Size: 265/70 R17 Year: 2002 Odometer: 81292

*(All Measurements Refer to Impacting Side)



Vehicle Geometry -- mm (in.)

a	<u>1931.2 (78.0)</u>	b	<u>1886 (74.25)</u>
c	<u>5778.5 (227.5)</u>	d	<u>1219.2 (48.0)</u>
e	<u>3562.4 (140.25)</u>	f	<u>996.95 (39.25)</u>
g	<u>727.08 (28.625)</u>	h	<u>1590.3 (62.61)</u>
i	<u>381 (15.0)</u>	j	<u>530.23 (20.875)</u>
k	<u>530.23 (20.875)</u>	l	<u>714.38 (28.125)</u>
m	<u>1727.2 (68.0)</u>	n	<u>1714.5 (67.5)</u>
o	<u>1188.4 (46.0)</u>	p	<u>82.55 (3.25)</u>
q	<u>774.7 (30.5)</u>	r	<u>469.9 (18.5)</u>
s	<u>393.7 (15.5)</u>	t	<u>1911.4 (75.25)</u>
Wheel Center Height Front	<u>381 (15.0)</u>		
Wheel Center Height Rear	<u>384.18 (15.125)</u>		
Wheel Well Clearance (FR)	<u>904.88 (35.625)</u>		
Wheel Well Clearance (RR)	<u>962.03 (37.875)</u>		
Frame Height (FR)	<u>635 (25.0)</u>		
Frame Height (RR)	<u>454.03 (17.875)</u>		
Engine Type	<u>8 CYL. GAS</u>		
Engine Size	<u>4.7L</u>		

Transmission Type:

Automatic

Weights kg (lbs)	Curb	Test Inertial	Gross Static	RWD
W-front	<u>1285 (2833)</u>	<u>1266 (2791)</u>	<u>1266 (2791)</u>	<u>Front GVWR 3650</u>
W-rear	<u>1016.5 (2241)</u>	<u>1009.2 (2225)</u>	<u>1009.2 (2225)</u>	<u>Rear GVWR 3900</u>
W-total	<u>2301.5 (5074)</u>	<u>2275.2 (5016)</u>	<u>2275.2 (5016)</u>	<u>Total GVWR 6650</u>

Note any damage prior to test: None

Figure 2. Vehicle Dimensions, Test NYTCB-1

vehicle. The test inertial and gross static weights were 2,279 kg (5,024 lbs). The test vehicle is shown in Figure 3, and vehicle dimensions are shown in Figure 4.

For test NYTCB-3, a 2003 Dodge Ram 1500 Quad Cab pickup truck was used as the test vehicle. The test inertial and gross static weights were 2,268 kg (5,001 lbs). The test vehicle is shown in Figure 5, and vehicle dimensions are shown in Figure 6.

The Suspension Method (12) was used to determine the vertical component of the center of gravity (c.g.) for the pickup trucks. This method is based on the principle that the c.g. of any freely suspended body is in the vertical plane through the point of suspension. The vehicle was suspended successively in three positions, and the respective planes containing the c.g. were established. The intersection of these planes pinpointed the location of the center of gravity. The longitudinal component of the c.g. was determined using the measured axle weights. The location of the final centers of gravity are shown in Figures 2, 4, 6, and 7 through 9.

Square black and white-checked targets were placed on the vehicle to aid in the analysis of the high-speed AOS videos, as shown in Figures 7 through 9. Checkered targets were placed at the c.g. on the left-side door, the right-side door, and the roof of the vehicle. The remaining targets were located for reference so that they could be viewed from the high-speed cameras for video analysis.

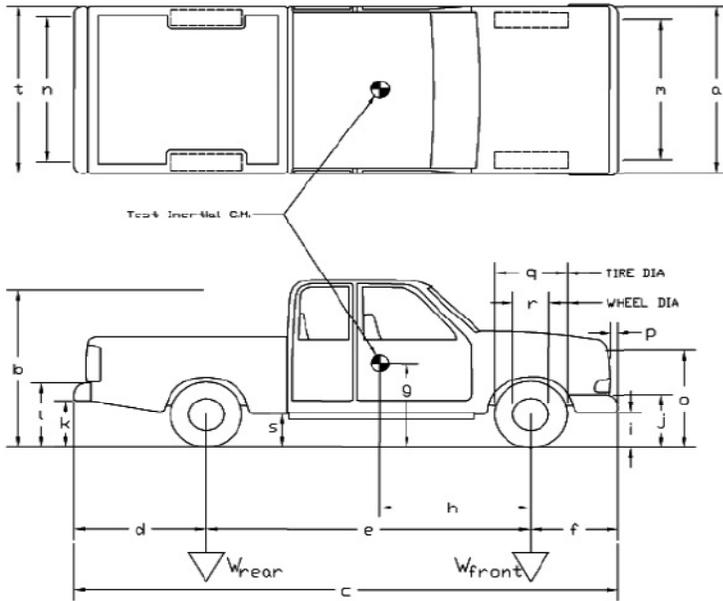
The front wheels of the test vehicle were aligned for camber, caster, and toe-in values of zero so that the vehicles would track properly along the guide cable. A 5B flash bulb was mounted on the left-quarter point of the vehicle's dash to pinpoint the time of impact with the test article on the high-speed video footage. The flash bulb was fired by a pressure tape switch mounted at the impact corner of the bumper. A remote controlled brake system was installed in the test vehicle so the vehicle could be brought safely to a stop after the test.



Figure 3. Test Vehicle, Test NYTCB-2

Date: 7/25/2007 Test Number: NYTCB-2 Model: Ram 1500 Q.C.
 Make: Dodge Vehicle I.D.#: 1D7HA18K83J506255
 Tire Size: 265/70 R17 Year: 2002 Odometer: 96569

*(All Measurements Refer to Impacting Side)



Vehicle Geometry -- mm (in.)

a	1931.2 (78.0)	b	1917.7 (75.5)
c	5778.5 (227.5)	d	1206.5 (47.5)
e	3582.4 (140.25)	f	1009.7 (39.75)
g	711.2 (28.0)	h	1625.6 (64.0)
i	355.6 (14.0)	j	647.7 (25.5)
k	520.7 (20.5)	l	730.25 (28.75)
m	1727.2 (68.0)	n	1720.9 (67.75)
o	1124 (44.25)	p	88.9 (3.5)
q	774.7 (30.5)	r	469.9 (18.5)
s	381 (15.0)	t	1911.4 (75.25)
Wheel Center Height Front	381 (15.0)		
Wheel Center Height Rear	384.18 (15.125)		
Wheel Well Clearance (FR)	889 (35.0)		
Wheel Well Clearance (RR)	965.2 (38.0)		
Frame Height (FR)	444.5 (17.5)		
Frame Height (RR)	635 (25.0)		
Engine Type	6 CYL. GAS		
Engine Size	3.7L		

Transmission Type:

Automatic

Weights kg (lbs)	Weights			RWD
	Curb	Test Inertial	Gross Static	
W-front	1232.9 (2718)	1215.1 (2681)	1216.1 (2681)	Front GVWR 3650
W-rear	1012 (2231)	1062.8 (2343)	1062.8 (2343)	Rear GVWR 3900
W-total	2244.8 (4949)	2278.8 (5024)	2278.8 (5024)	Total GVWR 6650

Note any damage prior to test: None

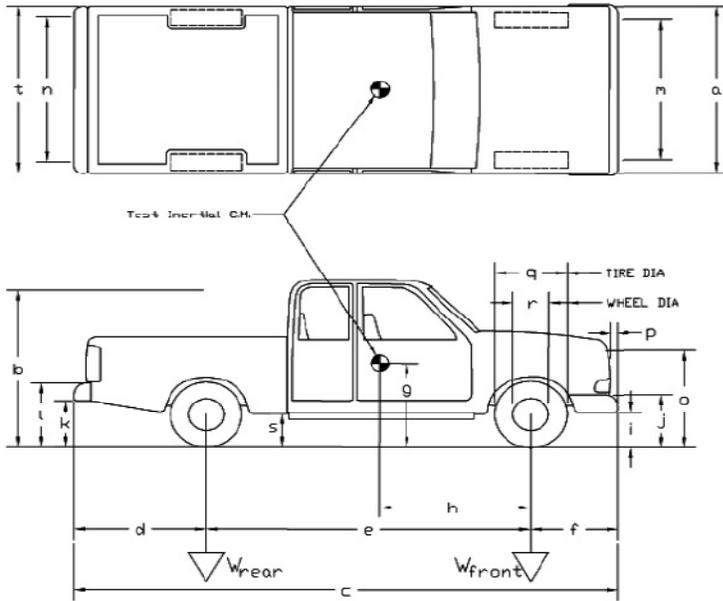
Figure 4. Vehicle Dimensions, Test NYTCB-2



Figure 5. Test Vehicle, Test NYTCB-3

Date: 8/30/2007 Test Number: NYTCB-3 Model: Ram 1500 Q.C.
 Make: Dodge Vehicle I.D.#: 1D7HA18D53S233366
 Tire Size: 245/70 R17 Year: 2003 Odometer: 98929

*(All Measurements Refer to Impacting Side)



Vehicle Geometry -- mm (in.)

a	1978 (77.875)	b	1905 (75.0)
c	5734.9 (227.75)	d	1212.9 (47.75)
e	3582.4 (140.25)	f	1009.7 (39.75)
g	736.6 (29.0)	h	1569.7 (61.8)
i	406.4 (16.0)	j	723.9 (28.5)
k	508 (20.0)	l	711.2 (28.0)
m	1714.5 (67.5)	n	1720.9 (67.75)
o	1193.8 (47.0)	p	88.9 (3.5)
q	762 (30.0)	r	469.9 (18.5)
s	431.8 (17.0)	t	1911.4 (75.25)
Wheel Center Height Front	355.6 (14.0)		
Wheel Center Height Rear	361.95 (14.25)		
Wheel Well Clearance (FR)	927.1 (36.5)		
Wheel Well Clearance (RR)	952.5 (37.5)		
Frame Height (FR)	488.95 (19.25)		
Frame Height (RR)	609.6 (24.0)		
Engine Type	B CYL. GAS		
Engine Size	5.7L HEMI		

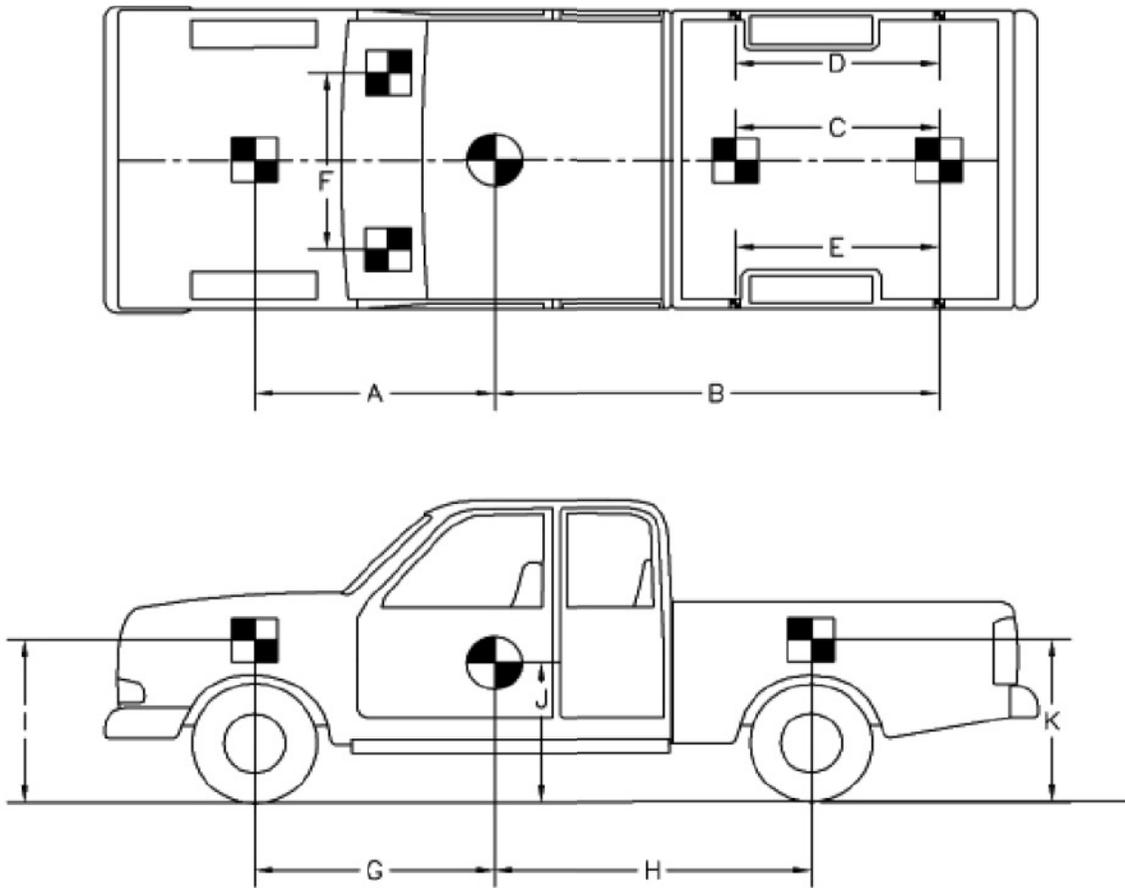
Transmission Type:

Automatic

Weights kg (lbs)	Curb	Test Inertial	Cross Static	RWD
W-front	1297.7 (2861)	1264.6 (2788)	1264.6 (2788)	Front GVWR 3650
W-rear	1005.6 (2217)	1003.8 (2213)	1003.8 (2213)	Rear GVWR 3900
W-total	2303.3 (5078)	2268.4 (5001)	2268.4 (5001)	Total GVWR 6650

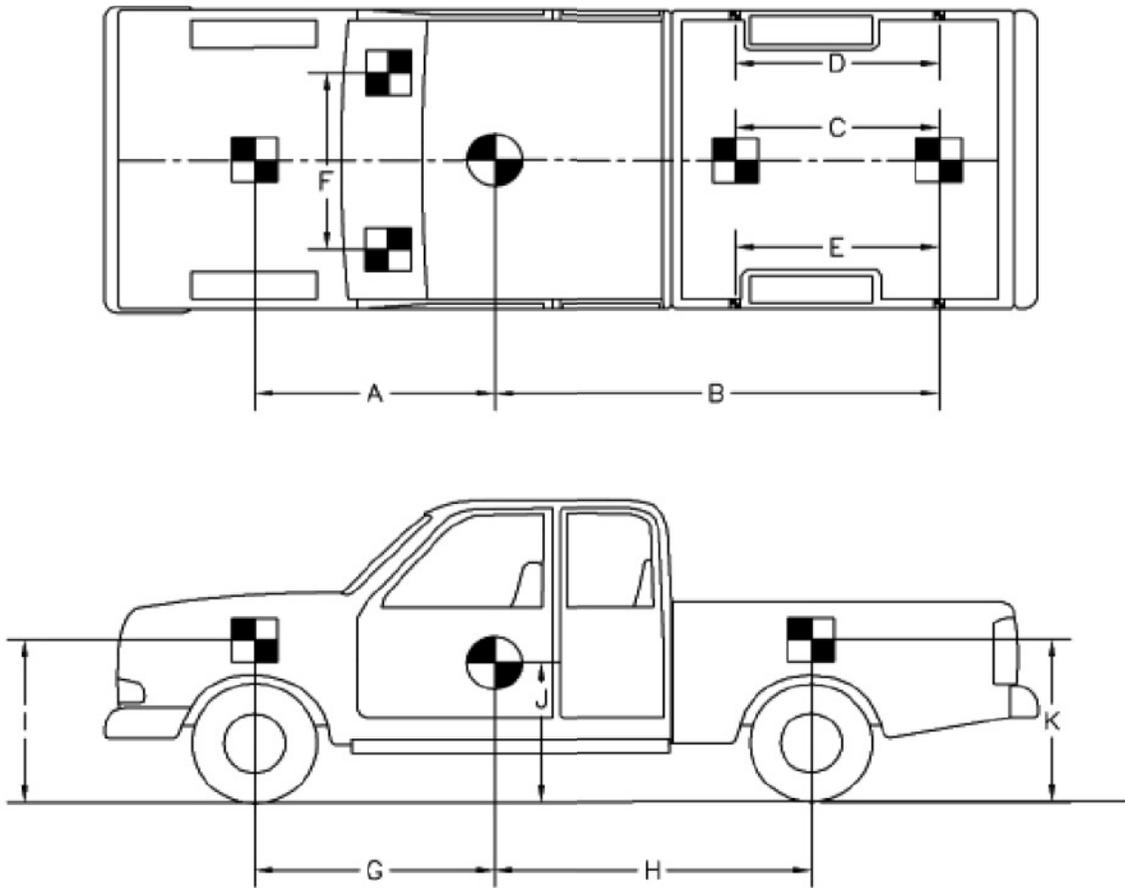
Note any damage prior to test: none

Figure 6. Vehicle Dimensions, Test NYTCB-3



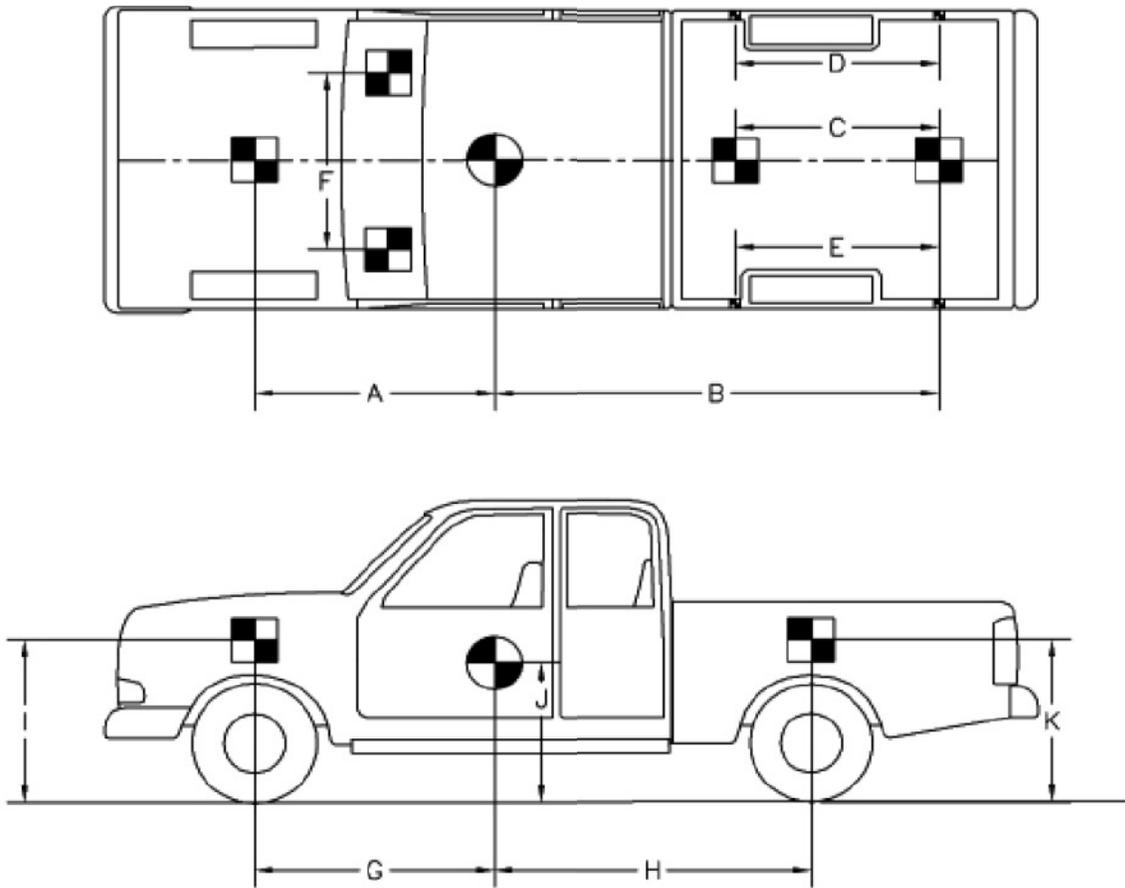
TEST #: NYTCB-1					
TARGET GEOMETRY-- mm (in.)					
A	<u>1861</u>	(73.25)	E	<u>1791</u>	(70.5)
B	<u>2737</u>	(107.75)	F	<u>1035</u>	(40.75)
C	<u>1219</u>	(48.0)	G	<u>1591</u>	(62.625)
D	<u>1778</u>	(70.0)	H	<u>1972</u>	(77.625)
			I	<u>1019</u>	(40.125)
			J	<u>714</u>	(28.125)
			K	<u>1080</u>	(42.5)

Figure 7. Vehicle Target Locations, Test NYTCB-1



TEST #: NYTCB-2					
TARGET GEOMETRY-- mm (in.)					
A	<u>1835</u>	(72.25)	E	<u>1759</u>	(69.25)
B	<u>2610</u>	(102.75)	F	<u>1016</u>	(40.0)
C	<u>1099</u>	(43.25)	G	<u>1626</u>	(64.0)
D	<u>1759</u>	(69.25)	H	<u>1937</u>	(76.25)
			I	<u>997</u>	(39.25)
			J	<u>711</u>	(28.0)
			K	<u>1086</u>	(42.75)

Figure 8. Vehicle Target Locations, Test NYTCB-2



TEST #: NYTBC-3					
TARGET GEOMETRY-- mm (in.)					
A	<u>1753</u>	(69.0)	E	<u>1626</u>	(64.0)
B	<u>2565</u>	(101.0)	F	<u>1035</u>	(40.75)
C	<u>1219</u>	(48.0)	G	<u>1570</u>	(61.8)
D	<u>1626</u>	(64.0)	H	<u>1993</u>	(78.45)
			I	<u>1041</u>	(41.0)
			J	<u>737</u>	(29.0)
			K	<u>1060</u>	(41.75)

Figure 9. Vehicle Target Locations, Test NYTBC-3

4.4 Data Acquisition Systems

4.4.1 Accelerometers

One triaxial piezoresistive accelerometer system with a range of ± 200 g's was used to measure the acceleration in the longitudinal, lateral, and vertical directions at a sample rate of 10,000 Hz. The environmental shock and vibration sensor/recorder system, Model EDR-4M6, was developed by Instrumented Sensor Technology (IST) of Okemos, Michigan and includes three differential channels as well as three single-ended channels. The EDR-4 was configured with 6 MB of RAM memory and a 1,500 Hz lowpass filter. "DynaMax 1 (DM-1)" and "DADiSP" computer software programs were used to analyze and plot the accelerometer data.

Another triaxial piezoresistive accelerometer system with a range of ± 200 g's was also used to measure the acceleration in the longitudinal, lateral, and vertical directions at a sample rate of 3,200 Hz. The environmental shock and vibration sensor/recorder system, Model EDR-3, was developed by Instrumented Sensor Technology (IST) of Okemos, Michigan. The EDR-3 was configured with 256 kB of RAM memory and a 1,120 Hz lowpass filter. "DynaMax1 (DM-1)" and "DADiSP" computer software programs were used to analyze and plot the accelerometer data.

For test no. NYTCB-3, an additional accelerometer system was used to measure the acceleration in the longitudinal, lateral, and vertical directions at a sample rate of 10,000 Hz. The environmental shock and vibration sensor/recorder system, a two-Arm piezoresistive accelerometer, was developed by Endevco of San Juan Capistrano, California. Three accelerometers were used to measure each of the longitudinal, lateral, and vertical accelerations independently. Data was collected using a Sensor Input Module (SIM), Model TDAS3-SIM-16M, which was developed by Diversified Technical Systems, Inc. (DTS) of Seal Beach, California. The SIM was configured with 16 MB SRAM memory and 8 sensor input channels with 250 kB SRAM/channel. The SIM was

mounted on a TDAS3-R4 module rack. The module rack is configured with isolated power/event/communications, 10BaseT Ethernet and RS232 communication, and an internal back-up battery. Both the SIM and module rack are crashworthy. “DTS TDAS Control” and “DADiSP” computer software programs and a customized Microsoft Excel worksheet were used to analyze and plot the accelerometer data.

4.4.2 Rate Transducers

An Analog Systems 3-axis rate transducer with a range of 1,200 degrees/sec in each of the three directions (pitch, roll, and yaw) was used to measure the rates of motion of the test vehicles. The rate transducer was mounted inside the body of the EDR-4M6 and recorded data at 10,000 Hz to a second data acquisition board inside the EDR-4M6 housing. The raw data measurements were then downloaded, converted to the proper Euler angles for analysis, and plotted. “DynaMax 1” and “DADiSP” computer software programs were used to analyze and plot the rate transducer data.

For test no. NYTCB-3, an additional angular rate sensor was used. The ARS-1500 has a range of 1,500 degrees/sec in each of the three directions (pitch, roll, and yaw) and was used to measure the rates of rotation of the test vehicle. The angular rate sensor was mounted on an aluminum block inside the test vehicle at the center of gravity and recorded data at 10,000 Hz to the SIM. The raw data measurements were then downloaded, converted to the proper Euler angles for analysis, and plotted. “DTS TDAS Control” and “DADiSP” computer software programs and a customized Microsoft Excel worksheet were used to analyze and plot the angular rate sensor data.

4.4.3 High-Speed Photography

For test no. NYTCB-1, four high-speed AOS VITcam digital video cameras, all with operating speeds of 500 frames/sec, were used to film the crash test. Four JVC digital video cameras and two Canon digital video cameras, all with standard operating speeds of 29.97 frames/sec, were

also used to film the crash test. Camera details and a schematic of all ten camera locations for test no. NYTCB-1 are shown in Figure 10.

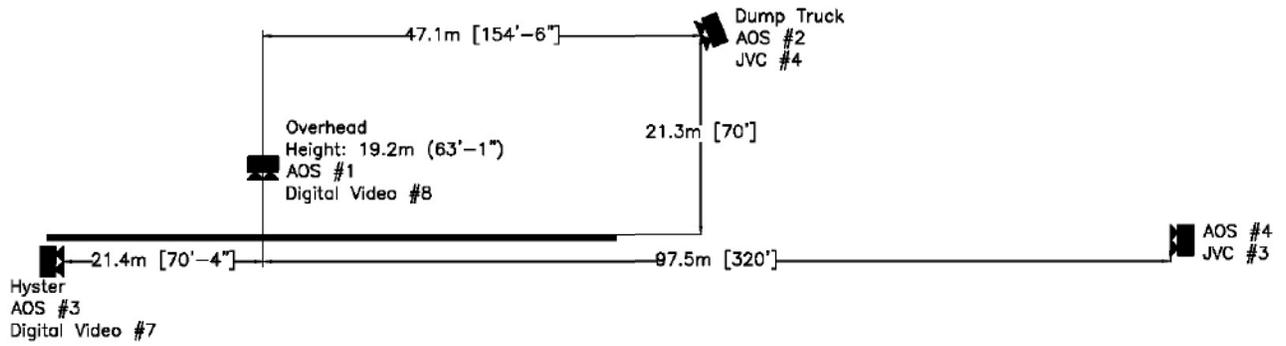
For test no. NYTCB-2, four high-speed AOS VITcam cameras, all with operating speeds of approximately 500 frames/sec, were used to film the crash test. Five JVC digital video cameras and two Canon digital video cameras, all with standard operating speeds of 29.97 frames/sec, were also used to film the crash test. Camera details and a schematic of all eleven camera locations for test no. NYTCB-2 are shown in Figure 11.

For test no. NYTCB-3, four high-speed AOS VITcam video cameras, and two high-speed VIS cameras, all with operating speeds of 500 frames/sec, were used to film the crash test. Five JVC digital video cameras and two Canon digital video cameras, all with standard operating speeds of 29.97 frames/sec, were also used to film the crash test. Camera details and a schematic of all thirteen camera locations for test no. NYTCB-3 are shown in Figure 12.

The AOS and VIS videos were analyzed using the ImageExpress MotionPlus and Weinberger Visart software, respectively. Actual camera speed and camera divergence factors were considered in the analysis of the high-speed videos.

4.4.4 Pressure Tape Switches

For test nos. NYTCB-1 through NYTCB-3, five pressure-activated tape switches, spaced at 2-m (6.56-ft) intervals, were used to determine the speed of the vehicle before impact. Each tape switch fired a strobe light which sent an electronic timing signal to the data acquisition system as the vehicle's left-front tire for test nos. NYTCB-1 and NYTCB-2 and the vehicle's right-front tire for test no. NYTCB-3 passed over it. Test vehicle speeds were determined from electronic timing mark data recorded using TestPoint software. Strobe lights and high-speed video analysis are used only as a backup in the event that vehicle speeds cannot be determined from the electronic data.



JVC #5
(panning)

JVC #2

21

	No.	Type	Operating Speed (frames/sec)	Lens	Lens Setting
High-Speed Video	1	Vitcam CTM	500	Fixed 12.5mm	-
	2	Vitcam CTM	500	Sigma 24-135	70
	3	Vitcam CTM	500	Fixed 50mm	-
	4	Vitcam CTM	500	Sigma 70-200	135
Digital Video	2	JVC - GZ-MC40(Everio)	29.97		
	3	JVC - GZ-MC40(Everio)	29.97		
	4	JVC - GZ-MC40(Everio)	29.97		
	5	JVC - GZ-MC40(Everio)	29.97		
	7	Canon-ZR90	29.97		
	8	Canon-ZR90	29.97		

Figure 10. Locations of Cameras, Test NYTCB-1

	No.	Type	Operating Speed (frames/sec)	Lens	Lens Setting
High-Speed Video	1	Vitcam CTM	500	Fixed 12.5mm	-
	2	Vitcam CTM	500	Sigma Zoom 24-70	70
	3	Vitcam CTM	500	Fixed 50mm	-
	4	Vitcam CTM	500	Sigma 70-200	135
Digital Video	1	JVC - GZ-MC500 (Everio)	29.97		
	2	JVC - GZ-MC40u (Everio)	29.97		
	3	JVC - GZ-MC40u (Everio)	29.97		
	4	JVC - GZ-MC40u (Everio)	29.97		
	5	JVC - GZ-MC27u (Everio)	29.97		
	7	Canon-ZR90	29.97		
	8	Canon-ZR90	29.97		

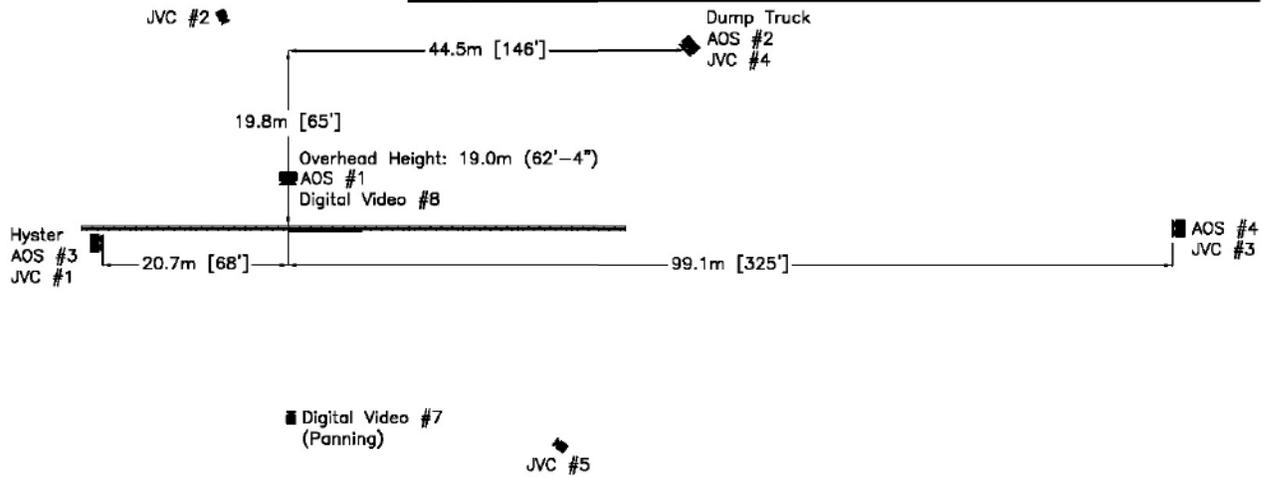


Figure 11. Locations of Cameras, Test NYTCB-2

Digital Video #2

	No.	Type	Operating Speed (frames/sec)	Lens	Lens Setting
High-Speed Video	1	Vitcam CTM	500	Kowa Fixed 8.5mm	-
	2	Vitcam CTM	500	Fuji Fixed 50mm	-
	3	Vitcam CTM	500	Sigma 24-70	50
	4	Vitcam CTM	500	Sigma 70-200	135
	7	VIS G2	500	Sigma 24-135	100
	17	Mini VIS	500	Fixed 12.5mm	-
	Digital Video	1	JVC - GZ-MC500 (Everio)	29.97	
2		JVC - GZ-MC40u (Everio)	29.97		
3		JVC - GZ-MC40u (Everio)	29.97		
4		JVC - GZ-MC40u (Everio)	29.97		
5		JVC - GZ-MC27u (Everio)	29.97		
7		Canon-ZR90	29.97		
8		Canon-ZR90	29.97		

23

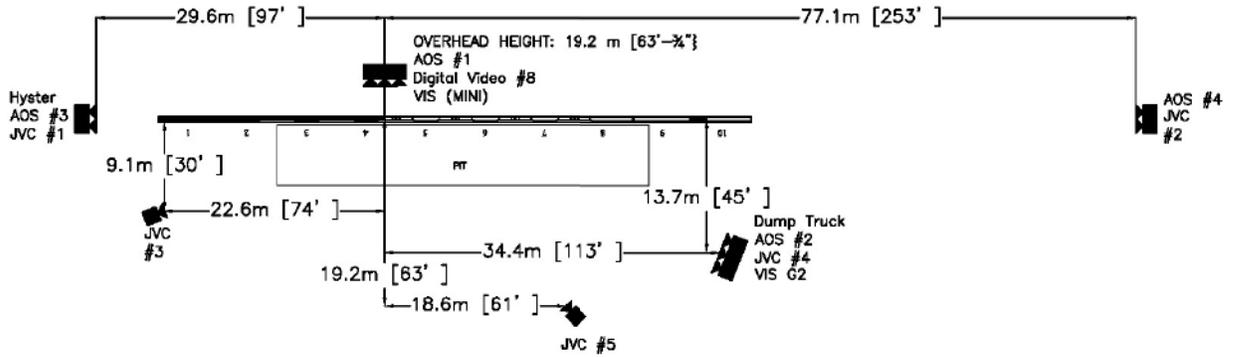


Figure 12. Locations of Cameras, Test NYTCB-3

5 DESIGN DETAILS - DESIGN NO. 1

5.1 Design Considerations

The NYSDOT designed and developed a box-beam stiffening system that was compatible with crashworthy, temporary concrete barrier sections and for the purpose of improving worker safety by reducing barrier deflections into active work-zones. For the stiffening system, several design considerations were required in order to allow the stiffened, temporary concrete barrier system to be practical and to meet real-world construction tolerances. First, it was necessary for the stiffening system to accommodate both vertical and horizontal alignment changes. Second, anchorage of the stiffening system to the barrier sections should be capable of transferring the impact loads while developing the flexural capacity of the box beam section. Finally, any portion of the stiffening system placed on the traffic-side face of the barrier must not significantly decrease the barrier's acceptable safety performance.

5.2 System Details

The 60.96-m (200-ft) long test installation consisted of box beam stiffened temporary concrete barrier sections in a free-standing configuration with both end sections anchored, as shown in Figures 13 through 23. The ten 6,096-mm (20-ft) long, temporary concrete barrier sections were placed on the tarmac with the first and last sections attached to the concrete. Box beam stiffeners were attached at three joints, as shown in Figures 24 and 25. The corresponding English-unit drawings are shown in Appendix A. Photographs of the test installation are shown in Figures 24 through 28.

The concrete used for the barrier sections consisted of a concrete mix with a minimum 28-day compressive strength of 21.0 MPa (3,000 psi). A minimum concrete cover of 38 mm (1.5 in.) was used along all rebar in the barrier. All the steel reinforcement in the barrier was ASTM A615

Grade 60 rebar. The section reinforcement details are shown in Figures 13 through 16.

Section reinforcement consisted of four No. 6 longitudinal bars, eight No. 4 bars for the vertical stirrups, four No. 6 lateral bars, and nine No. 4 bars for the anchor hole reinforcement loops. Each of the two lower longitudinal rebar was 5.83 m (19 ft - 1.5 in.) long, while each of the upper two longitudinal rebar was 5.89 m (19 ft - 4 in.) long. The vertical spacings of the lower and upper longitudinal bars was 171 mm (6.75 in.) and 648 mm (2 ft - 1.5 in.) from the ground to their centers, respectively. The vertical stirrup spacing varied longitudinally, as shown in Figure 15. The upper and lower lateral bars were 152 mm (6 in.) and 356 mm (14 in.) long, respectively. The vertical spacings of the lower and upper lateral bars were 191 mm (7.5 in.) and 476 mm (18.75 in.) from the ground to their centers, respectively. The 865-mm (34.0625-in.) long, anchor hole loops were bent into a U-shape, and they reinforced the anchor hole area, as shown in Figures 15 and 16.

The barrier sections used a connection key, as shown in Figures 17 through 20. The connection key was comprised of ASTM A36 13-mm (0.5-in.) thick, steel plates welded together to form the key shape. Two stiffeners were welded to the top plate with their interior faces in contact with the I-beam shape and 7.9 mm (0.31 in.) up from the bottom of the top plate, as shown in Figures 17 through 19.

A connection key was configured at each end of the section, as shown in Figure 15. The connection key consisted of one ASTM A500 steel tube and three ASTM A36 steel plates. Three U-shaped plates were welded on to the sides of the tube, as shown in Figure 20. A steel drop pin was inserted into the steel tubes of two adjoining sections to form the connection, as shown in Figure 17.

The end sections were fastened to the tarmac with nine 25-mm (1-in.) diameter by 394-mm (15.5-in.) long, A36 steel rods, five anchors and four anchors on the traffic and back sides, respectively, as shown in Figure 14. Each anchor rod was driven into a hole drilled in the concrete

to an embedment depth of 127 mm (5 in.), as shown in Figure 13.

The three joints between barrier nos. 4 and 7 were stiffened with a box beam section, as shown in Figures 13 and 21 through 23. Each box beam stiffener consisted of a 152-mm x 152-mm x 4.8-mm (6-in. x 6-in. x 0.1875-in.) ASTM A500 Grade C box beam, which was 3,658 mm (12 ft) long. Two 19-mm (0.75 in.) holes were drilled through the barriers at an angle of 6 degrees, as shown in Figure 22. The box beams were connected to the barriers with 19-mm (0.75-in.) diameter by 432-mm (17-in.) long, Grade 5 continuously threaded rod and two 19-mm (0.75-in.) diameter nuts. An 83-mm (3.25-in.) outside diameter x 22-mm (0.875-in.) inside diameter x 9.5-mm (0.375-in.) thick Grade 5 fender washer was placed on the traffic side of the barrier between the barrier and the nut. A 203-mm x 203-mm x 6.4-mm (8-in. x 8-in. x 0.25-in.) A36 steel plate was placed on the back side of the barrier between the nut and the box beam section, as shown in Figure 21.

5.3 Special Features

As shown in Figure 23, the holes placed within the ends of the box beam stiffening rails were oversized. The oversized holes were utilized to allow for vertical alignment changes in the barrier system. For horizontal alignment changes, shim washers were designed for use when placed between the box beam rail and the back-side face of the temporary concrete barrier sections, as shown in Figure 21. Threaded rods were used to attach the box beam rails to the barrier sections. The length of the rods, or alternative hex head or dome head bolts, should possess sufficient length to allow for the placement of shims, if needed. As depicted in Figures 13, 21, and 23, large plate washers were used to retain the box beam rails and transfer the rod load to the top and bottom webs of each stiffening rail, rather than allowing the rod and nut to bend the washer into each beam's bearing flange. Finally, the size of the box beam stiffening rail was selected to be consistent with the standard sizes used for the NYSDOT's box beam guide rail and median barrier.

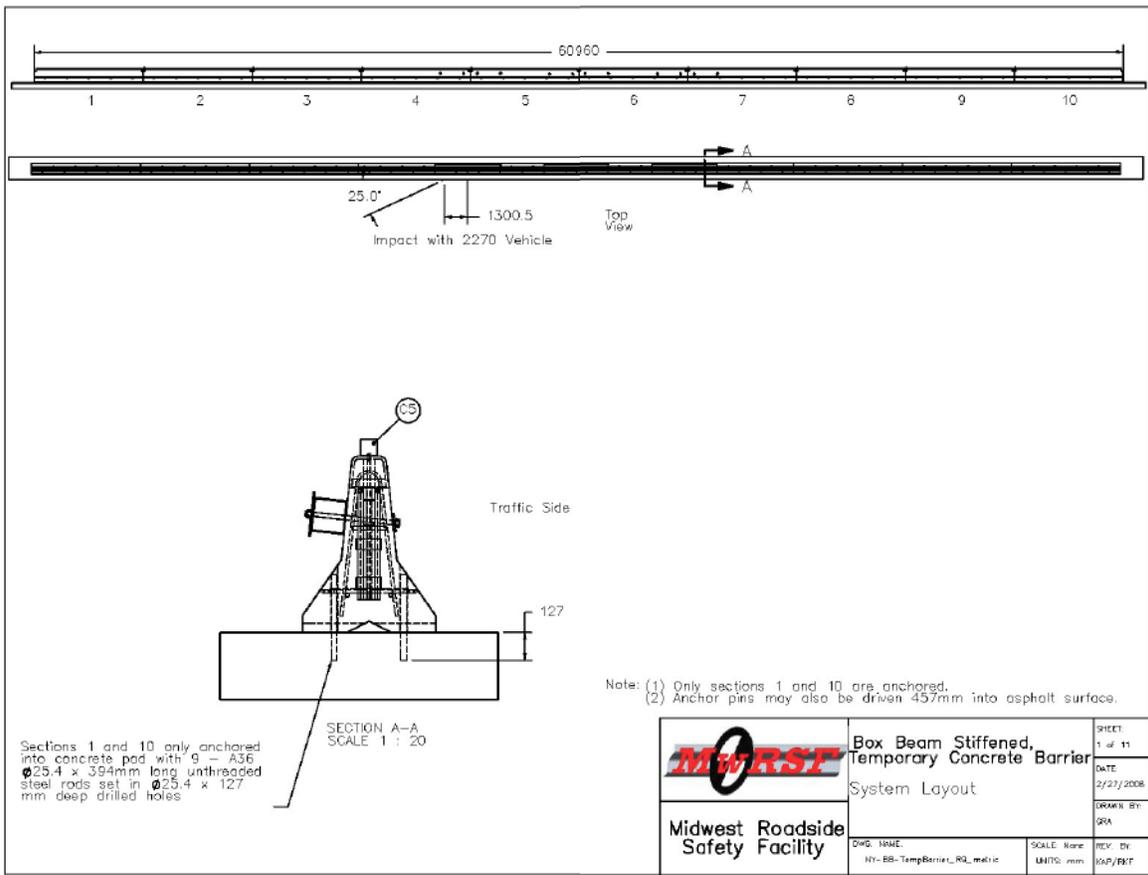


Figure 13. Stiffened Temporary Concrete Barrier System Layout, Test NYTCB-1

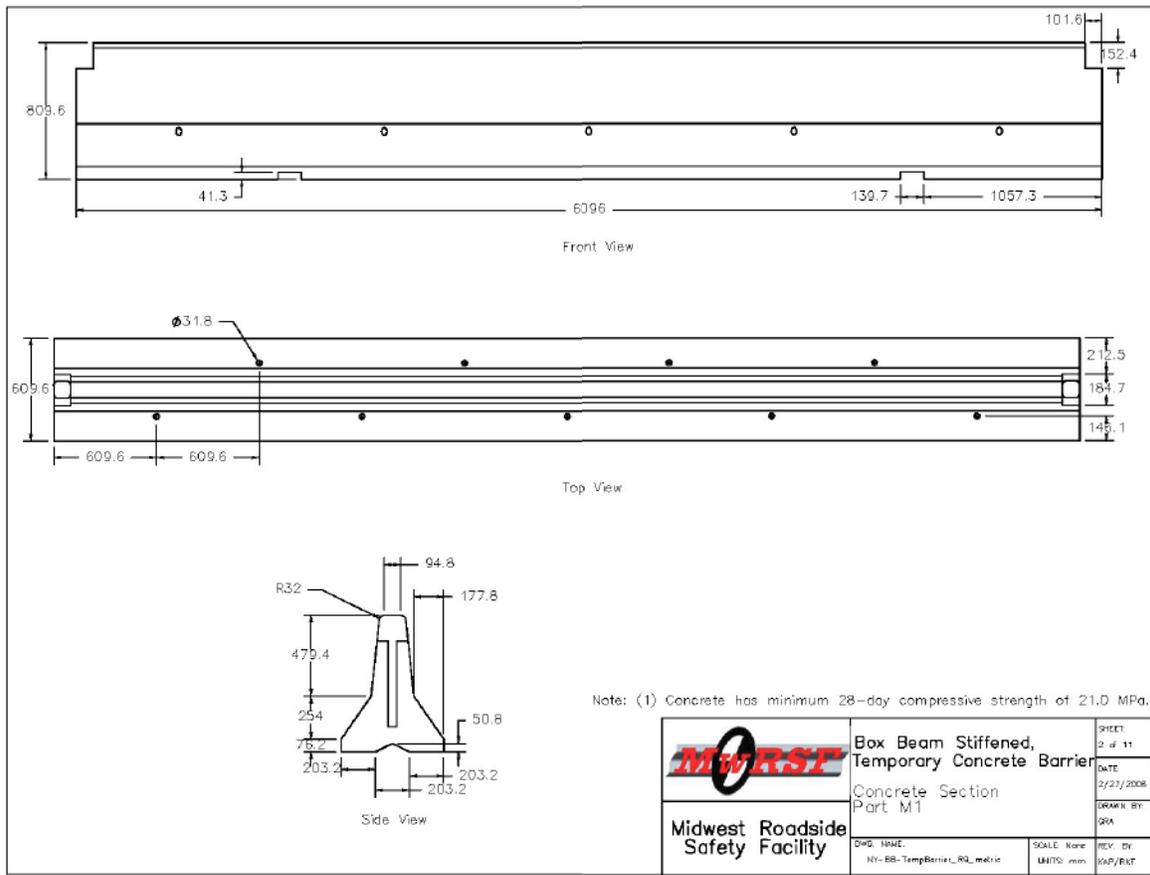


Figure 14. Temporary Concrete Barrier Details, Test NYTCB-1

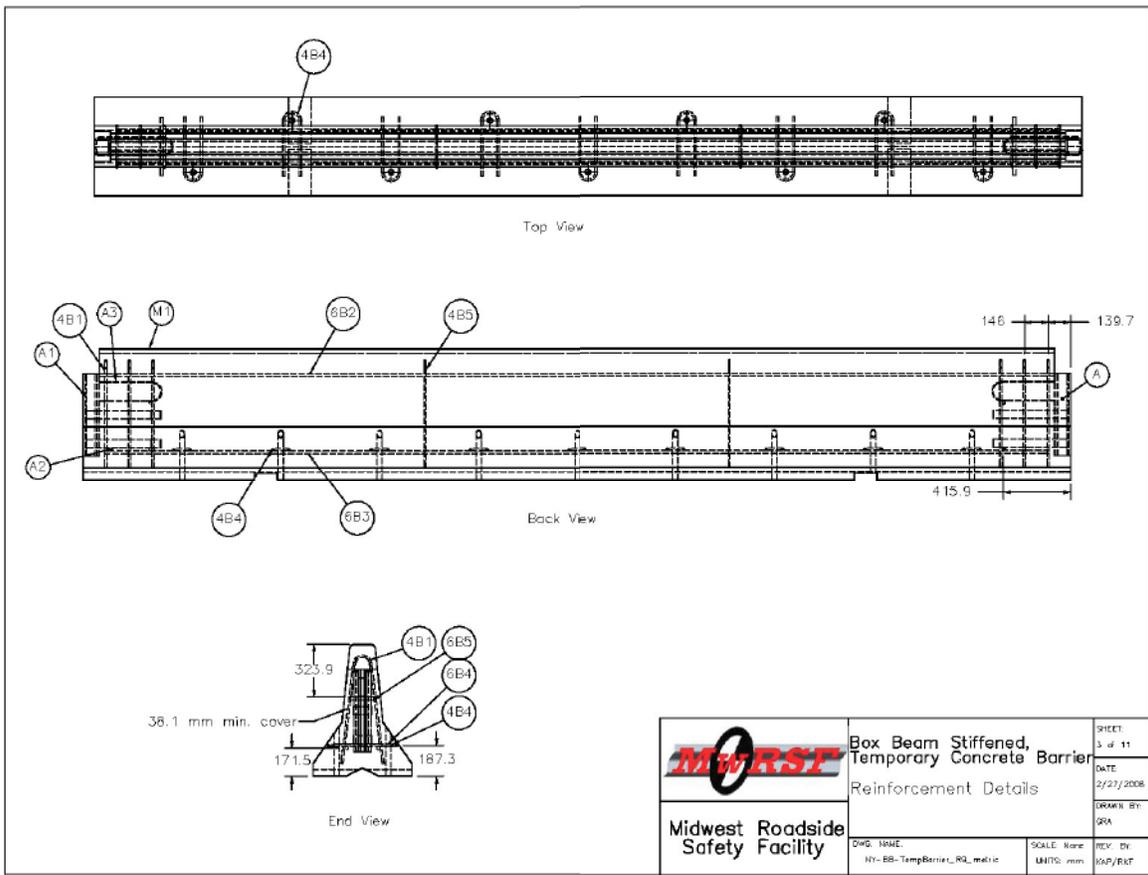


Figure 15. Temporary Concrete Barrier Reinforcement Details, Test NYTCB-1

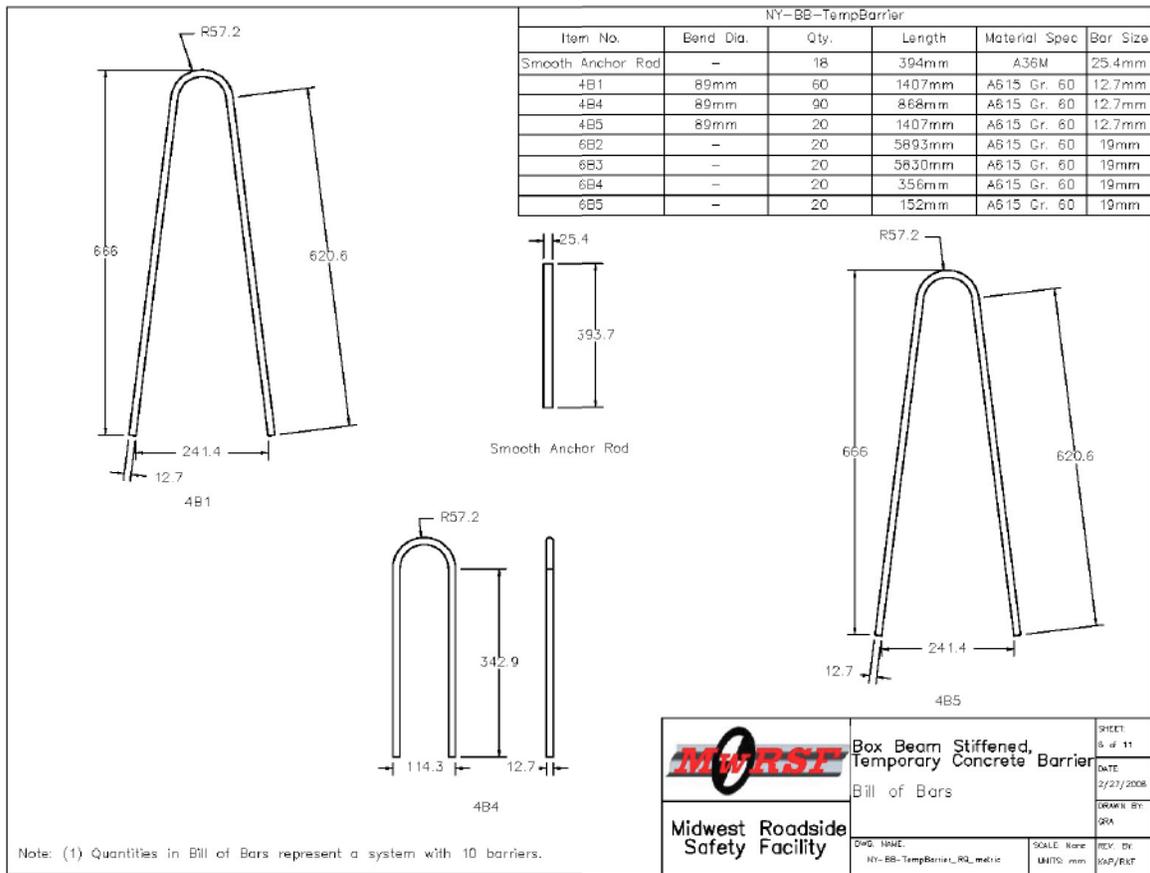


Figure 16. Bill of Bars, Test NYTCB-1

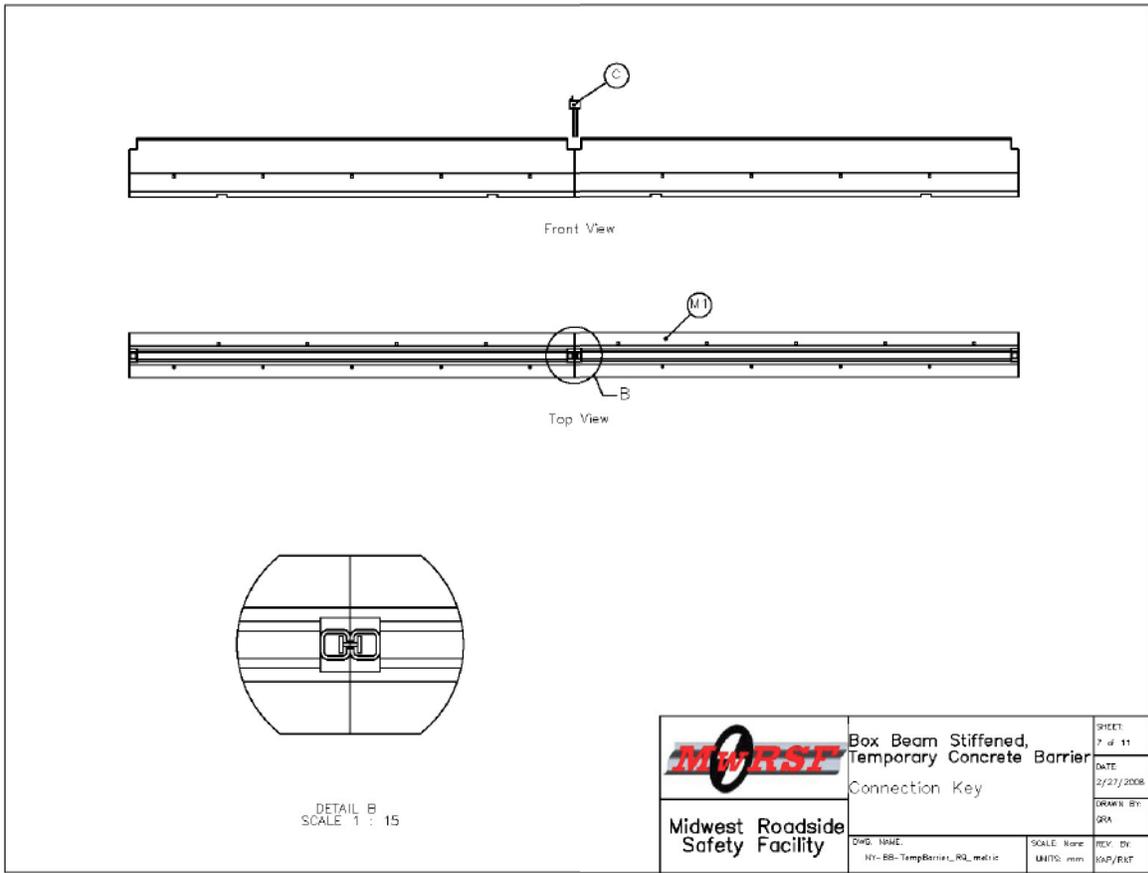


Figure 17. Temporary Concrete Barrier Connection Details, Test NYTCB-1

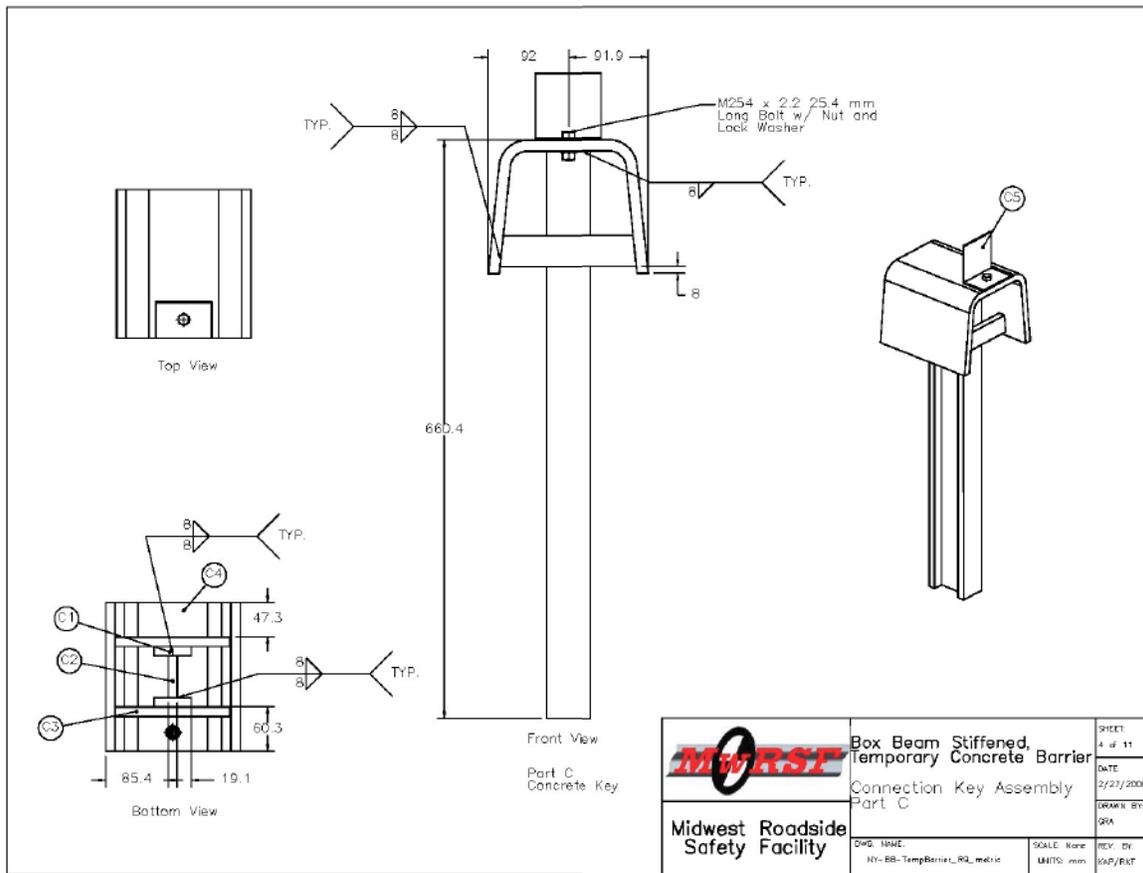


Figure 18. Connection Key Assembly Details, Test NYTCB-1

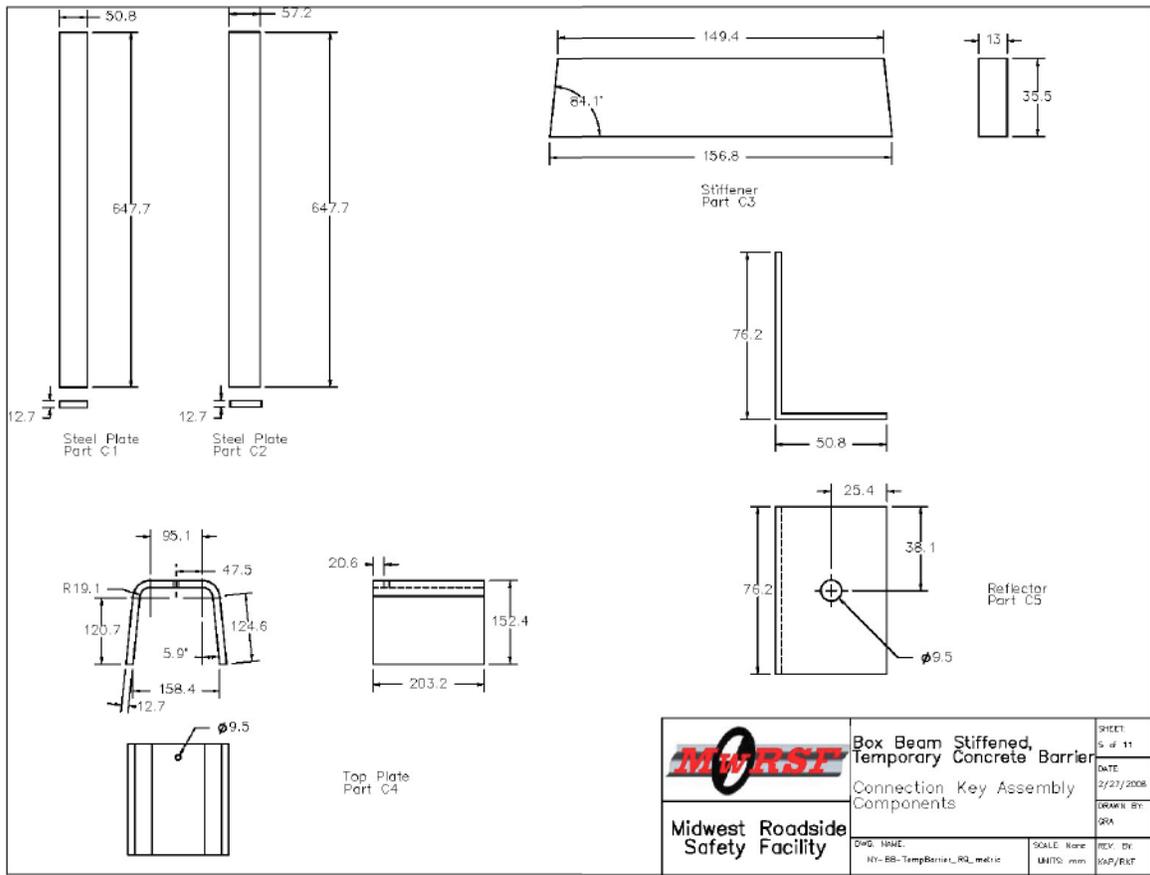


Figure 19. Connection Key Assembly Details, NYTCB-1

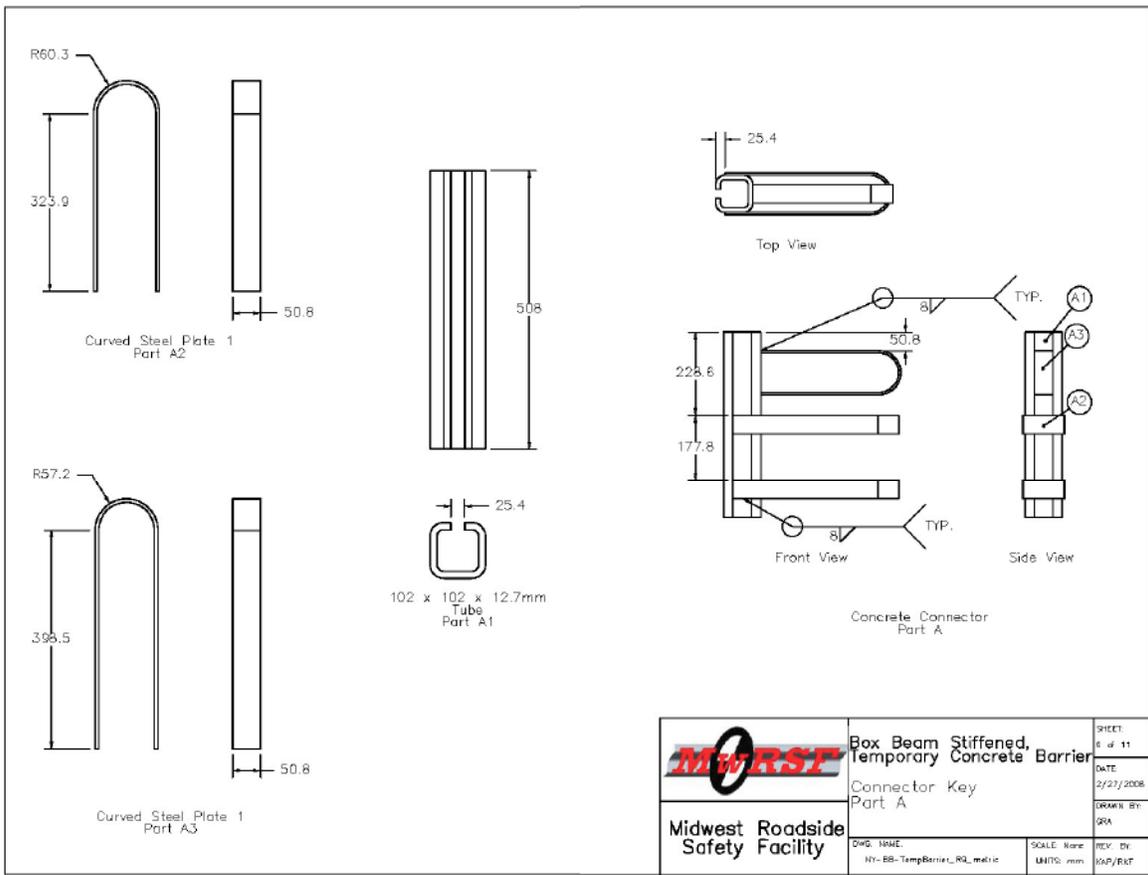


Figure 20. Temporary Concrete Barrier Connector Assembly Details, Test NYTCB-1

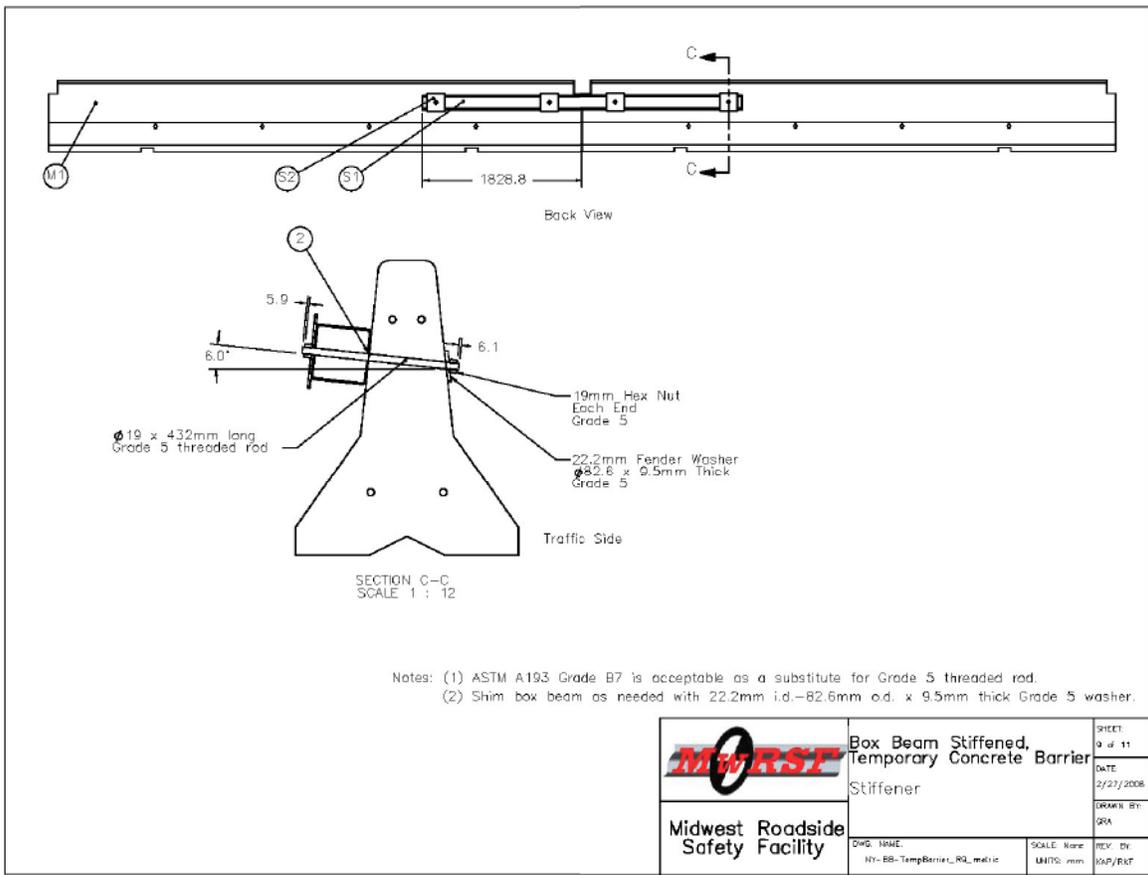
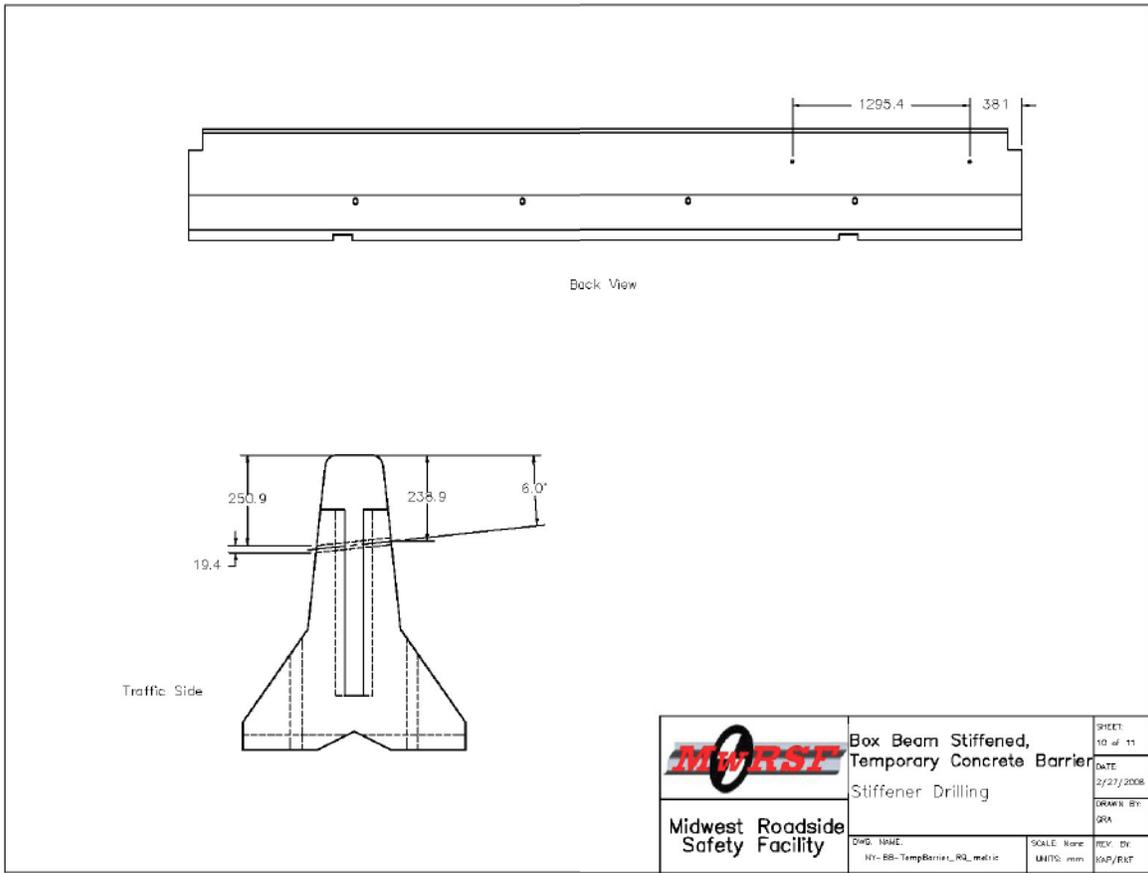


Figure 21. Box Beam Stiffener Details, Test NYTCB-1



 Midwest Roadside Safety Facility	Box Beam Stiffened, Temporary Concrete Barrier	SHEET: 10 of 11
	Stiffener Drilling	DATE: 2/27/2008
DWG. NAME: NY-BB-TempBarrier_RL_metric	SCALE: None	REV. BY: GAP/EKT
	UNITS: mm	

Figure 22. Temporary Concrete Barrier Stiffener Hole Details, Test NYTCB-1

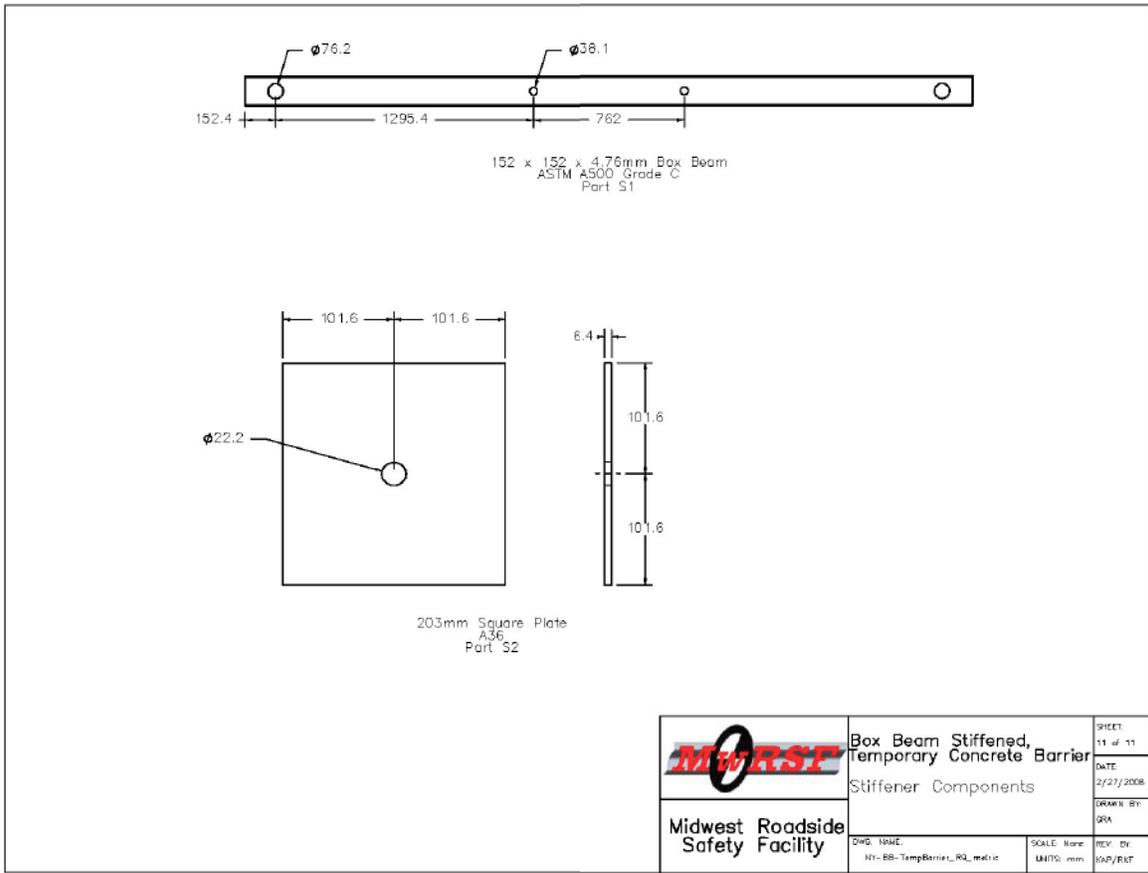


Figure 23. Box Beam Stiffener Details, Test NYTCB-1



Figure 24. Box Beam Stiffened Temporary Concrete Barrier, Test NYTCB-1

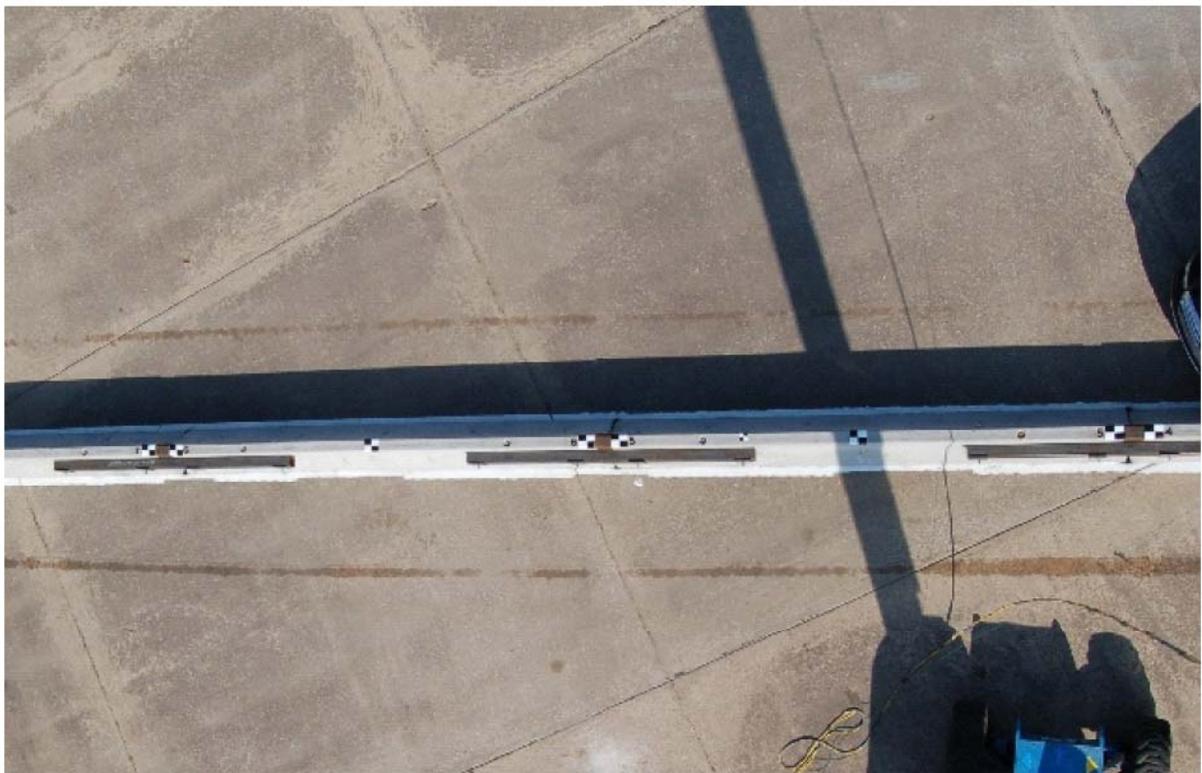


Figure 25. Box Beam Stiffeners, Test NYTCB-1



Figure 26. Box Beam Stiffener Attachment Bolts, Test NYTCB-1



Figure 27. Connection Key, Test NYTCB-1



Figure 28. Anchored Barrier Ends, Test NYTCB-1

6 FULL-SCALE CRASH TEST NO. 1

6.1 Test NYTCB-1

The 2,275-kg (5,016-lb) pickup truck impacted the stiffened temporary concrete barrier system at a speed of 99.5 km/h (61.8 mph) and at an angle of 24.6 degrees. A summary of the test results and sequential photographs are shown in Figure 29. An English-unit summary of the test results and sequential photographs are shown in Appendix B. Additional sequential photographs are shown in Figures 30 through 32. Documentary photographs of the crash test are shown in Figures 33 and 34.

6.2 Test Description

Initial vehicle impact was to occur 1,300 mm (51.2 in.) upstream from the downstream end of barrier no. 4, as shown in Figure 35. Actual vehicle impact occurred at the targeted impact location. At 0.004 sec, the left-front quarter panel crushed inward. At 0.010 sec, the left-front tire became airborne. At 0.018 sec, barrier no. 4 deflected backward. At 0.022 sec, barrier no. 5 deflected backward. At 0.024 sec, the left-front tire ruptured as the tire was compressed between the vehicle and barrier no. 4. At 0.034 sec, the hood became ajar. At 0.042 sec, the front of the vehicle pitched upward. At 0.054 sec, the stiffener connecting barrier nos. 4 and 5 bent significantly. At this same time, the vehicle redirected. At 0.088 sec, the stiffener between barrier nos. 5 and 6 deflected. At 0.102 sec, the right-front tire became airborne. At 0.178 sec, barrier nos. 3 and 6 deflected. At 0.216 sec, the vehicle became parallel to the system with a resultant velocity of 85.4 km/h (53.1 mph). At 0.230 sec, the left-front bumper corner scraped along the top of barrier no. 5. At 0.242 sec, the stiffener between barrier nos. 6 and 7 deflected. At 0.244 sec, the left-rear tire contacted the system. At this same time, the front of the vehicle pitched downward. At 0.300 sec, the vehicle became airborne as the right-rear tire left the ground. At 0.394 sec, the vehicle rolled away from the

system. At 0.402 sec, barrier no. 7 deflected with the vehicle positioned at the downstream end of barrier no. 6. At 0.468 sec, the right-front tire contacted the ground. At 0.486 sec, the system reached its maximum deflection. At 0.512 sec, barrier no. 8 deflected. At 0.524 sec, the front bumper contacted the ground. At this same time, the vehicle reached its maximum pitch angle. At 0.842 sec, the vehicle redirected toward the system. At 0.892 sec, the vehicle rolled toward the system. At 1.050 sec, the left-front bumper corner contacted barrier no. 8. At 1.534 sec, barrier no. 9 deflected backward. At 1.610 sec, barrier no. 10 pivoted about the anchored base with the vehicle positioned at its midline. At 1.890 sec, the vehicle redirected away from the system. At 1.942 sec, the vehicle exited the system at an angle of 7 degrees and at a resultant velocity of 62.9 km/h (39.1 mph). The vehicle came to rest 62.26 m (204 ft - 3 in.) downstream from impact and 4.57 m (15 ft) laterally behind a line projected parallel to the traffic-side face of the barrier. The trajectory and final position of the pickup truck are shown in Figures 29 and 36.

6.3 Barrier Damage

Damage to the barrier was moderate, as shown in Figures 37 through 41. Barrier damage consisted of contact marks, concrete cracking, barrier spalling, cracks, and deformed box beam sections. The length of vehicle contact along the system was approximately 38.3 m (125.8 ft), which spanned from 1.75 m (5 ft - 9 in.) upstream from the downstream end of barrier no. 4 through the downstream end of barrier no. 10.

Contact and tire marks were visible on the front face of barrier nos. 4 through 10. The back side of barrier no. 3 experienced concrete spalling 152 mm (6 in.) wide and 356 mm (14 in.) in height. The back upstream end of barrier no. 4 experienced concrete spalling 584 mm (23 in.) wide and 254 mm (10 in.) tall. The front downstream edge of barrier no. 4 also experienced concrete spalling 305 mm (12 in.) wide and 178 mm (7 in.) tall. A 381-mm (15-in.) wide by 127-mm (5-in.)

tall area of concrete spalling was found on the back side of barrier no. 5, beginning 762 mm (30 in.) downstream from the barrier's upstream end. The front side of barrier no. 5 also experienced concrete spalling 102 mm (4 in.) wide and 178 mm (7 in.) tall. Concrete spalling occurred on the top-front upstream end of barrier no. 6, measuring 51 mm (2 in.) wide by 76 mm (3 in.) tall. The bottom-front face of barrier no. 6 also experienced concrete spalling at 1,168 mm (46 in.) downstream from the upstream end, measuring 152 mm (6 in.) wide by 76 mm (3 in.) tall. Minor concrete spalling occurred at the bottom-front face of barrier no. 6, measuring 102 mm (4 in.) tall and 1,219 mm (48 in.) long. The back side of barrier no. 6 experienced significant concrete spalling, measuring 102 mm (4 in.) wide by 76 mm (3 in.) tall at the bottom-downstream corner of the barrier. Concrete spalling on the back side of barrier no. 6, measuring 127 mm (5 in.) wide by 76 mm (3 in.) tall, occurred at 838 mm (33 in.) upstream from the downstream end of the barrier. A 178-mm (7-in.) wide by 102-mm (4-in.) tall area of concrete spalling was found on the back side 533 mm (21 in.) downstream from the upstream end of barrier no. 7.

A 76-mm (3-in.) long crack was found on the back side of barrier no. 3 and began 1,219 mm (48 in.) from the downstream end of the barrier. Cracks were found on the back side of barrier no. 4 at 2,997 mm (118 in.), 3,658 mm (144 in.), and 4,699 mm (185 in.) downstream of the upstream end of the barrier. Hairline cracking was found on the back side at the downstream end of barrier no. 4 and at the upstream and downstream ends of barrier no. 5. Cracks were also found on the back side of barrier no. 5 and spanned from the top to the bottom of the barrier and were located 1,295 mm (51 in.), 1,828 mm (72 in.), 2,413 mm (95 in.), 3,073 mm (121 in.), and 3,683 mm (145 in.) downstream from the upstream end of the barrier. Two hairline cracks spanned the height of the front side of barrier no. 6 at 1,803 mm (71 in.) and 3,048 mm (120 in.) downstream of the upstream end of the barrier.

The joint between barrier nos. 2 and 3 was observed to have widened from its pre-test width. The joint between barrier nos. 3 and 4 rotated. The box beam stiffeners all experienced minor bending. The box beam rods at the front-downstream end of barrier no. 4 and front-upstream end of barrier no. 5 were sheared off. The downstream box beam rod was bent at the front of barrier no. 5. All connection keys remained undamaged. The anchor rods in barrier nos. 1 and 10 remained undamaged, and these barriers experienced no movement. Minor bending of the plate washers was observed. No buckling of the box beam webs nor bending of the box beam flanges was observed under the plate washers.

The permanent set of the barrier system is shown in Figure 37. The maximum lateral permanent set barrier deflection was 660 mm (26 in.) at the downstream end of barrier no. 4 and the upstream end of barrier no. 5, as measured in the field. The maximum lateral dynamic barrier deflection was 700 mm (27.6 in.) at the upstream end of barrier no. 5, as determined from high-speed digital video analysis. The working width of the system was found to be 1,311 mm (51.6 in.).

6.4 Vehicle Damage

Exterior vehicle damage was moderate, as shown in Figures 42 and 43. Occupant compartment deformations to the left side and center of the floorboard were judged insufficient to cause serious injury to the vehicle occupants. Maximum longitudinal deflections of 19 mm (0.75 in.) were located near the left-front corner of the left-side floor pan. Maximum lateral deflections of 38 mm (1.5 in.) were located near the left-front corner of the floorboard. Maximum vertical deflections of 32 mm (1.25 in.) were located near the left front of the floorboard. Complete occupant compartment deformations and the corresponding locations are provided in Appendix C.

Damage was concentrated on the left-front corner of the vehicle. The left corner of the front bumper deformed inward and the right side was detached. The left-front tire's side walls were

punctured, and the tire deflated. The left-front quarter panel experienced scrapes above the wheel well and was deformed inward. The right-front quarter panel deformed inward and buckled near the hood. The left side experienced scrapes, contact marks, and dents. The left-rear wheel assembly disengaged from the vehicle. The tailgate, which experienced minor scraping and denting, disengaged, except that it remained attached by the right-side cable. The hood's front center was dented. The left headlight and left taillight disengaged from their housings. The lower-right side of the windshield experienced "spider-web" cracking. The lower-left side of the windshield experienced a crack that propagated to the center of the windshield. The roof and all other window glass remained undamaged.

6.5 Occupant Risk Values

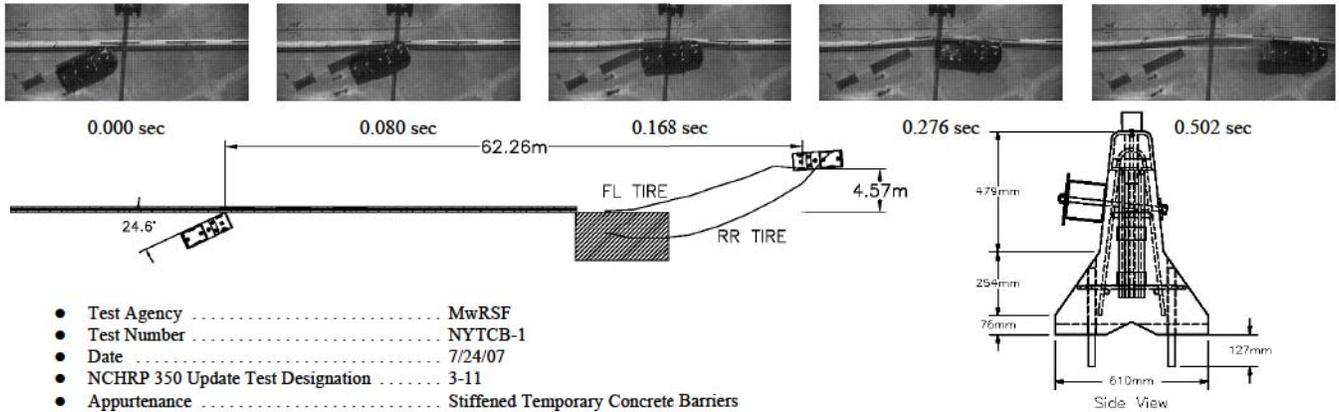
The longitudinal and lateral occupant impact velocities were determined to be -4.67 m/s (-15.32 ft/s) and 6.33 m/s (20.77 ft/s), respectively. The maximum 0.010-sec average occupant ridedown decelerations in the longitudinal and lateral directions were 4.72 g's and 8.36 g's, respectively. It is noted that the occupant impact velocities (OIV) and occupant ridedown decelerations (ORD) were within the suggested limits provided in the currently proposed Update to NCHRP Report No. 350. The THIV and PHD values were determined to be 7.45 m/s (24.44 ft/s) and 8.71 g's, respectively. The results of the occupant risk, as determined from the accelerometer data, are summarized in Figure 29. Results are shown graphically in Appendix D. The results from the rate transducer are shown graphically in Appendix D.

6.6 Discussion

The analysis of the test results for test no. NYTCB-1 showed that the stiffened temporary concrete barrier system with anchored ends adequately contained and redirected the 2270P vehicle with controlled lateral displacements of the barrier system. There were no detached elements nor

fragments which showed potential for penetrating the occupant compartment nor presented undue hazard to other traffic. Deformations of, or intrusion into, the occupant compartment that could have caused serious injury did not occur. The test vehicle did not penetrate nor ride over the barrier system and remained upright during and after the collision. Vehicle roll, pitch, and yaw angular displacements were noted, but they were deemed acceptable because they did not adversely influence occupant risk safety criteria nor cause rollover. After collision, the vehicle's trajectory revealed minimum intrusion into adjacent traffic. In addition, the vehicle exited the barrier within the exit box. Therefore, test no. NYTCB-1 conducted on the stiffened temporary concrete barrier system with anchored end barriers was determined to be acceptable according to the TL-3 safety performance criteria of test designation no. 3-11 found in the currently proposed Update to NCHRP Report No. 350.

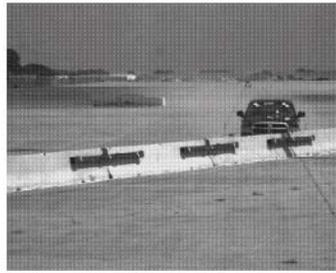
During the test, the anchor rods and nuts on the front-downstream end of barrier section no. 4 and the front-upstream end of barrier section no. 5, used to attach the box beam to the barrier, were sheared off. This result likely occurred as the vehicle was in contact with the barrier face and snagged on the protruding threaded rods and nuts. It should be noted that the rod and nut provide restraint for the box beam and the resulting barrier stiffening. As such, it is recommended that future design variations attempt to reduce the snag potential on the rod and nut as barrier deflections may increase with premature rod fracture. One alternative would be to incorporate dome head bolts on the traffic-side face of the barrier. This option was suggested during the construction of the barrier system.



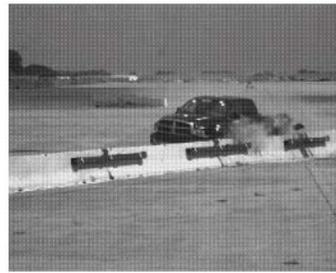
- Test Agency MwRSF
- Test Number NYTCB-1
- Date 7/24/07
- NCHRP 350 Update Test Designation 3-11
- Appurtenance Stiffened Temporary Concrete Barriers
- Total Length 60.96 m
- Key Elements - Barrier
 - Description New York TCB with Connection Keys
 - Length 6,096 mm
 - Base Width 610 mm
 - Height 810 mm
- Key Elements - Anchor Ends
 - Size 25 mm diameter ASTM A36 rod
 - Length 394 mm
 - Number per Barrier 5 traffic-side, 4 back-side
- Key Elements - Box Beam Stiffener
 - Size 152 mm x 152 mm x 4.8 mm
 - Length 3,658 mm
 - Connector Rod 19 mm diameter x 432 mm long Grade 5
 - Plate Washer 203 mm x 203 mm x 6.4 mm
- Type of Soil N/A
- Test Vehicle
 - Type/Designation 2270P
 - Make and Model 2002 Dodge Ram 1500 Quad Cab 4x2
 - Curb 2,302 kg
 - Test Inertial 2,275 kg
 - Gross Static 2,275 kg
- Impact Conditions
 - Speed 99.5 km/h
 - Angle 24.6 degrees
 - Impact Location 1,300 mm upstream from downstream end of barrier 4

- Exit Conditions
 - Speed 62.9 km/h
 - Angle 7 deg
 - Exit Box Criterion Pass
- Post-Impact Trajectory
 - Vehicle Stability Satisfactory
 - Stopping Distance 62.3 m downstream
4.6 m laterally behind
- Occupant Impact Velocity
 - Longitudinal 4.67 m/s < 12.2 m/s
 - Lateral 6.33 m/s < 12.2 m/s
- Occupant Ridedown Deceleration
 - Longitudinal 4.72 g's < 20.49 g's
 - Lateral 8.36 g's < 20.49 g's
- THIV (not required) 7.45 m/s
- PHD (not required) 8.71 g's
- Test Article Damage Moderate
- Test Article Deflections
 - Permanent Set 660 mm
 - Dynamic 700 mm
 - Working Width 1,311 mm
- Vehicle Damage Moderate
 - VDS¹³ 11-LFQ-3
 - CDC¹⁴ 11-LYEN2
 - Maximum Deformation 38 mm
- Angular Displacements
 - Roll -10.5 deg
 - Pitch -11.4 deg
 - Yaw 28.0 deg

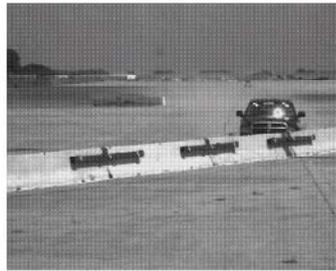
Figure 29. Summary of Test Results and Sequential Photographs, Test NYTCB-1



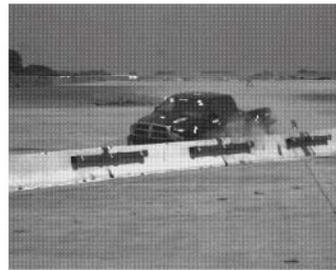
0.000 sec



0.296 sec



0.064 sec



0.358 sec



0.076 sec



0.426 sec



0.134 sec



0.536 sec



0.194 sec



0.696 sec

Figure 30. Additional Sequential Photographs, Test NYTCB-1



0.000 sec



0.398 sec



0.054 sec



0.476 sec



0.076 sec



0.590 sec



0.126 sec



0.798 sec



0.222 sec



1.908 sec

Figure 31. Additional Sequential Photographs, Test NYTCB-1



0.000 sec



0.414 sec



0.060 sec



0.564 sec



0.114 sec



0.842 sec



0.182 sec



1.050 sec



0.252 sec



1.752 sec

Figure 32. Additional Sequential Photos, Test NYTCB-1



Figure 33. Documentary Photographs, Test NYTCB-1



Figure 34. Documentary Photographs, Test NYTCB-1



Figure 35. Impact Location, Test NYTCB-1



Figure 36. Vehicle Final Position and Trajectory Marks, Test NYTCB-1



Figure 37. Temporary Barrier Damage, Test NYTCB-1



Figure 38. Temporary Barrier Damage, Test NYTCB-1

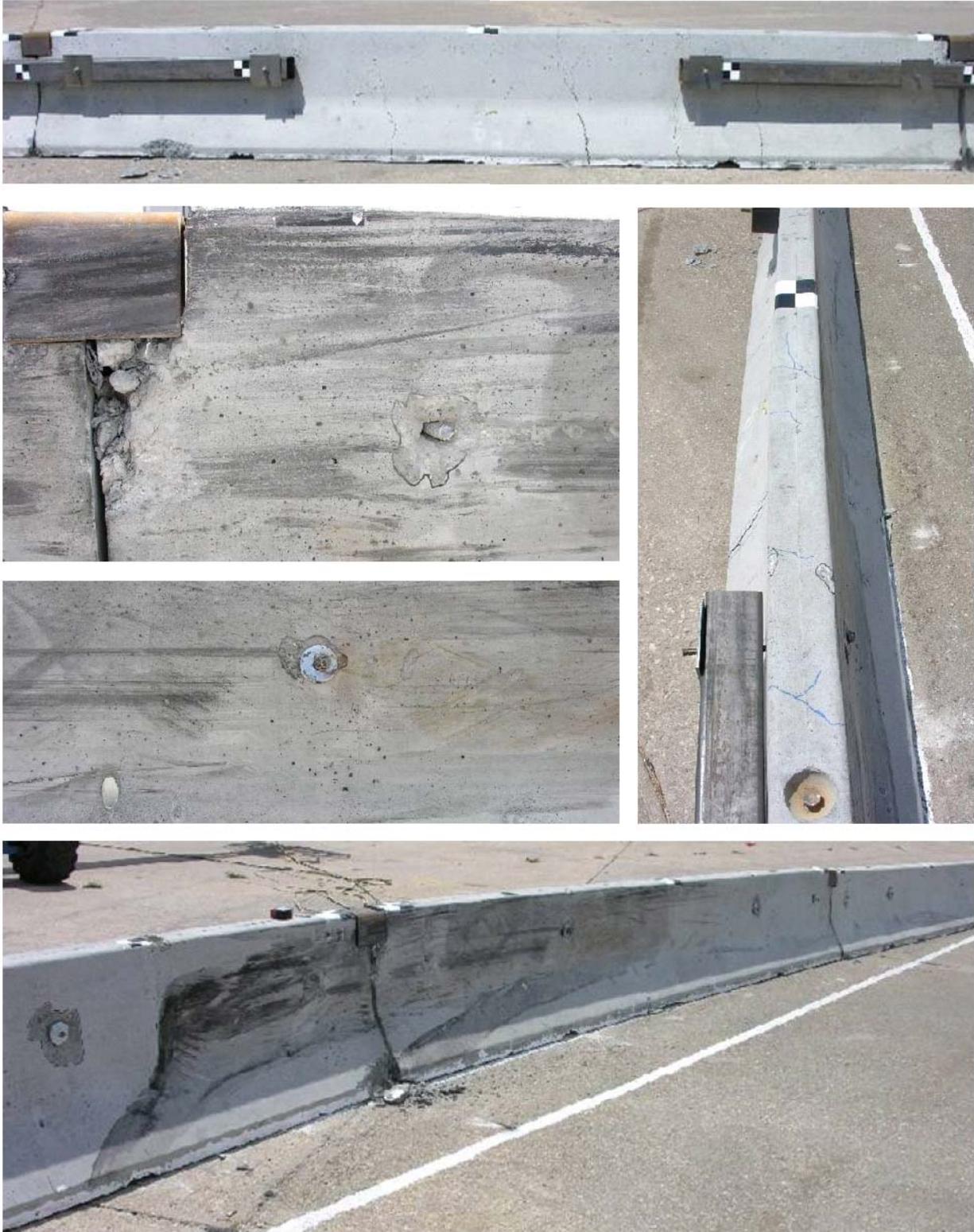


Figure 39. Barrier No. 5 Damage, Test NYTCB-1

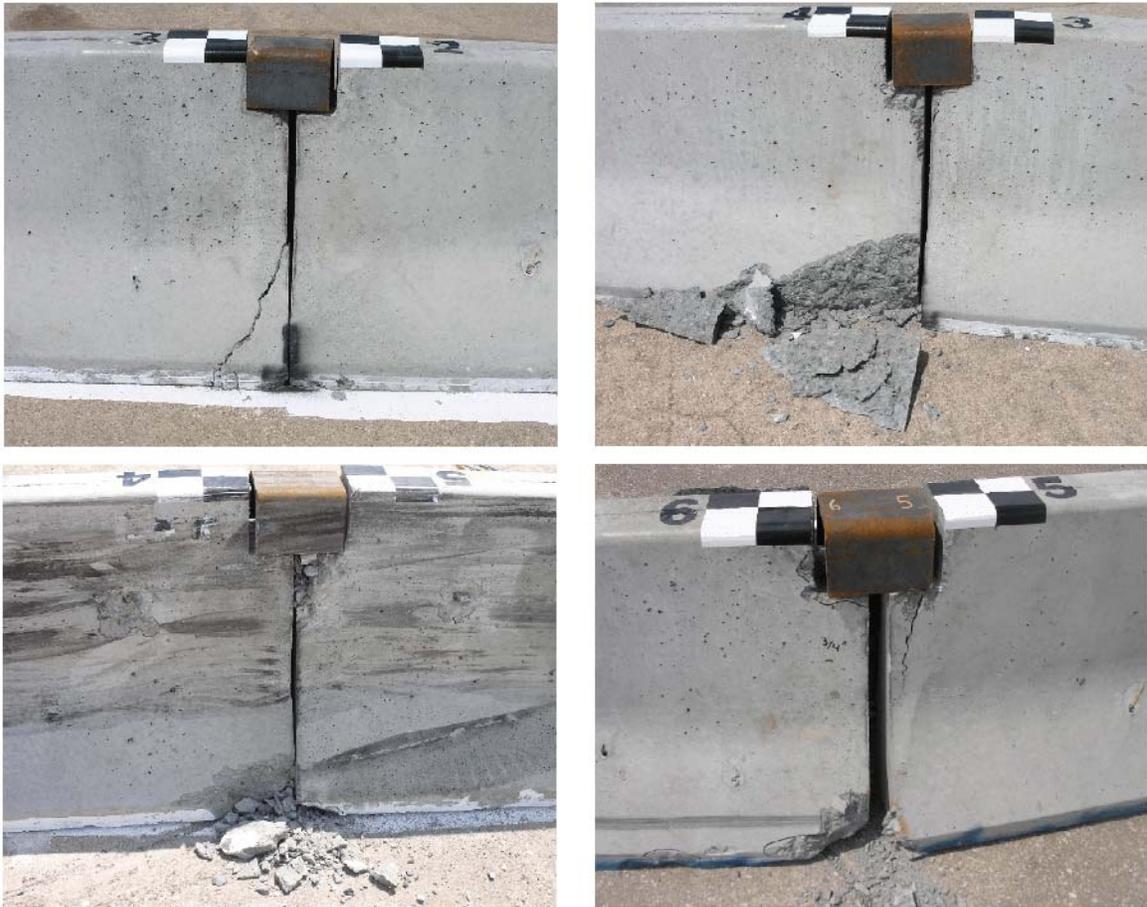


Figure 40. Joint Connection Damage - Joints 2-3, 3-4, 4-5, and 5-6, Test NYTCB-1



Figure 41. Temporary Barrier Box Beam Stiffener Damage, Test NYTCB-1



Figure 42. Vehicle Damage, Test NYTCB-1



Figure 43. Vehicle Damage, Test NYTCB-1

7 DESIGN DETAILS - DESIGN NO. 2

The temporary concrete barrier system was identical to the previous system, except that the box beam stiffeners were removed, as shown in Figure 44. Once again, the 60.96-m (200-ft) long test installation consisted of temporary concrete barrier sections in a free-standing configuration with both end sections anchored. The system was constructed with the identical concrete barrier sections, connection keys, and anchored ends as in the stiffened system. Photographs of the test installation are shown in Figures 45 and 46. Complete system drawings in English and metric units are shown in Appendix E.

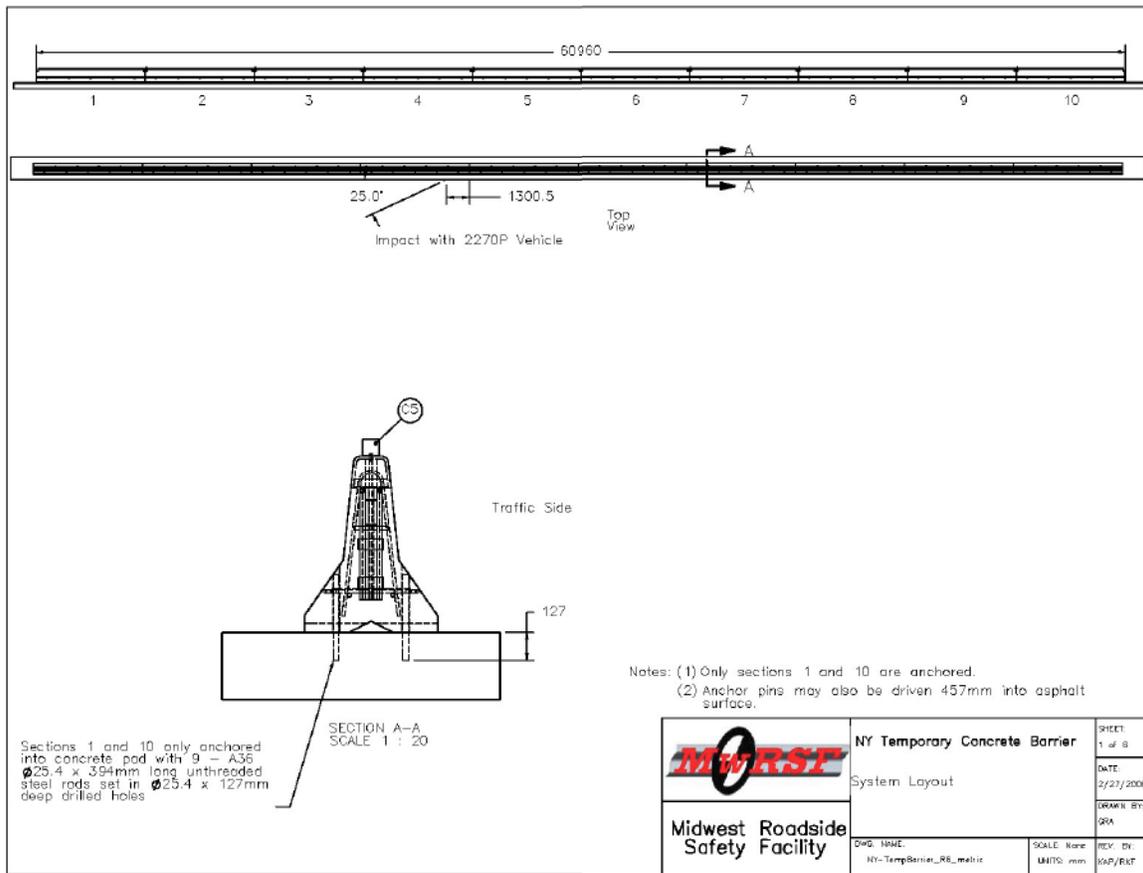


Figure 44. Unstiffened Temporary Concrete Barrier System Layout, Test NYTCB-2



Figure 45. Unstiffened Temporary Concrete Barrier, Test NYTCB-2

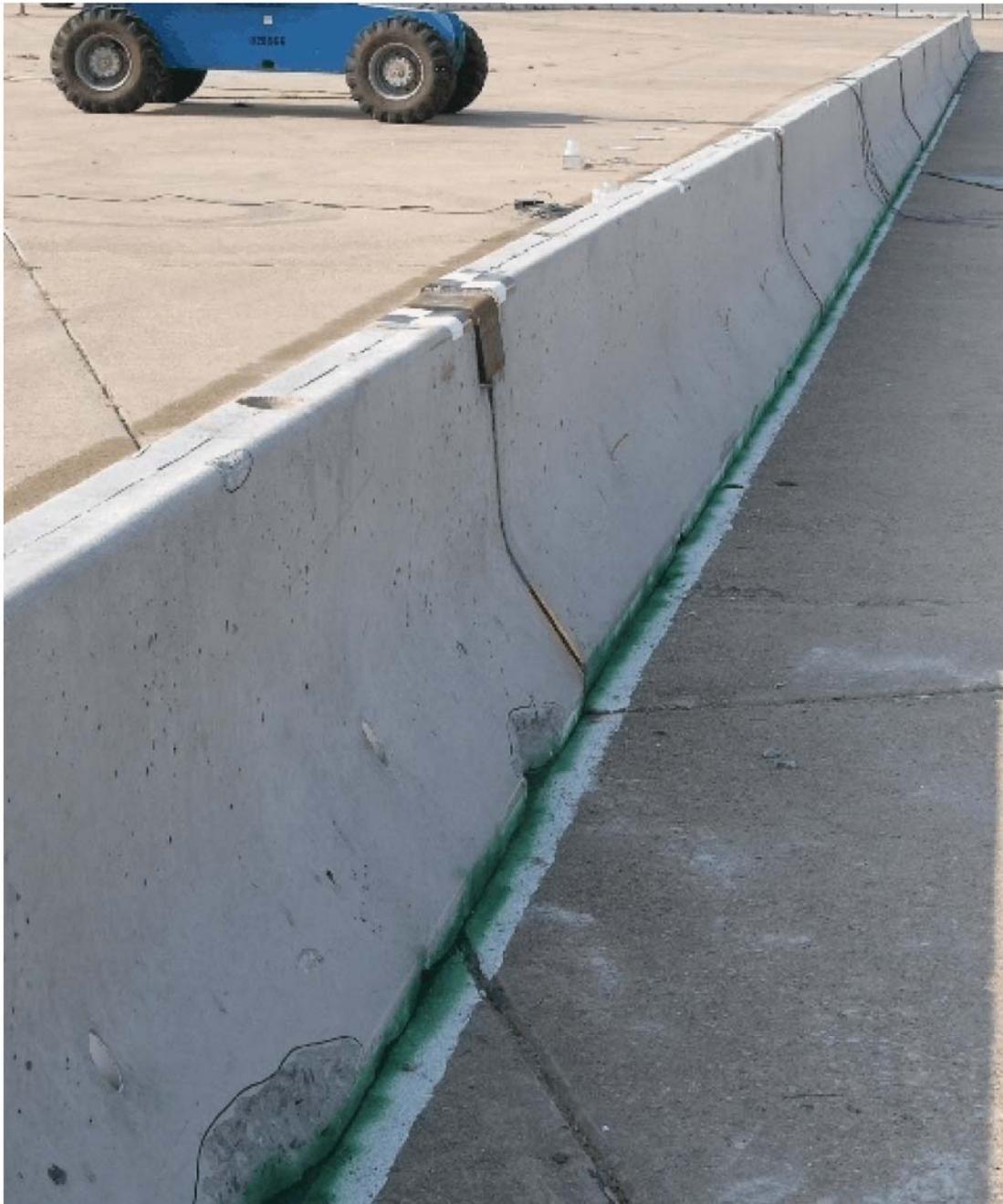


Figure 46. New York Temporary Concrete Barrier, Test NYTCB-2

8 FULL-SCALE CRASH TEST NO. 2

8.1 Test NYTCB-2

The 2,279-kg (5,024-lb) pickup truck impacted the unstiffened temporary concrete barrier system at a speed of 98.5 km/h (61.2 mph) and at an angle of 25.8 degrees. A summary of the test results and the sequential photographs are shown in Figure 47. An English-unit summary of the test results and sequential photographs are shown in Appendix B. Additional sequential photographs are shown in Figures 48 through 50. Documentary photographs of the crash test are shown in Figures 51 through 55.

8.2 Test Description

Initial vehicle impact was to occur 1,300 mm (51.2 in.) upstream from the downstream end of barrier no. 4, as shown in Figure 56. Actual vehicle impact occurred at the targeted impact location. Immediately after impact, the left-front quarter panel crushed inward. At 0.010 sec, barrier nos. 4 and 5 deflected away from traffic. At 0.012 sec, the left-front tire climbed the front face of barrier no. 4. At 0.032 sec, the vehicle yawed as it redirected. At 0.034 sec, the left-front quarter panel protruded over the top of the barrier. At 0.040 sec, the back side of barrier no. 4 experienced concrete spalling which disengaged from the barrier. At 0.042 sec, the vehicle climbed the front face of the system, and the vehicle's front end pitched upward. At 0.054 sec, concrete spalling occurred at the downstream end on the back side of barrier no. 3. At 0.056 sec, barrier no. 6 deflected backward due to movement of barrier no. 5. At 0.196 sec, barrier no. 7 deflected toward traffic. At 0.210 sec, barrier no. 3 moved slightly downstream. At 0.216 sec, the vehicle became parallel to the barrier with a resultant velocity of 82.7 km/h (51.4 mph). As the truck continued to redirect, it rolled toward the system. At 0.282 sec, the right-rear tire became airborne which resulted in the entire vehicle becoming airborne. At 0.296 sec, the front of the vehicle reached its maximum pitch upward

and began pitching downward. At 0.420 sec, the vehicle exited the system at an angle of 4.7 degrees and a resultant velocity of 72.8 km/h (45.2 mph). At 0.554 sec, the right-front tire contacted the ground. At 0.556 sec, the right-front corner of the bumper contacted the ground. The vehicle continue downstream before coming to rest 58.8 m (192 ft - 11.5 in.) downstream from impact and 2.0 m (6 ft - 5 in.) laterally away from the traffic-side face of the barrier. The trajectory and final position of the truck are shown in Figures 47 and 57.

8.3 Barrier Damage

Damage to the barrier was moderate, as shown in Figures 58 through 61. Barrier damage consisted of tire and gouge marks, concrete barrier cracking, and spalling concrete. The length of the vehicle contact along the system was approximately 13.97 m (45.8 ft), which spanned from 1.78 m (70 in.) upstream from the downstream end of barrier no. 4 through the downstream end of barrier no. 6.

Contact marks were visible on the front face of barrier nos. 4 through 6. Tire marks were found 1,778 mm (70 in.) upstream from the downstream end of barrier no. 4 and continued through the downstream end of barrier no. 5. Tire marks were also found beginning at the midpoint of barrier no. 6 and continued through the end of barrier no. 6. Blue contact marks were found on barrier nos. 4 and 5.

Cracking was found on the front and back sides of barrier no. 4 from the center of the barrier to the downstream end. Major cracking was found throughout the front and back sides of barrier no. 5. Minor cracking was also found throughout the length of barrier no. 6 and on both the front and back sides.

The lower downstream-back corner of barrier no. 2 experienced concrete spalling measuring 127 mm (5 in.) wide and 102 mm (4 in.) tall. The lower upstream-back corner of barrier no. 3 also

experienced concrete spalling measuring 76 mm (3 in.) wide and 229 mm (9 in.) tall. Barrier no. 4 experienced major concrete spalling at the lower front-downstream corner with a 305-mm (12-in.) wide by 254-mm (10-in.) tall piece removed. Minor concrete spalling began at impact and extended for a length of 1,194 mm (47 in.) downstream at the lower face of barrier no. 4. Major concrete spalling 229 mm (9 in.) wide by 305 mm (12 in.) tall was found on the upstream-front side of the top of barrier no. 5. The upper upstream-back corner of barrier no. 5 experienced concrete spalling measuring 152 mm (6 in.) wide by 178 mm (7 in.) tall. The upper downstream-back corner of barrier no. 5 also experienced concrete spalling measuring 76mm (3 in.) wide by 279mm (11 in.) tall. The lower-front face of barrier no. 5 experienced major concrete spalling 229 mm (9 in.) wide and 279 mm (11 in.) tall. A 711-mm (28-in.) long by 330-mm (13 in.) tall piece of concrete was removed from the lower-upstream end of the front side of barrier no. 6. Minor concrete spalling was located on the lower upstream-back side of barrier no. 6. Concrete spalling measuring 51mm (2 in.) wide and 254 mm (10 in.) tall was found on the upper-upstream corner of barrier no. 7.

All connection keys remained undamaged. The anchor rods in barrier nos. 1 and 10 remained undamaged, and these barriers encountered little to no movement.

The permanent set of the barrier system is shown in Figures 58 and 59. The maximum lateral permanent set barrier deflection was 1,003 mm (39.5 in.) at the downstream end of barrier no. 4 and the upstream end of barrier no. 5, as measured in the field. The maximum lateral dynamic barrier deflection was 1,023 mm (40.25 in.) at the midpoint of barrier no. 5, as determined from high-speed digital video analysis. The working width of the system was found to be 1,630 mm (64.2 in.).

8.4 Vehicle Damage

Exterior vehicle damage was moderate, as shown in Figures 62 and 63. Occupant compartment deformations to the left side and center of the floorboard were judged insufficient to

cause serious injury to the vehicle occupants, as shown in Figure 64. Maximum longitudinal deflections of 76 mm (3 in.) were located near the left-front corner of the left-side floor pan. Maximum lateral deflections of 25 mm (1 in.) were located near the front center of the left-side floor pan. Maximum vertical deflections of 70 mm (2.75 in.) were located near the middle-front area of the left-side floor pan. Complete occupant compartment deformations and the corresponding locations are provided in Appendix C.

Damage was concentrated on the left-front corner of the vehicle. The left-front and right-front quarter panels buckled inward toward the engine compartment. The left corner of the front bumper deformed and both sides were partially detached from the vehicle. The left-front tire's side wall experienced a 127-mm (5-in.) long gash, and the tire deflated. The left-front wheel assembly was deformed into the wheel well. A small gouge was found in the left-rear tire, and the tire deflated. The left-front door was ajar at the top. Scrape marks and dents were found at the bottom of the left front and left-rear doors, the left-front and right-front quarter panels, the left-rear corner of the box, and the right-rear corner of the cab. The left side of the box portion separated from the cab. The left-rear axle deformed upward. The left-side headlight and taillight disengaged from the vehicle. The left side of the rear bumper buckled inward. The tailgate disengaged, except it remained attached by the left-side cable. The front frame on the left side was deformed. The left-side upper control arm and pin were bent and scraped. All window glass in the vehicle remained undamaged.

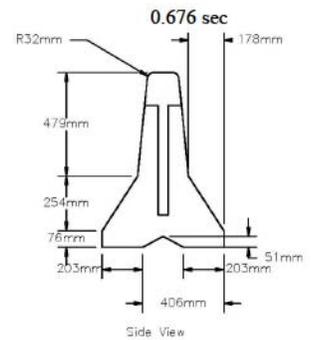
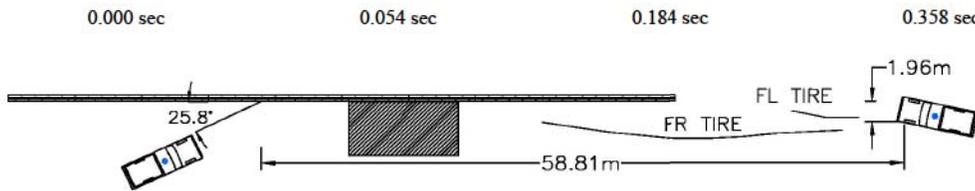
8.5 Occupant Risk Values

The longitudinal and lateral occupant impact velocities were determined to be -4.84 m/s (-15.88 ft/s) and 6.32 m/s (20.74 ft/s), respectively. The maximum 0.010-sec average occupant ridedown decelerations in the longitudinal and lateral directions were -5.44 g's and 8.09 g's, respectively. It is noted that the occupant impact velocities (OIV) and occupant ridedown

decelerations (ORD) were within the suggested limits provided in the currently proposed Update to NCHRP Report No. 350. The THIV and PHD values were determined to be 7.59 m/s (24.89 ft/s) and 8.19 g's, respectively. The results of the occupant risk, as determined from the accelerometer data, are summarized in Figure 47. Results are shown graphically in Appendix F. The results from the rate transducer are shown graphically in Appendix F.

8.6 Discussion

The analysis of the test results for test no. NYTCB-2 showed that the unstiffened temporary concrete barrier system with anchored ends adequately contained and redirected the 2270P vehicle with controlled lateral displacements of the barrier system. There were no detached elements nor fragments which showed potential for penetrating the occupant compartment nor presented undue hazard to other traffic. Deformations of, or intrusions into, the occupant compartment that could have caused serious injury did not occur. The test vehicle did not penetrate nor ride over the barrier system and remained upright during and after the collision. Vehicle roll, pitch, and yaw angular displacements were noted, but they were deemed acceptable because they did not adversely influence occupant risk safety criteria nor cause rollover. After collision, the vehicle's trajectory revealed minimum intrusion into adjacent traffic lanes. In addition, the vehicle exited the barrier within the exit box. Therefore, test no. NYTCB-2 conducted on the unstiffened temporary concrete barrier system with anchored ends was determined to be acceptable according to the TL-3 safety performance criteria of test designation no. 3-11 found in the currently proposed Update to NCHRP Report No. 350.



- Test Agency MwRSF
- Test Number NYTCB-2
- Date 7/25/07
- NCHRP 350 Update Test Designation 3-11
- Appurtenance Unstiffened Temporary Concrete Barriers
- Total Length 60.96 m
- Key Elements - Barrier
 - Description New York TCB with Connection Keys
 - Length 6,096 mm
 - Base Width 610 mm
 - Height 810 mm
- Key Elements - Anchor Ends
 - Size 25 mm diameter ASTM A36 rod
 - Length 394 mm
 - Number per Barrier 5 traffic-side, 4 back side
- Type of Soil N/A
- Test Vehicle
 - Type/Designation 2270P
 - Make and Model 2002 Dodge Ram 1500 Quad Cab 4x2
 - Curb 2,245 kg
 - Test Inertial 2,279 kg
 - Gross Static 2,279 kg
- Impact Conditions
 - Speed 98.5 km/h
 - Angle 25.8 degrees
 - Impact Location 1,300 mm upstream from downstream end of barrier 4
- Exit Conditions
 - Speed 72.8 km/h
 - Angle 4.7 degrees
 - Exit Box Criterion Pass

- Post-Impact Trajectory
 - Vehicle Stability Satisfactory
 - Stopping Distance 58.81 m downstream
1.96 m laterally away
- Occupant Impact Velocity
 - Longitudinal -4.84 m/s < 12.2 m/s
 - Lateral 6.32 m/s < 12.2 m/s
- Occupant Ridedown Deceleration
 - Longitudinal -5.44 g's < 20.49 g's
 - Lateral 8.09 g's < 20.49 g's
- THIV (not required) 7.59 g's
- PHD (not required) 8.19 g's
- Test Article Damage Moderate
- Test Article Deflections
 - Permanent Set 1,003 mm
 - Dynamic 1,023 mm
 - Working Width 1,630 mm
- Vehicle Damage Moderate
 - VDS¹³ 11-LFQ-3
 - CDC¹⁴ 11-LYEN4
 - Maximum Deformation 76 mm
- Angular Displacements
 - Roll -12.4 deg
 - Pitch -10.6 deg
 - Yaw 43.1 deg

Figure 47. Summary of Test Results and Sequential Photographs, Test NYTCB-2



0.000 sec



0.172 sec



0.020 sec



0.214 sec



0.030 sec



0.256 sec



0.070 sec



0.392 sec



0.124 sec



0.548 sec

Figure 48. Additional Sequential Photographs, Test NYTCB-2



0.000 sec



0.210 sec



0.010 sec



0.316 sec



0.028 sec



0.460 sec



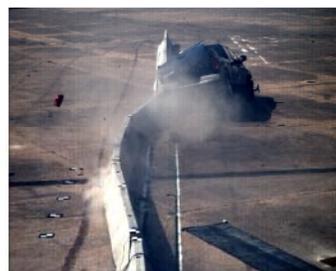
0.054 sec



0.620 sec



0.094 sec



0.722 sec

Figure 49. Additional Sequential Photographs, Test NYTCB-2



0.000 sec



0.296 sec



0.036 sec



0.440 sec



0.056 sec



0.630 sec



0.150 sec



0.986 sec



0.212 sec



2.654 sec

Figure 50. Additional Sequential Photographs, Test NYTCB-2



Figure 51. Documentary Photographs, Test NYTCB-2



Figure 52. Documentary Photographs, Test NYTCB-2



Figure 53. Documentary Photographs, Test NYTCB-2



Figure 54. Documentary Photographs, Test NYTCB-2



Figure 55. Documentary Photographs, Test NYTCB-2

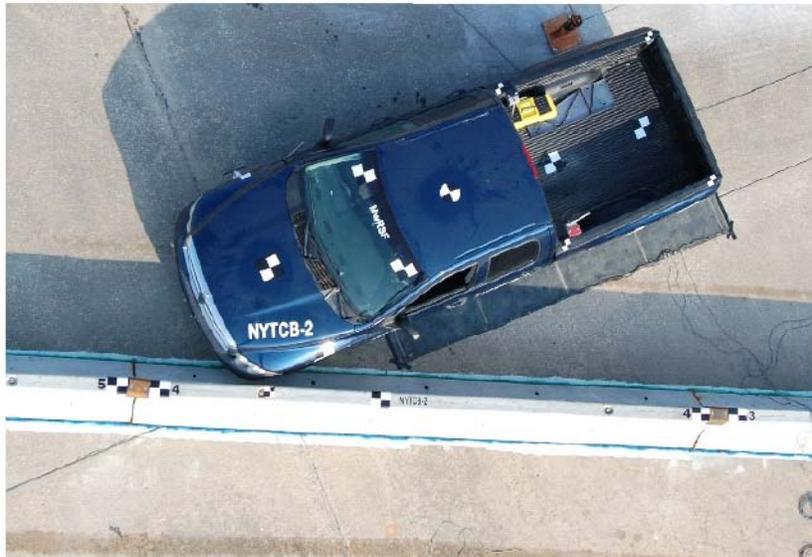


Figure 56. Impact Location, Test NYTCB-2



Figure 57. Vehicle Final Position and Trajectory Marks, Test NYTCB-2



Figure 58. Temporary Barrier Damage, Test NYTCB-2



Figure 59. Temporary Barrier Damage, Test NYTCB-2



Figure 60. Barrier No. 5 Damage, Test NYTCB-2

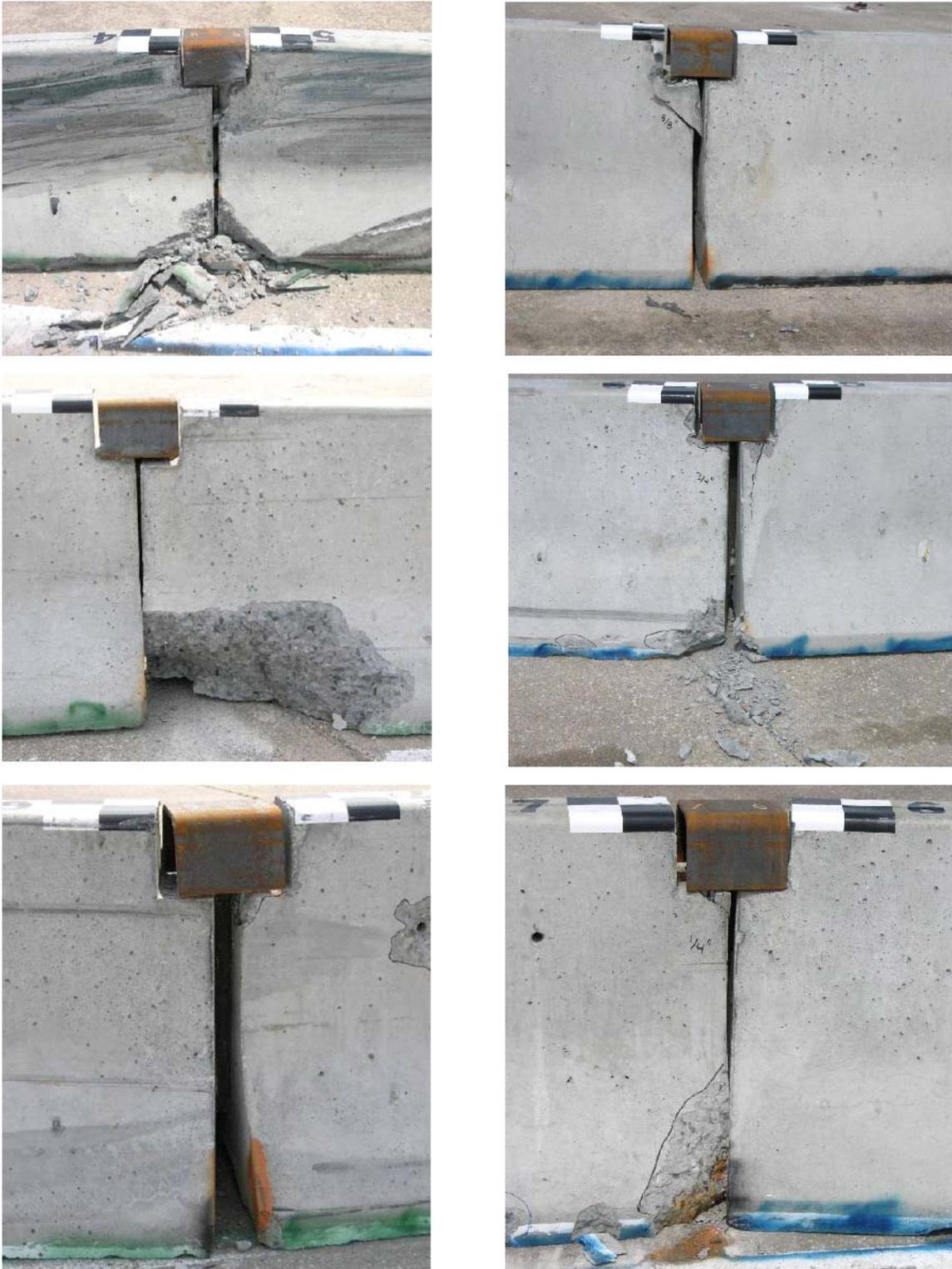


Figure 61. Joint Connection Damage for Joints 4-5, 5-6, and 6-7, Test NYTCB-2



Figure 62. Vehicle Damage, Test NYTCB-2



Figure 63. Vehicle Damage, Test NYTCB-2



Figure 64. Occupant Compartment Deformation, Test NYTCB-2

9 DESIGN MODIFICATIONS - DESIGN NO. 3

The temporary concrete barrier system was identical to that of design no. 1, except for changing the size of the box beam stiffener and placing the system adjacent to a vertical drop off, as shown in Figures 65 and 68. For this installation, each box beam stiffener consisted of a 152-mm x 203-mm x 6.4-mm (6-in. x 8-in. x 0.25-in.) ASTM A500 Grade C box beam, which was 3,658 mm (12 ft) long. The stiffeners were connected to the barrier sections with the same connecting rod, except that the length was increased to 483 mm (19 in.), as shown in Figures 66 and 67. In addition, the six joints between barrier section nos. 2 and 8 were stiffened with a box beam stiffener. Furthermore, the system was installed with the back side of the sections placed 305 mm (12 in.) away from the edge of a bridge deck, as shown in Figure 65. Once again, the size of the box beam stiffening rail was selected to be consistent with the standard sizes used for the NYSDOT's box beam guide rail and median barrier.

The 60.96-m (200-ft) long, test installation consisted of temporary concrete barrier sections in a free-standing configuration with both end sections anchored. The system was constructed with identical concrete barrier sections, connection keys, and anchored ends as in the first and second designs. Photographs of the test installation are shown in Figures 68 through 69. Complete system drawings in English and metric units are shown in Appendix G.

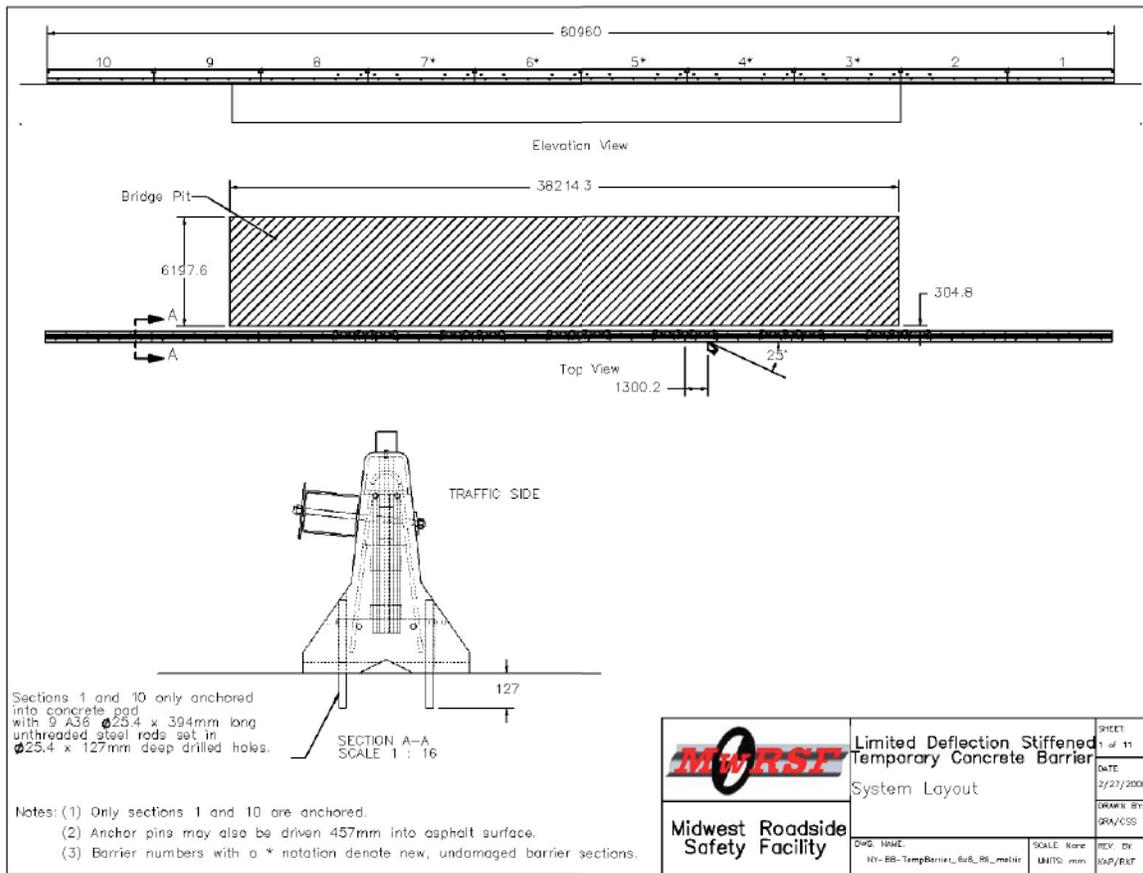


Figure 65. Stiffened Temporary Concrete Barrier System Layout, Test NYTCB-3

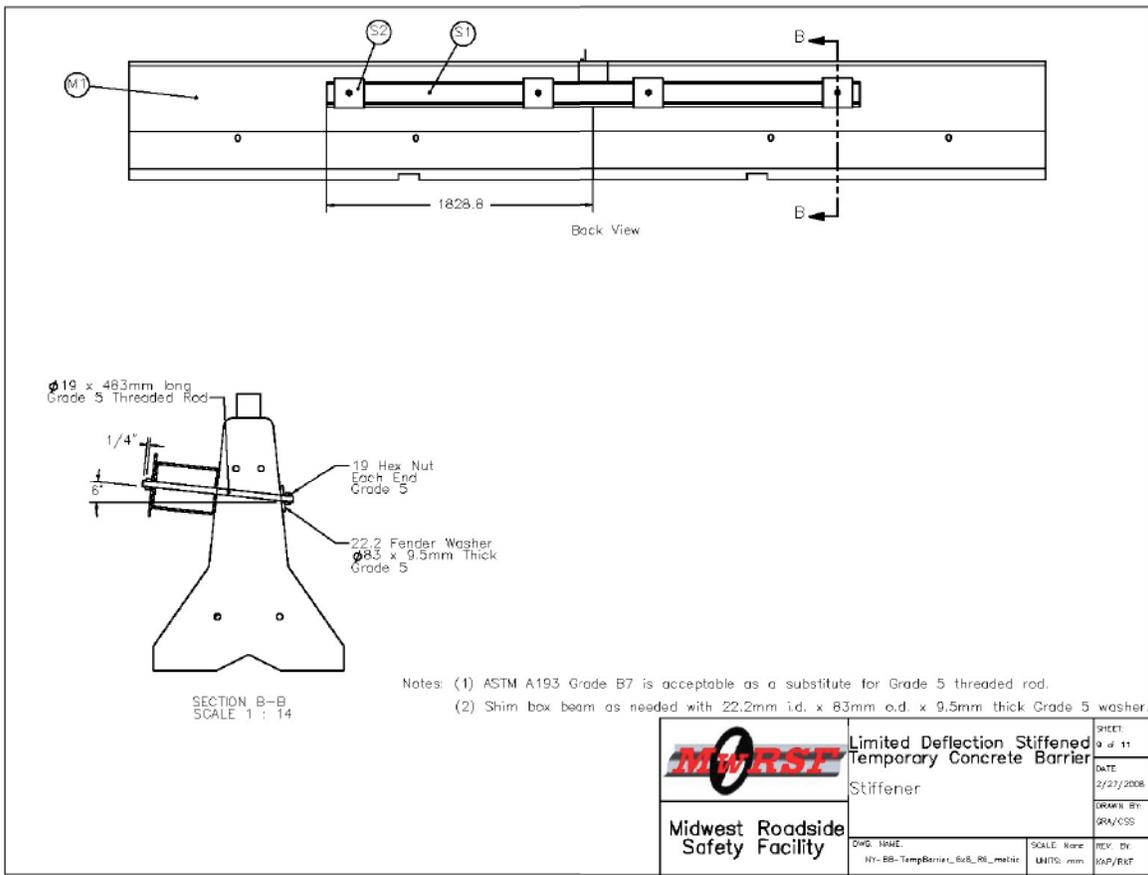


Figure 66. Box Beam Stiffener Details, Test NYTCB-3

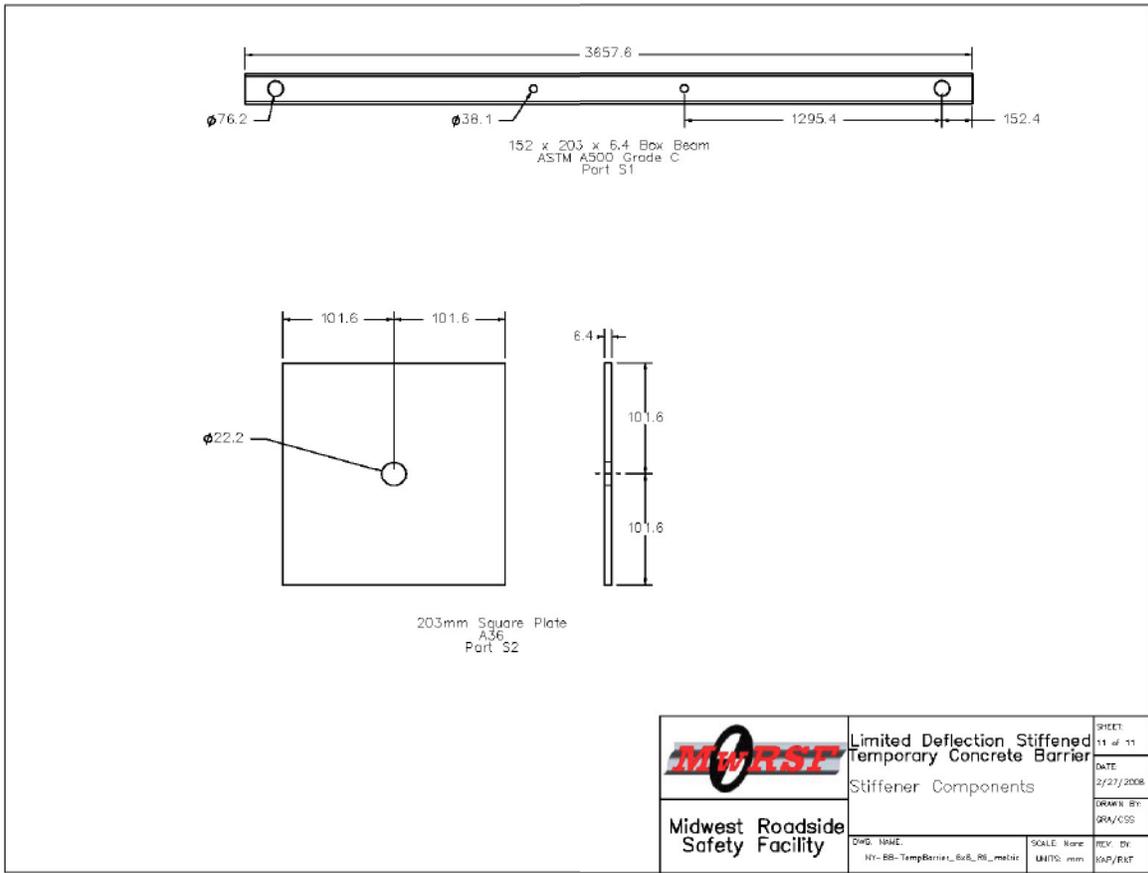


Figure 67. Box Beam Stiffener Details, Test NYTCB-3

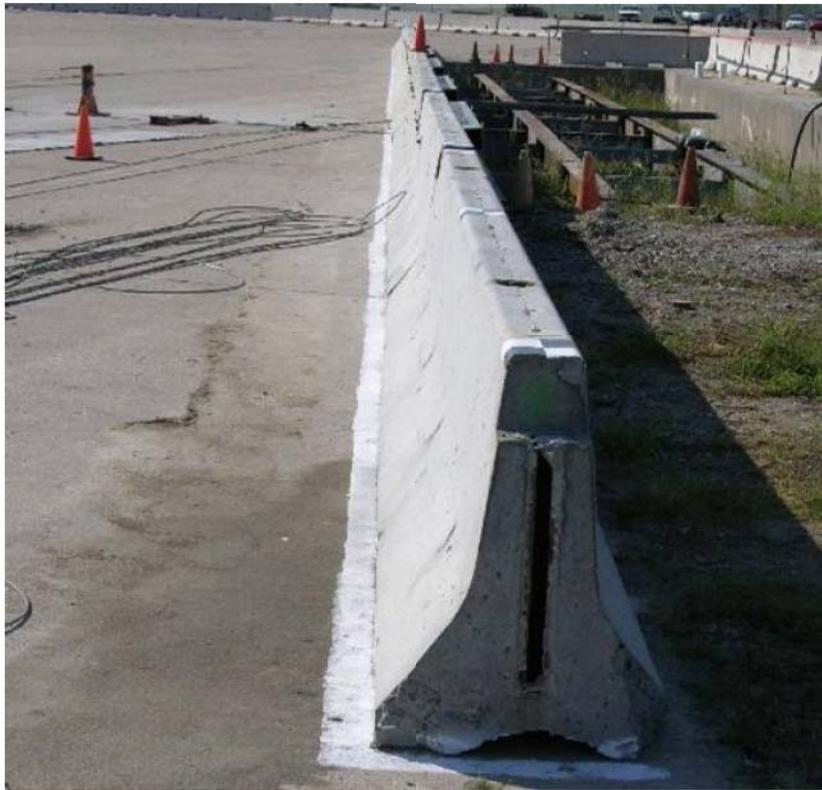


Figure 68. Box Beam Stiffened Temporary Concrete Barrier System, Test NYTCB-3



Figure 69. Box Beam Stiffeners, Test NYTCB-3

10 FULL-SCALE CRASH TEST NO. 3

10.1 Test NYTCB-3

The 2,268-kg (5,001-lb) pickup truck impacted the stiffened temporary concrete barrier system at a speed of 102.2 km/h (63.5 mph) and at an angle of 24.4 degrees. A summary of the test results and sequential photographs are shown in Figure 70. An English-unit summary of the test results and sequential photographs are shown in Appendix B. Additional sequential photographs are shown in Figures 71 through 73. Documentary photographs are shown in Figures 74 and 75.

10.2 Test Description

Initial vehicle impact was to occur 1,300 mm (51.2 in.) upstream from the downstream end of barrier no. 4, as shown in Figures 65 and 76. Actual vehicle impact occurred at the targeted impact location. At 0.004 sec after impact, the right corner of the front bumper crushed inward. At 0.010 sec, the right-front tire climbed barrier no. 4. At 0.014 sec, the right-front tire ruptured as the tire was compressed between the vehicle and barrier no. 4. At 0.018 sec, barrier no. 4 deflected backward. At this same time, the box beam stiffener between barrier nos. 4 and 5 bent away from the barriers. At 0.026 sec, the right-front tire was airborne and in contact with the front face of barrier no. 4. At 0.028 sec, the hood became ajar. At 0.030 sec, barrier no. 5 deflected backward. At 0.032 sec, the vehicle redirected as the front of the vehicle was located near the joint between barrier nos. 4 and 5. At 0.036 sec, the front of the vehicle pitched upward. At 0.040 sec, the box beam stiffeners located at the joints between barrier nos. 3 and 4 and barrier nos. 5 and 6 bent away from the barriers. At 0.042 sec, the right-front door became ajar. At 0.056 sec, small concrete pieces disengaged at the joint between barrier nos. 3 and 4 as barrier no. 4 rotated. At 0.082 sec, concrete pieces disengaged from the base of barrier no. 5 as the barrier continued to deflect backward. At this same time, the right-side headlight disengaged from the vehicle. At 0.084 sec, the back-downstream

corner of barrier no. 5 cracked. At 0.088 sec, barrier nos. 3 and 6 deflected backward. At 0.100 sec, the back-upstream corner of barrier no. 5 cracked. At 0.114 sec, the box beam stiffener between barrier nos. 2 and 3 bent away from the barriers. At 0.116 sec, the left-front tire became airborne with the front of the vehicle located at the middle of barrier no. 5. At 0.152 sec, the box beam stiffener between barrier nos. 6 and 7 bent away from the barriers. At 0.160 sec, the joint between barrier nos. 4 and 5 protruded beyond the edge of the bridge deck. At 0.172 sec, barrier no. 7 deflected backward. At 0.178 sec, the right-rear tire contacted the upstream end of barrier no. 5, and the entire right side of the vehicle was in contact with the system. At 0.192 sec, the right-rear tire climbed the front face of barrier no. 5. At 0.210 sec, the vehicle became parallel to the system with a resultant velocity of 80.7 km/h (50.1 mph). At 0.214 sec, the box beam stiffener between barrier nos. 6 and 7 bent. At 0.222 sec, the front of the vehicle ceased pitching upward. At 0.270 sec, the vehicle's right rear of the vehicle lost contact with the system. At 0.292 sec, the left-rear tire became airborne. At 0.320 sec, the back-upstream corner of barrier no. 6 and the back edge of barrier no. 5 protruded beyond the edge of the bridge deck. At 0.374 sec, barrier nos. 4 and 5 ceased movement. At 0.446 sec, the vehicle exited the system at an angle of 1.7 degrees and at a resultant velocity of 87.2 km/h (54.2 mph). At 0.498 sec, the system reached its maximum deflection. At 0.634 sec, the vehicle rolled slightly clockwise toward the barrier. At 0.710 sec, the front bumper of the vehicle contacted the ground, and the vehicle ceased pitching. At 0.786 sec, the right-front tire contacted the ground. At 0.798 sec, the vehicle rolled slightly counterclockwise away from the barrier. At 0.950 sec, the right-rear tire contacted the ground, and the vehicle ceased rolling counterclockwise. At 0.964 sec, the left-rear tire contacted the ground. The vehicle came to rest 57.69 m (189 ft - 3.25 in.) downstream from impact and 3.81 m (12 ft - 6 in.) laterally behind a line projected parallel to the traffic-side face of the barrier. The trajectory and final position of the vehicle are shown in

Figures 70 and 77.

10.3 Barrier Damage

Damage to the barrier was moderate, as shown in Figures 78 through 84. Barrier damage consisted of contact and gouge marks, concrete barrier cracking, spalling of the concrete, and deformed box beam sections. The length of vehicle contact along the temporary barrier system was approximately 31.7 m (104 ft), which spanned from 1,783 mm (70.2 in.) upstream from the downstream end of barrier no. 4 through 3,785 mm (149 in.) downstream from the upstream end of barrier no. 5 and from 1,753 mm (69 in.) downstream from the upstream end of barrier no. 6 through the downstream end of barrier no. 10.

Tire marks were visible on the front face of barrier nos. 4 through 10. Gouge marks were found on the upstream front face of barrier no. 5.

Cracking was found on the front and back sides of barrier no. 3. One 3.2-mm (0.125 in.) wide crack was found on the back side of barrier no. 3 and began 1,016 mm (40 in.) downstream from the upstream end of the barrier. Three hairline cracks were found on the front side of barrier no. 3 and began 1,676 mm (66 in.), 2,388 mm (94 in.), and 3,658 mm (144 in.) downstream from the upstream end of the barrier and traveled from the top to the bottom of the barrier. Major cracking was found throughout the front and back sides of barrier nos. 4 and 5. Hairline cracks were located on the back side of barrier no. 4 at 1,499 mm (59 in.), 2,413 mm (95 in.), 4,826 mm (190 in.), and 5,486 mm (216 in.) downstream from the upstream end of barrier no. 4. Two 1.6-mm (0.06-in.) wide cracks were located 3,048 mm (120 in.) and 3,607 mm (142 in.) downstream from the upstream end of the barrier with the front side experiencing hairline cracks at the same locations. A 3.2-mm (0.13-in.) wide crack was located on the back side of barrier no. 4 at 4,242 mm (167 in.) downstream from the upstream end of the barrier with the front side experiencing hairline cracking at the same location.

A 1.6-mm (0.06-in.) wide crack was located on the back side at 3,073 mm (121 in.) downstream from the upstream end of barrier no. 5. Three 6.4-mm (0.25-in.) cracks were found on the back side of barrier no. 5 at 1,422 mm (56 in.), 1,829 mm (72 in.), and 2,515 mm (99 in.) downstream from the upstream end of the barrier with hairline cracks on the front side at these same locations. A 3.2-mm (0.13-in.) wide crack was also found on the back side of barrier no. 5 at 3,759 mm (148 in.) downstream from the upstream end of the barrier with a hairline crack on the front side at this location. A hairline crack was located on the front and back sides of barrier no. 5 at 4,597 mm (181 in.) downstream from the upstream end of the barrier. Minor hairline cracking was located on the front of barrier no. 6 at 1,676 mm (66 in.), 2,337 mm (92 in.), 3,302 mm (130 in.), and 4,267 mm (168 in.) downstream from the upstream end of the barrier. One 1.6-mm (0.06-in.) wide crack was found on the front and back sides of barrier no. 7 at 1,829 mm (72 in.) downstream from the upstream end of the barrier.

Concrete spalling occurred on barrier nos. 3 through 7. The downstream corner of barrier no. 3 experienced minor concrete spalling. A 737-mm (29-in.) long and 216-mm (8.5-in.) tall piece of concrete was removed from the front side of barrier no. 4 near impact. Minor concrete spalling was found on the back-upstream end of barrier no. 4, the lower-front face of barrier no. 5, and the front faces of barrier nos. 6 and 7. A 686-mm (27-in.) long by 483-mm (19-in.) tall piece of concrete was removed from the lower back-downstream corner of barrier no. 5, and exposed the steel rebar.

The box beam stiffener located across the joint between barrier nos. 4 and 5 sustained significant bending. The box beam stiffener placed across the joints between barrier nos. 2 and 3, 3 and 4, 5 and 6, and 6 and 7 experienced minor bending. The box beam rods on the front sides of barrier nos. 4 through 6 were bent, and scrape marks were found on the corresponding nuts and washers. All connection keys remained undamaged, except for minor contact marks. The anchor

rods in barrier nos. 1 and 10 remained undamaged, and these barriers experienced no movement. Minor bending of the plate washers was observed. No buckling of the box beam webs or bending of the box beam flanges was observed with the plate washers.

The permanent set of the barrier system is shown in Figure 78. The maximum lateral permanent set barrier deflection was 660 mm (26 in.) at the downstream end of barrier no. 4, as measured in the field. The center of gravity of barrier no. 5 was displaced 19 mm (0.75 in.) off of the bridge deck edge. The maximum lateral dynamic barrier deflection was 784 mm (30.9 in.) at the upstream end of barrier no. 5, as determined from high-speed digital analysis. The working width of the system was found to be 1,304 mm (51.3 in.).

10.4 Vehicle Damage

Exterior vehicle damage was moderate, as shown in Figures 85 and 86. Occupant compartment deformations to the right side and center of the floorboard were judged insufficient to cause serious injury to the vehicle occupants, as shown in Figure 87. Maximum longitudinal deflections of 89 mm (3.5 in.) were located near the middle-front area of the right-side floor pan. Maximum lateral deflections of 16 mm (0.625 in.) were located near the right-front door. Occupant compartment deformations and the corresponding locations are provided in Appendix C.

Damage was concentrated on the right-front corner of the vehicle. The right-front quarter panel deformed inward toward the engine compartment. The hood and the top of the right-side door were ajar. Scrapes and contact marks were found along the entire right side. The right-front wheel assembly rotated 36 degrees from normal position. The edge of the right-front steel rim was deformed and cracked. The right-front tire's sidewall was torn, and the tire deflated. The right-rear steel rim was deformed, and the tire deflated. The right-side upper control arm link to the power steering cylinder fractured. The right-side headlight disengaged from the vehicle. The lower-left side

of the windshield had “spider-web” cracking. The roof, left side, and rear of the vehicle and all other window glass remained undamaged.

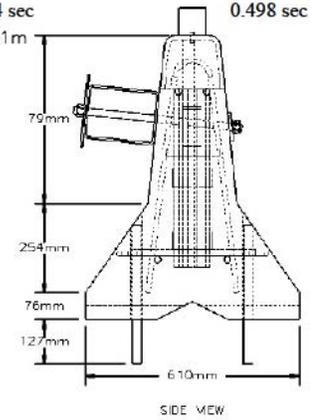
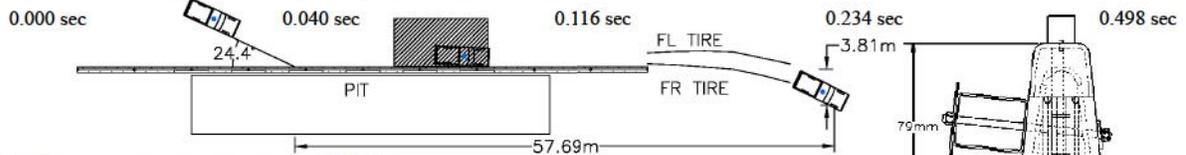
10.5 Occupant Risk Values

The occupant impact velocities and the occupant ridedown decelerations were calculated from both the DTS and the EDR-3. From the DTS, the longitudinal and lateral occupant impact velocities were determined to be -4.77 m/s (-15.64 ft/s) and 6.06 m/s (19.88 ft/s), respectively. From the EDR-3 data, the longitudinal and lateral occupant impact velocities were determined to be -5.32 m/s (-17.44 ft/s) and 6.86 m/s (22.50 ft/s), respectively. The maximum 0.010-sec average occupant ridedown decelerations in the longitudinal and lateral directions were -7.15 g's and 6.64 g's, respectively, as determined by the DTS data. The maximum 0.010-sec average occupant ridedown decelerations in the longitudinal and lateral directions were -7.85 g's and 5.83 g's, respectively, as determined from the EDR-3 data. It is noted that the occupant impact velocities (OIV) and the occupant ridedown decelerations (ORD) were within the suggested limits provided in currently proposed Update to NCHRP Report No. 350. The THIV and PHD values were determined to be 7.25 m/s (23.77 ft/s) and 7.93 g's, respectively. The results of the occupant risk, as determined from the accelerometer data, are summarized in Figure 70. Results are shown graphically in Appendix H. Results from the rate transducer are shown graphically in Appendix H.

10.6 Discussion

The analysis of the test results for test no. NYTCB-3 showed that the stiffened temporary concrete barrier system with anchored ends adequately contained and redirected the 2270P vehicle with controlled lateral displacements of the barrier system. There were no detached elements nor fragments which showed potential for penetrating the occupant compartment nor presented undue hazard to other traffic. Deformations of, or intrusion into, the occupant compartment that could have

caused serious injury did not occur. The test vehicle did not penetrate nor ride over the box beam stiffened temporary concrete barrier system and remained upright during and after the collision. Vehicle roll, pitch, and yaw angular displacements were noted, but they were deemed acceptable because they did not adversely influence occupant risk safety criteria nor cause rollover. After collision, the vehicle's trajectory revealed minimum intrusion into adjacent traffic lanes. In addition, the vehicle exited the barrier within the exit box. Therefore, test no. NYTCB-3 conducted on the stiffened temporary concrete barrier system with anchored ends was determined to be acceptable according to the TL-3 safety performance criteria of test designation no. 3-11 found in the currently proposed Update to NCHRP Report No. 350.



- Test Agency MwRSF
- Test Number NYTCB-3
- Date 8/30/07
- NCHRP 350 Update Test Designation 3-11
- Appurtenance Stiffened Temporary Concrete Barriers
- Total Length 60.96 m
- Barrier Offset 305 mm
- Key Elements - Barrier
 - Description New York TCB with Connection Keys
 - Length 6,096 mm
 - Base Width 610 mm
 - Height 810 mm
- Key Elements - Anchor Ends
 - Size 25 mm ASTM A36 rod
 - Length 394 mm
 - Number per Barrier 5 traffic-side, 4 back-side
- Key Elements - Box Beam Stiffener
 - Dimensions 152 mm x 203 mm x 6.4 mm
 - Length 3,658 mm
 - Connector Rod 19 mm diameter x 483 mm long Grade 5
- Type of Soil N/A
- Test Vehicle
 - Type/Designation 2270P
 - Make and Model 2003 Dodge Ram 1500 Quad Cab 4x2
 - Curb 2,303 kg
 - Test Inertial 2,268 kg
 - Gross Static 2,268 kg
- Impact Conditions
 - Speed 102.2 km/h
 - Angle 24.4 degrees
 - Impact Location 1,300 mm upstream from downstream end of barrier no. 4
- Exit Conditions
 - Speed 87.2 km/h
 - Angle 1.7 degrees
 - Exit Box Criterion Pass
- Post-Impact Trajectory
 - Vehicle Stability Satisfactory
 - Stopping Distance 57.69 m downstream
3.81 m laterally behind

- Occupant Impact Velocity (DTS)
 - Longitudinal 4.77 m/s < 12.2 m/s
 - Lateral 6.06 m/s < 12.2 m/s
- Occupant Ridedown Deceleration (DTS)
 - Longitudinal -7.15 g's < 20.49 g's
 - Lateral 6.64 g's < 20.49 g's
- Occupant Impact Velocity (EDR-3)
 - Longitudinal -5.32 m/s < 12.2 m/s
 - Lateral 6.86 m/s < 12.2 m/s
- Occupant Ridedown Deceleration (EDR-3)
 - Longitudinal -7.85 g's < 20.49 g's
 - Lateral 5.83 g's < 20.49 g's
- THIV (not required) 7.25 m/s
- PHD (not required) 7.93 g's
- Test Article Damage Moderate
- Test Article Deflections
 - Permanent Set 660 mm
 - Dynamic 784 mm
 - Working Width 1,304 mm
- Vehicle Damage Moderate
 - VDS¹³ 1-RFQ-3
 - CDC¹⁴ 1-RYEN2
 - Maximum Deformation 89 mm
- Angular Displacements
 - Roll -18.2 deg
 - Pitch 9.7 deg
 - Yaw -27.5 deg

Figure 70. Summary of Test Results and Sequential Photographs, Test NYTCB-3



0.000 sec



0.544 sec



0.042 sec



0.754 sec



0.142 sec



0.950 sec



0.236 sec



1.244 sec



0.398 sec



1.896 sec

Figure 71. Additional Sequential Photographs, Test NYTCB-3



0.000 sec



0.518 sec



0.056 sec



0.784 sec



0.128 sec



1.100 sec



0.252 sec



1.374 sec



0.398 sec



1.860 sec

Figure 72. Additional Sequential Photographs, Test NYTCB-3



0.000 sec



0.000 sec



0.118 sec



0.033 sec



0.198 sec



0.200 sec



0.258 sec



0.467 sec



0.362 sec



0.834 sec

Figure 73. Additional Sequential Photographs, Test NYTCB-3



Figure 74. Documentary Photographs, Test NYTCB-3



Figure 75. Documentary Photographs, Test NYTCB-3

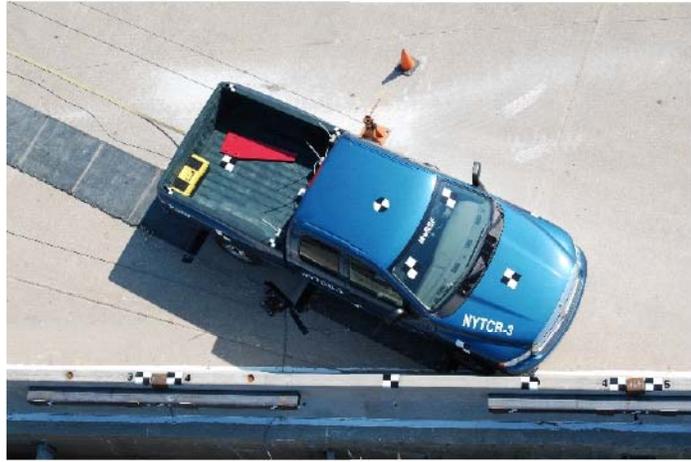


Figure 76. Impact Location, Test NYTCB-3



Figure 77. Vehicle Final Position and Trajectory Marks, Test NYTCB-3



Figure 78. Box Beam Stiffened Temporary Barrier Damage, Test NYTCB-3



Figure 79. Box Beam Stiffened Temporary Barrier Damage, Test NYTCB-3



Figure 80. Box Beam Stiffened Temporary Barrier Damage, Test NYTCB-3



Figure 81. Box Beam Stiffened Temporary Barrier Damage, Test NYTCB-3

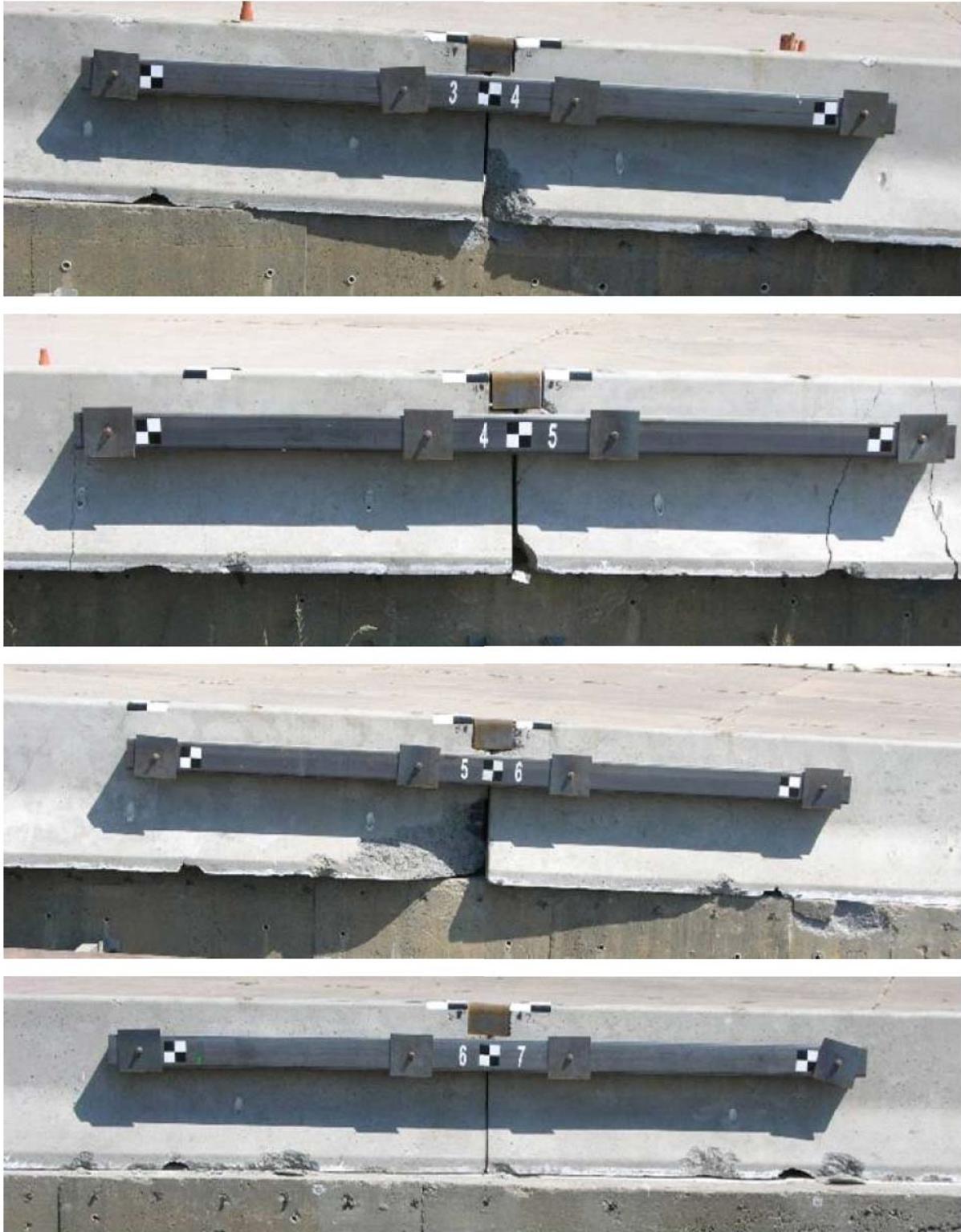


Figure 82. Joint Damage, Test NYTCB-3



Figure 83. Joint Connection Damage, Test NYTCB-3



Figure 84. Connector Rod Damage, Test NYTCB-3



Figure 85. Vehicle Damage, Test NYTCB-3

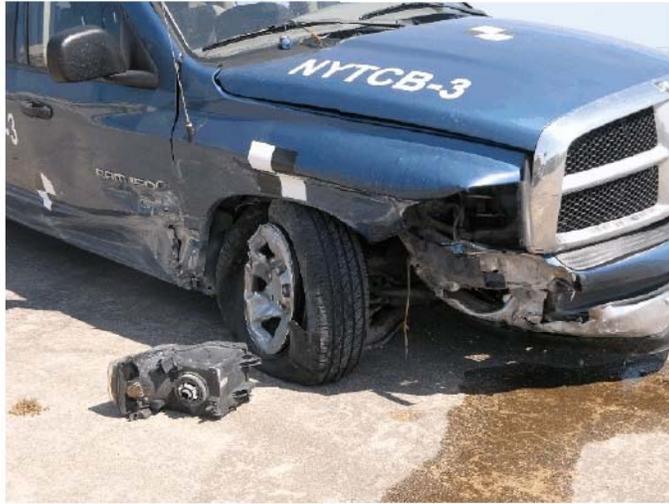


Figure 86. Additional Vehicle Damage, Test NYTCB-3



Figure 87. Occupant Compartment Deformation, Test NYTCB-3

11 SUMMARY, CONCLUSIONS, AND DISCUSSION

This study set out to evaluate the potential for reducing barrier deflections through the use of box beam stiffening on an acceptable NYSDOT TCB design. In addition, all safety performance evaluations were to be performed using the criteria found in the currently proposed Update to NCHRP Report No. 350. The systems were constructed with ten 6,096-mm (20-ft) long, temporary concrete barrier sections utilizing a connection key between the barrier sections and with the first and last sections anchored to the tarmac and subjected to full-scale vehicle crash testing. Three full-scale crash tests were performed on the various temporary barrier systems. A summary of the safety performance evaluation of each of the three tests is provided in Table 3.

The first full-scale crash test, test no. NYTCB-1, was performed on a stiffened version of the temporary concrete barrier system according to test designation 3-11 of the currently proposed Update to NCHRP Report No. 350. This system consisted of 3,658-mm (12-ft) long, box beam stiffeners spanning each joint between barrier nos. 4 and 7. The box beam sections were configured with 152-mm x 152-mm x 4.8-mm (6-in. x 6-in. x 0.1875-in.) steel tubes. The first and last barrier sections were anchored into the concrete. The test consisted of a 2,275-kg (5,016-lb) pickup truck impacting the barrier system at a speed of 99.5 km/h (61.9 mph) and at an angle of 24.6 degrees, resulting in an impact severity of 151.01 kJ (111.34 kip-ft). The impact point for this test was 1.3 m (4 ft - 3 3/16 in.) upstream from the downstream end of barrier no. 4. The maximum permanent set and dynamic deflections were 660 mm (26 in.) and 700 mm (27.6 in.), respectively. The test results were found to meet all of the currently proposed Update to NCHRP Report No. 350 safety requirements as the pickup truck was safely redirected and brought to a controlled stop.

The second full-scale crash test, test no. NYTCB-2, was performed on an unstiffened version of the temporary concrete barrier system according to test designation 3-11 of the currently proposed

Update to NCHRP Report No. 350. This system consisted of free-standing temporary concrete barriers with the first and last barrier sections anchored to the concrete. The test consisted of a 2,279-kg (5,024-lb) pickup truck impacting the barrier system at a speed of 98.5 km/h (61.2 mph) and at an angle of 25.8 degrees, resulting in an impact severity of 161.62 kJ (119.16 kip-ft). The impact point for this test was 1.3 m (4 ft - 3 3/16 in.) upstream from the downstream end of barrier no. 4. The maximum permanent set and dynamic deflections were 1,003 mm (39.5 in.) and 1,023 mm (40.3 in.), respectively. The test results were found to meet all of the currently proposed Update to NCHRP Report No. 350 safety requirements as the pickup truck was safely redirected and brought to a controlled stop.

The third full-scale crash test, test no. NYTCB-3, was performed on a stiffened version of the temporary concrete barrier system according to test designation 3-11 of the currently proposed Update to NCHRP Report No. 350. This system consisted of 3,658-mm (12-ft) long, box beam stiffeners spanning each joint between barrier nos. 2 and 8. The box beam sections were configured with 152-mm x 203-mm x 6.4-mm (6-in. x 8-in. x 0.25-in.) steel tubes. In addition, the system was installed with the back side of the barriers placed 305 mm (12 in.) from the edge of a bridge deck. The first and last barrier sections were anchored to the concrete. The test consisted of a 2,268-kg (5,001-lb) pickup truck impacting the barrier system at a speed of 102.2 km/h (63.5 mph) and at an angle of 24.4 degrees, resulting in an impact severity of 156.03 kJ (115.04 kip-ft). The impact point for this test was 1.3 m (4 ft - 3 3/16 in.) upstream from the downstream end of barrier no. 4. The maximum permanent set and dynamic deflections were 660 mm (26 in.) and 784 mm (30.9 in.), respectively. The test results were found to meet all of the currently proposed Update to NCHRP Report No. 350 safety requirements as the pickup truck was safely redirected and brought to a controlled stop.

Following a review of the test results, it was evident that all three crash tests were performed with approximately the same impact severity (I.S.) when considering the combined effect of vehicle mass, impact speed, and impact angle. In summary, the impact severities were 151.01 kJ (111.34 kip-ft), 161.62 kJ (119.16 kip-ft), and 156.03 kJ (115.04 kip-ft) for test nos. NYTCB-1, NYTCB-2, and NYTCB-3, respectively. The maximum dynamic deflections observed during test nos. NYTCB-1, NYTCB-2, and NYTCB-3 were 700 mm (27.6 in.), 1,023 mm (40.3 in.), and 784 mm (30.9 in.), respectively.

Upon examination of the I.S. values and maximum dynamic deflections, it was evident that the box beam stiffening system was effective in reducing barrier deflections. In general, the box beam system reduced dynamic deflections from 23 to 32 percent over those observed for the non-stiffened TCB. Two sizes of box beam rails were evaluated. Unfortunately, the two rail sizes were implemented in tests that were not directly comparable. The smaller tube size was installed on a barrier system supported by a wide concrete foundation (test no. NYTCB-1), while the larger tube size was installed on a barrier system adjacent to a vertical drop off (test no. NYTCB-3). Even though larger barrier deflections were observed in test no. NYTCB-3 as compared to NYTCB-1, the larger tube size likely contributed to reduced barrier deflections, especially since several barrier sections had lost partial contact with the concrete foundation as their bases had moved past the deck edge.

As noted previously, the free-standing temporary concrete barrier system, with end sections pinned on each end, was impacted in test no. NYTCB-2 and resulted in permanent set and dynamic deflections of 1,003 mm (39.5 in.) and 1,023 mm (40.3 in.), respectively. On the contrary, TTI test no. 473220-14 was performed on a similar barrier system, but without the end sections pinned, thus resulting in permanent set and dynamic deflections of 1,270 mm (50.0 in.) and 1,270 mm (50.0 in.),

respectively. The impact severities for test nos. NYTCB-2 and 473220-14 were 161.62 kJ (119.16 kip-ft) and 151.83 kJ (111.94 kip-ft). Since test no. NYTCB-2 was slightly more severe than test no. 473220-14, it was clear that pinning the end barrier sections decreased deflections by nearly 20 percent.

At this time, it is not believed to be highly beneficial to use stronger stiffening elements than those used in test no. NYTCB-3 and placed across the joints of the barrier sections. This opinion is based upon the fact that significant flexibility remains within the barrier section itself. It should be noted that the barrier performed well but was likely near its ultimate strength as significant cracking and bending was observed in several barrier sections. If desirable, modest increases in steel reinforcement could reduce damage and barrier flexing during extreme impact events. At the ends of several barrier sections and in all tests, the toe regions of the sections fractured with significant loss of concrete, thus reducing the moment capacity of the joints under loading and during barrier translation and rotation. If the toe regions were to have remained intact during the impact event, lower deformations to the box beam rails would likely have resulted. Once again, modest increases in steel reinforcement at the section ends and in the toes should provide increased moment capacity at the joints, thus resulting in an increased propensity for further reducing barrier deflections.

If additional steel reinforcement is implemented in the barrier sections, there would likely be greater benefit from implementing the larger box sections to stiffen the barrier system.

Table 3. Summary of Safety Performance Evaluation Results

Evaluation Factors	Evaluation Criteria	Test NYTCB-1	Test NYTCB-2	Test NYTCB-3
Structural Adequacy	A. Test article should contain and redirect the vehicle or bring the vehicle to a controlled stop; the vehicle should not penetrate, underride, or override the installation although controlled lateral deflection of the test article is acceptable.	S	S	S
Occupant Risk	D. Detached elements, fragments or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present an undue hazard to other traffic, pedestrians, or personnel in a work zone. Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.3 and Appendix E of the currently proposed Update to NCHRP Report No. 350.	S	S	S
	F. The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.	S	S	S
	H. Longitudinal and lateral occupant impact velocities should fall below the preferred value of 9.1 m/s (30.0 ft/s), or at least below the maximum allowable value of 12.2 m/s (40.0 ft/s).	S	S	S
	I. Longitudinal and lateral occupant ridedown accelerations should fall below the preferred value of 15.0 g's, or at least below the maximum allowable value of 20.49 g's.	S	S	S
Vehicle Trajectory	M. After impact, the vehicle shall exit the barrier within the exit box.	S	S	S

S - Satisfactory
 U - Unsatisfactory
 NA - Not Available

12 RECOMMENDATIONS

Stiffened and unstiffened versions of the New York State DOT's temporary concrete barrier system with anchored ends, as described in this report, were successfully crash tested according to the criteria found in the currently proposed Update to NCHRP Report No. 350. The test results indicate that these designs are suitable for use on Federal-aid highways. However, any significant modifications made to the stiffened and unstiffened designs would require additional analysis and can only be verified through the use of full-scale crash testing.

The second stiffened system was tested with a clear gap of 305 mm (12 in.) between the back side of the barriers and the bridge deck edge. As observed in test no. NYTCB-3, the center of gravity of one barrier section was shoved beyond the edge of the bridge deck. However, its connection to the other sections prevented it from falling off. Thus, the stiffened versions of New York State's temporary concrete barrier system are recommended for use over the normal range of accidents involving vehicles of 2,268 kg (5,000 lbs) or less. In addition, the stiffened TCB can be placed with a 305 mm (12 in.) gap between the bridge deck edge and the back side of the barrier sections.

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14 APPENDICES

APPENDIX A

English-Unit System Drawings, Test NYTCB-1

Figure A-1. Stiffened Temporary Concrete Barrier System Layout (English), Test NYTCB-1

Figure A-2. Temporary Concrete Barrier Details (English), Test NYTCB-1

Figure A-3. Temporary Concrete Barrier Reinforcement Details (English), Test NYTCB-1

Figure A-4. Bill of Bars (English), Test NYTCB-1

Figure A-5. Temporary Concrete Barrier Connection Details (English), Test NYTCB-1

Figure A-6. Connection Key Assembly Details (English), Test NYTCB-1

Figure A-7. Connection Key Assembly Details (English), Test NYTCB-1

Figure A-8. Temporary Concrete Barrier Connector Assembly Details (English), Test NYTCB-1

Figure A-9. Box Beam Stiffener Details (English), Test NYTCB-1

Figure A-10. Temporary Concrete Barrier Stiffener Hole Details (English), Test NYTCB-1

Figure A-11. Box Beam Stiffener Details (English), Test NYTCB-1

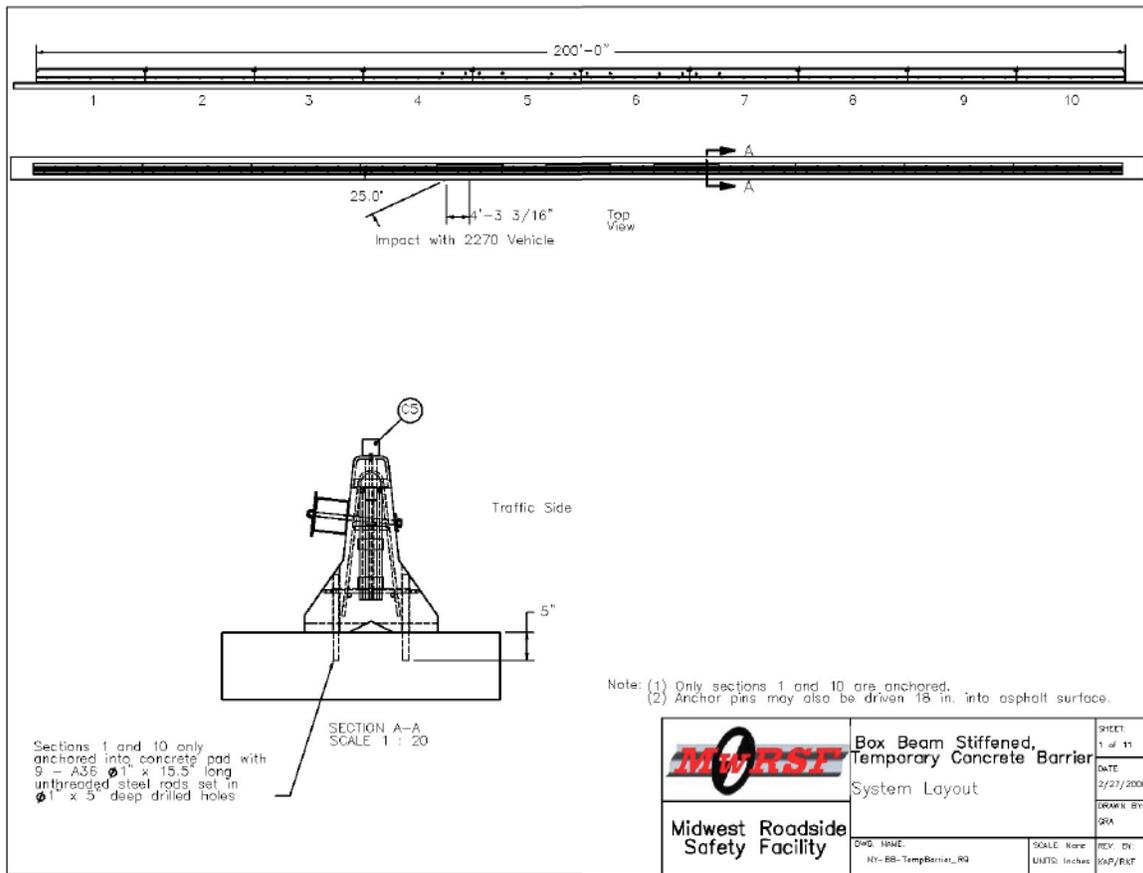


Figure A-1. Stiffened Temporary Concrete Barrier System Layout (English), Test NYTCB-1

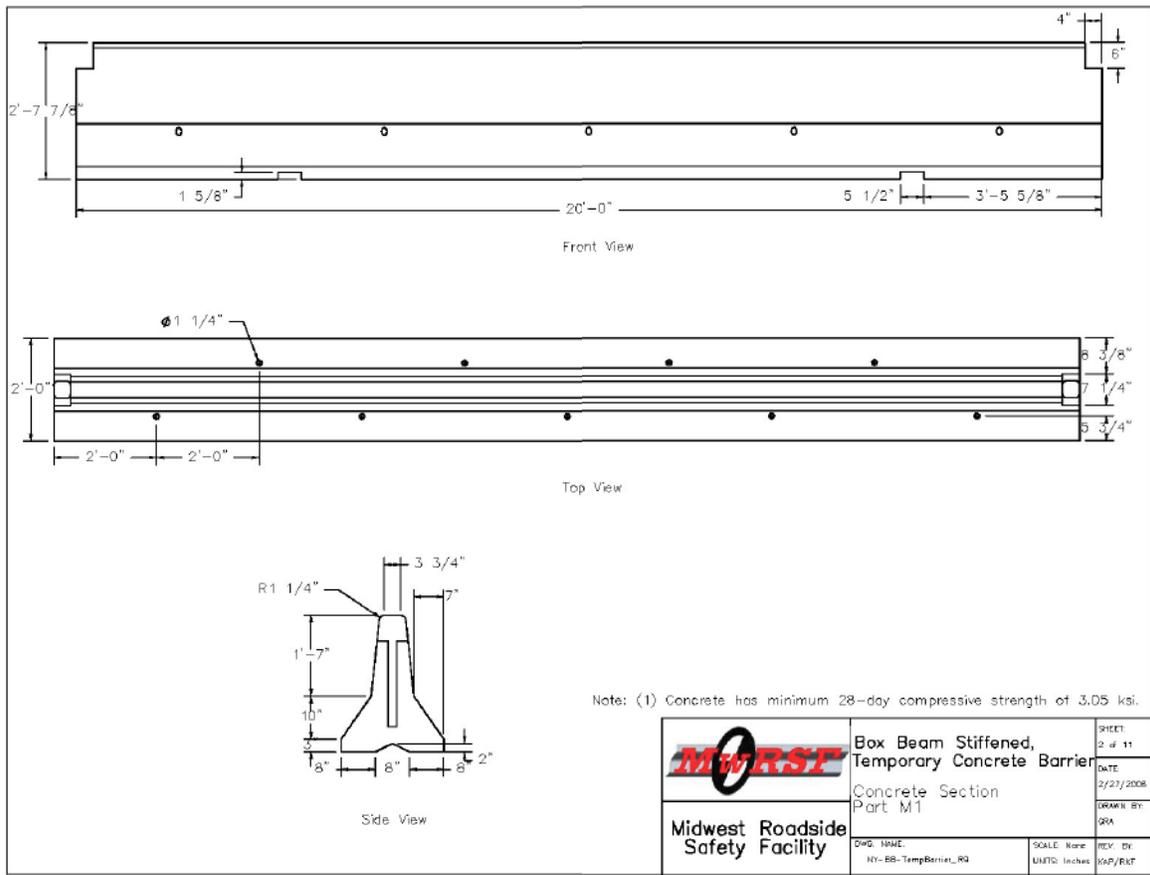


Figure A-2. Temporary Concrete Barrier Details (English), Test NYTCB-1

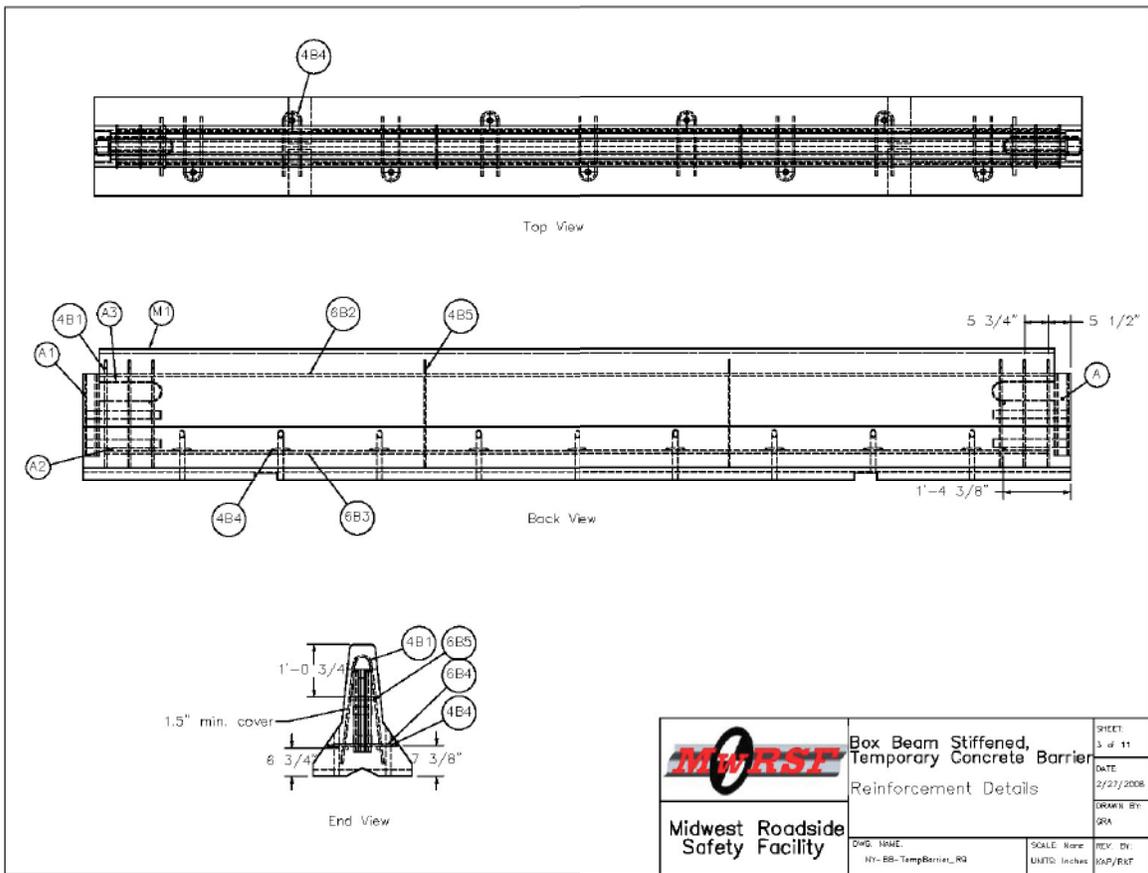


Figure A-3. Temporary Concrete Barrier Reinforcement Details (English), Test NYTCB-1

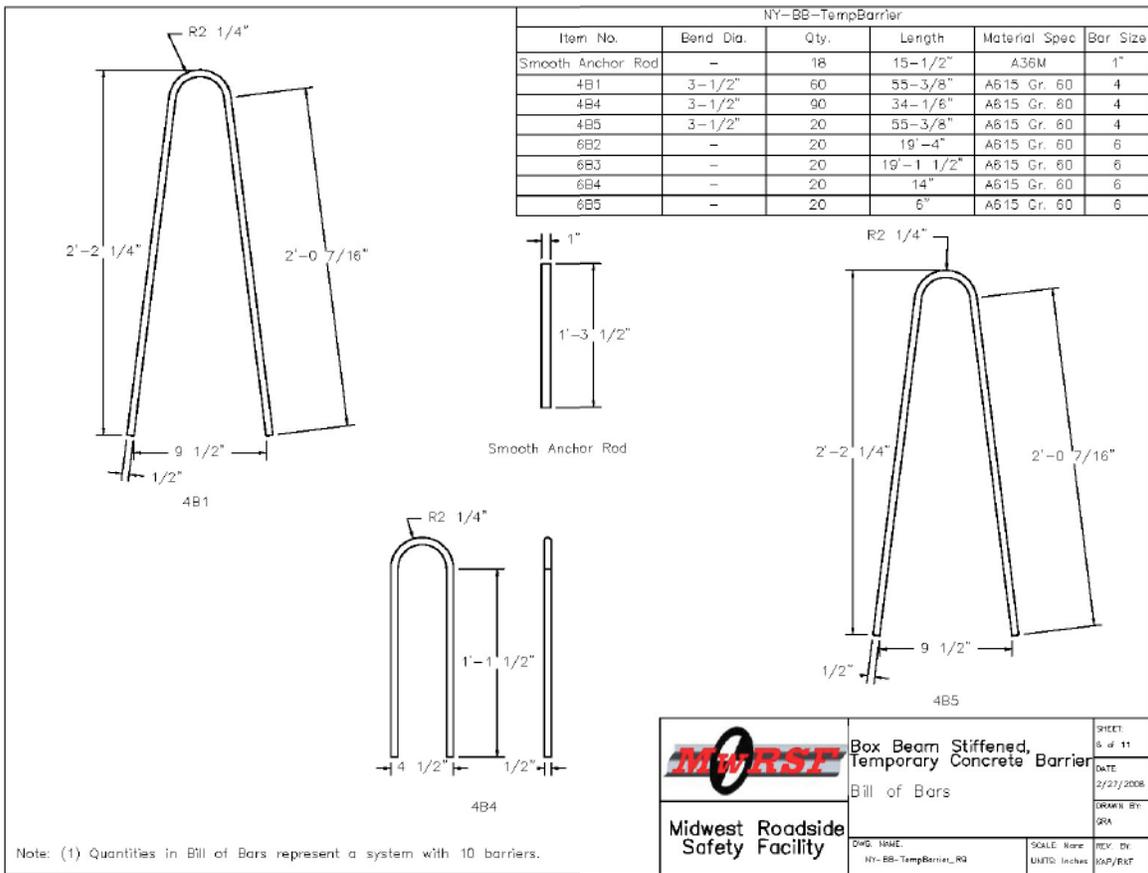


Figure A-4. Bill of Bars (English), Test NYTCB-1

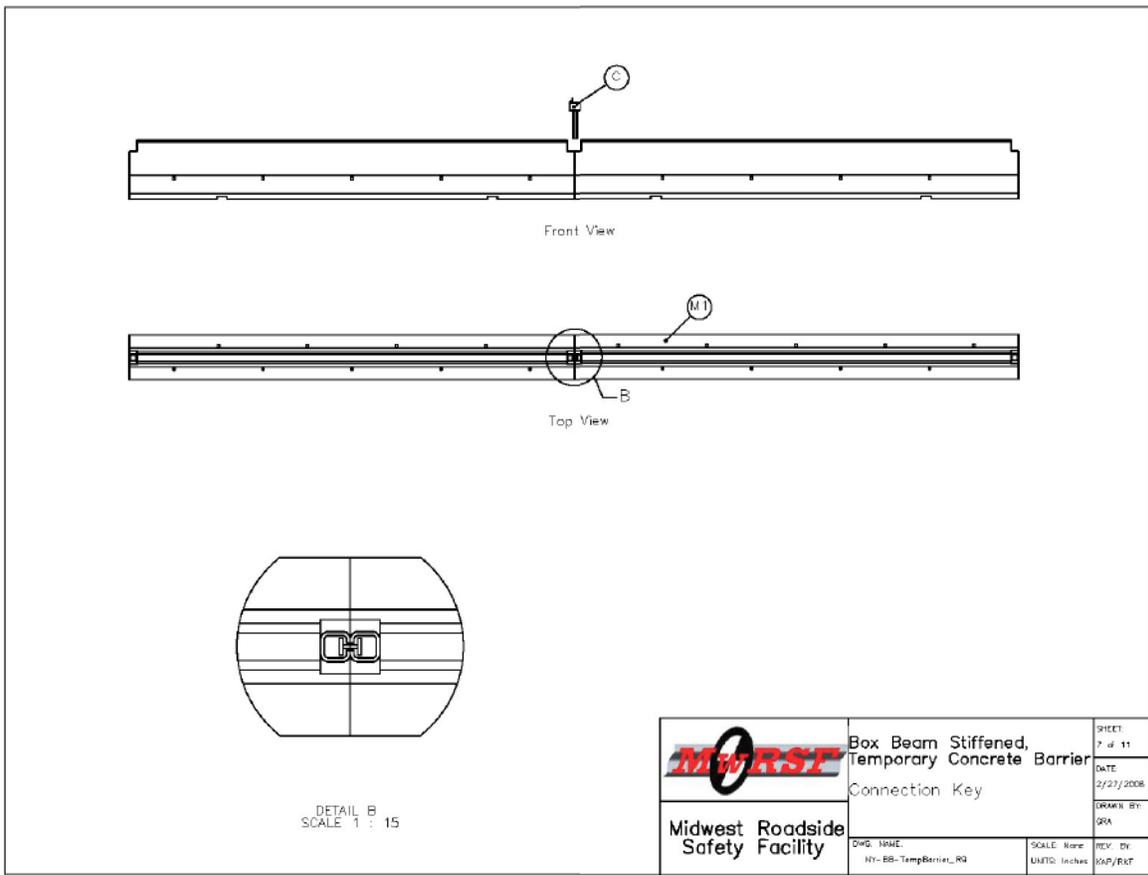
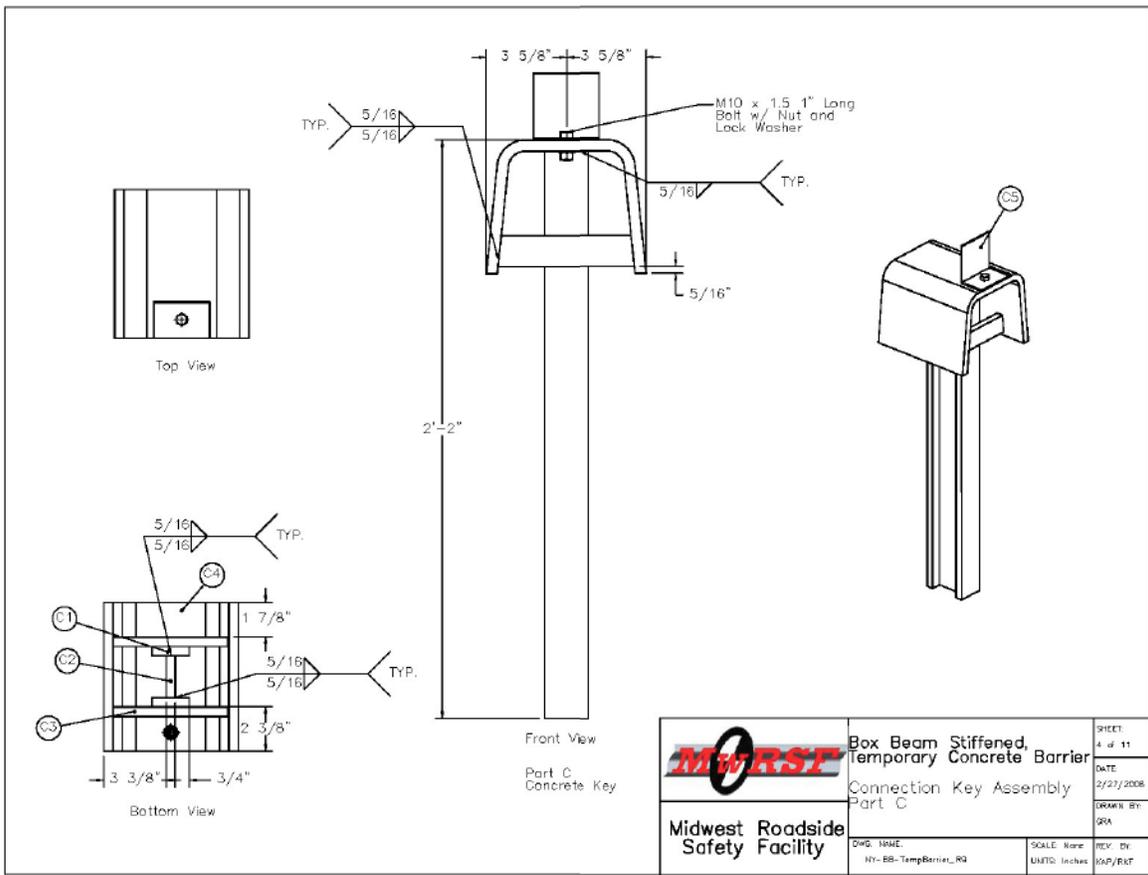


Figure A-5. Temporary Concrete Barrier Connection Details (English), Test NYTCB-1



	Box Beam Stiffened, Temporary Concrete Barrier	SHEET: 4 of 11
	Connection Key Assembly Part C	DATE: 2/27/2008
Midwest Roadside Safety Facility	DWG. NAME: NY-BB-TempBarrier_R3	DRAWN BY: GSA
	SCALE: None UNITS: Inches	REV. BY: GSA/BKT

Figure A-6. Connection Key Assembly Details (English), Test NYTCB-1

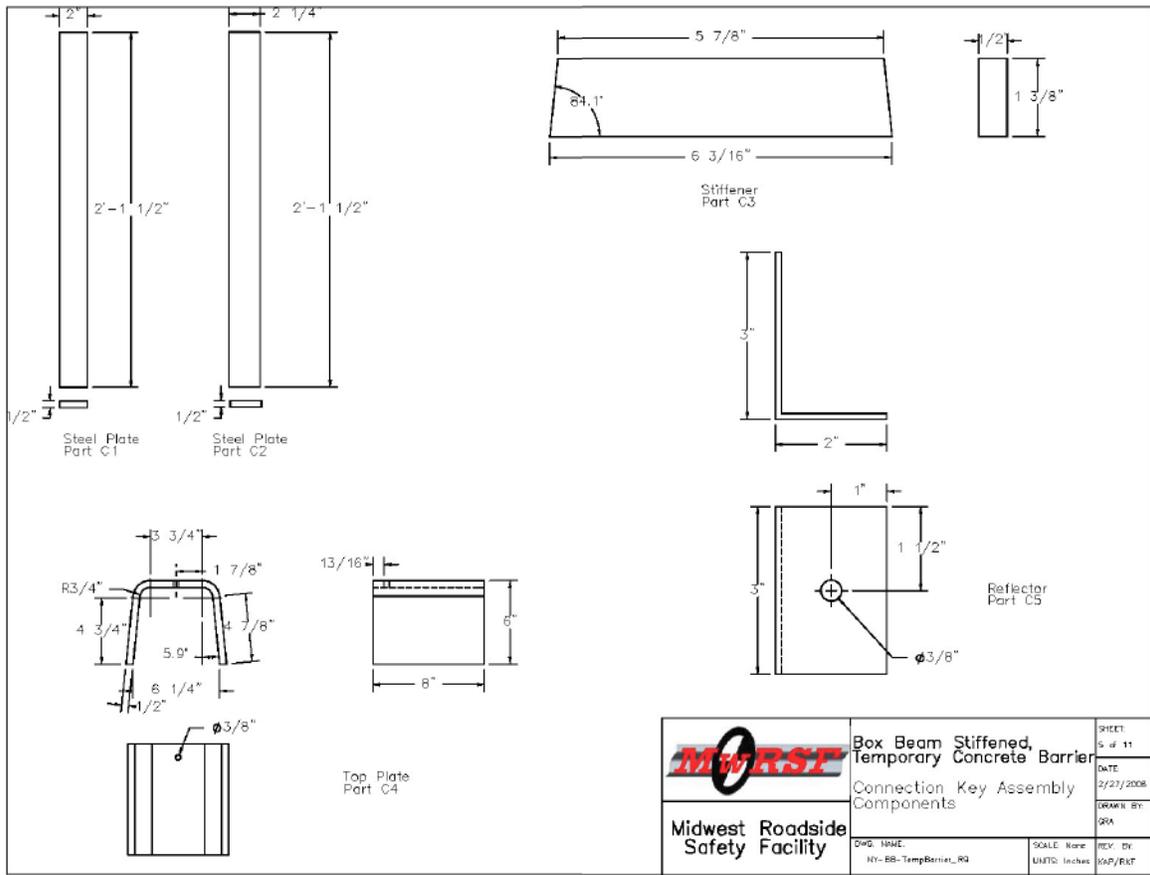


Figure A-7. Connection Key Assembly Details (English), NYTCB-1

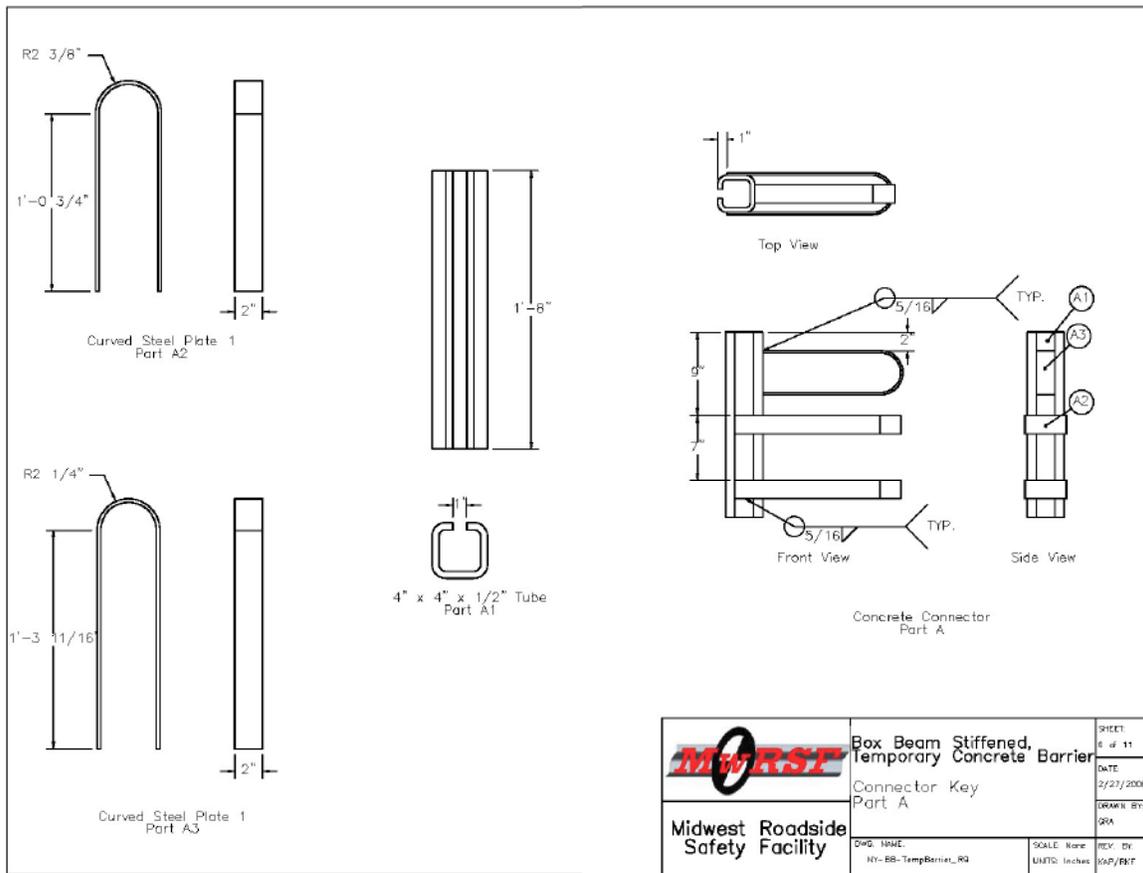


Figure A-8. Temporary Concrete Barrier Connector Assembly Details (English), Test NYTCB-1

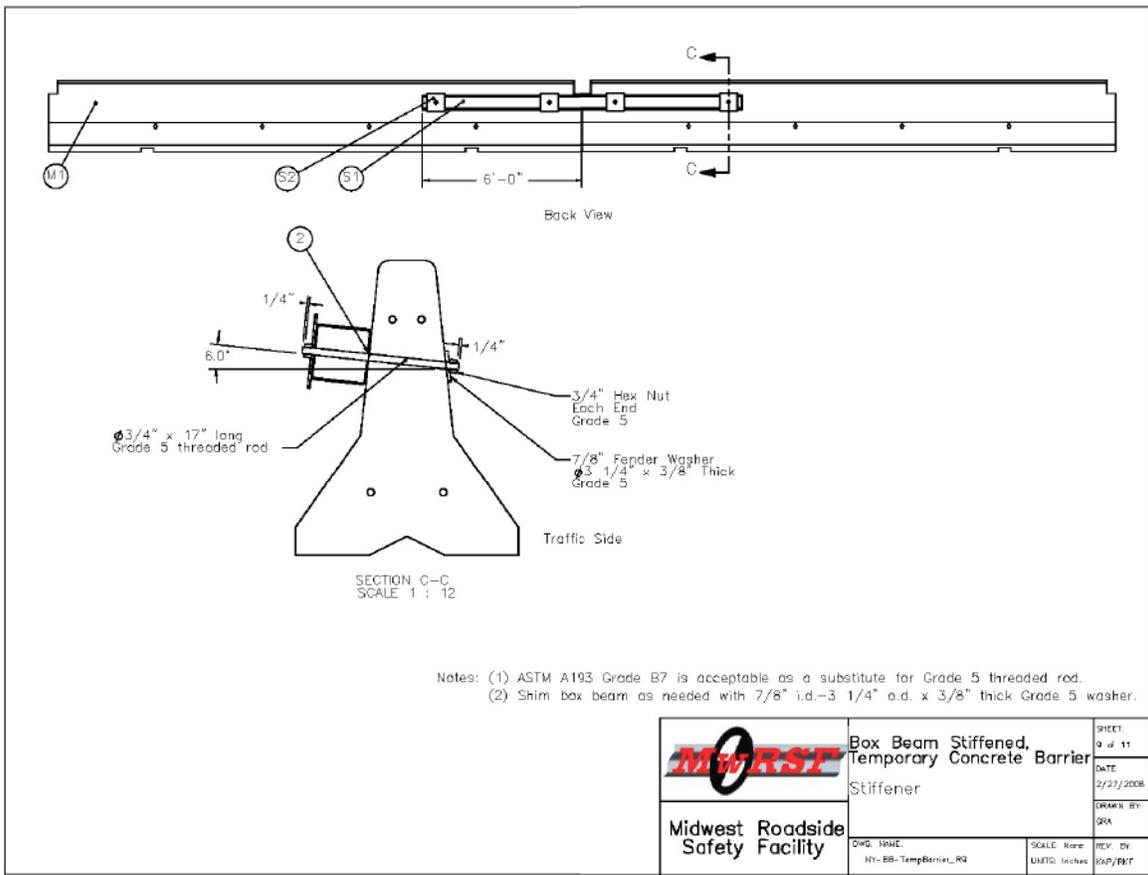


Figure A-9. Box Beam Stiffener Details (English), Test NYTCB-1

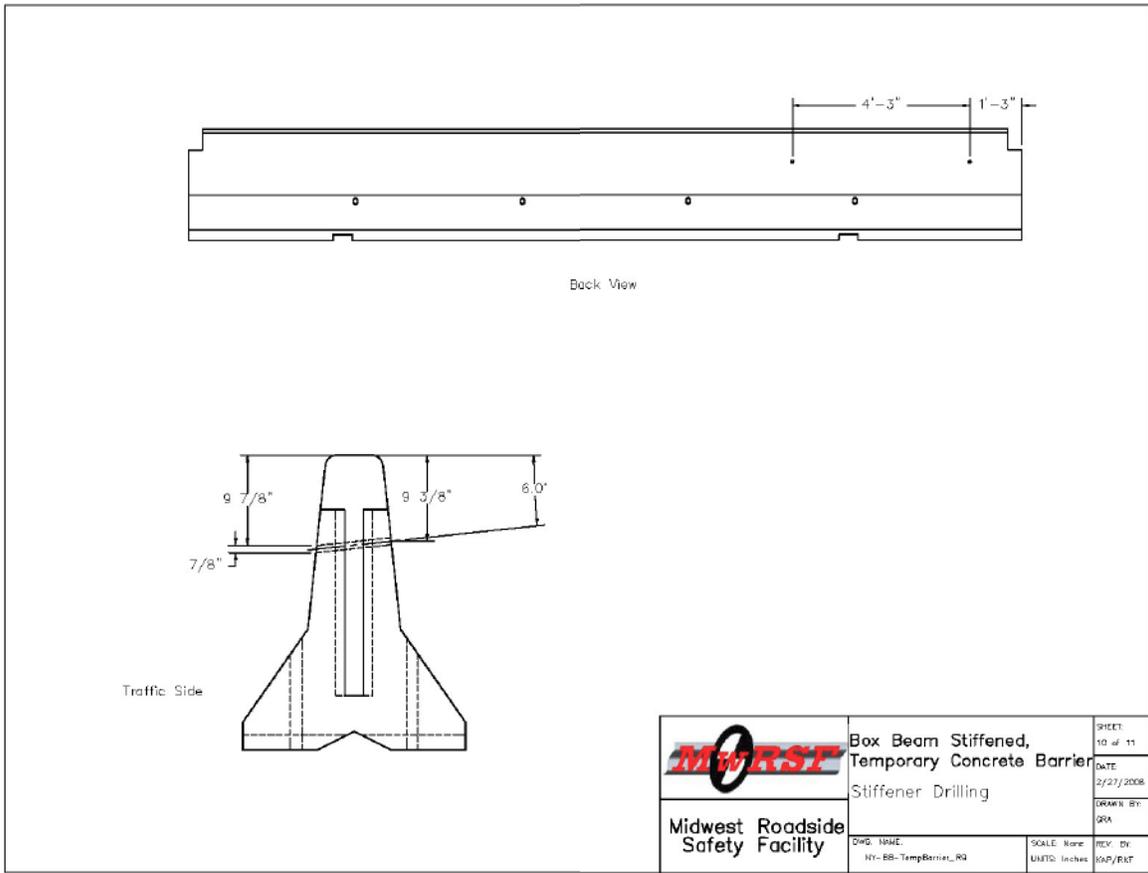


Figure A-10. Temporary Concrete Barrier Stiffener Hole Details (English), Test NYTCB-1

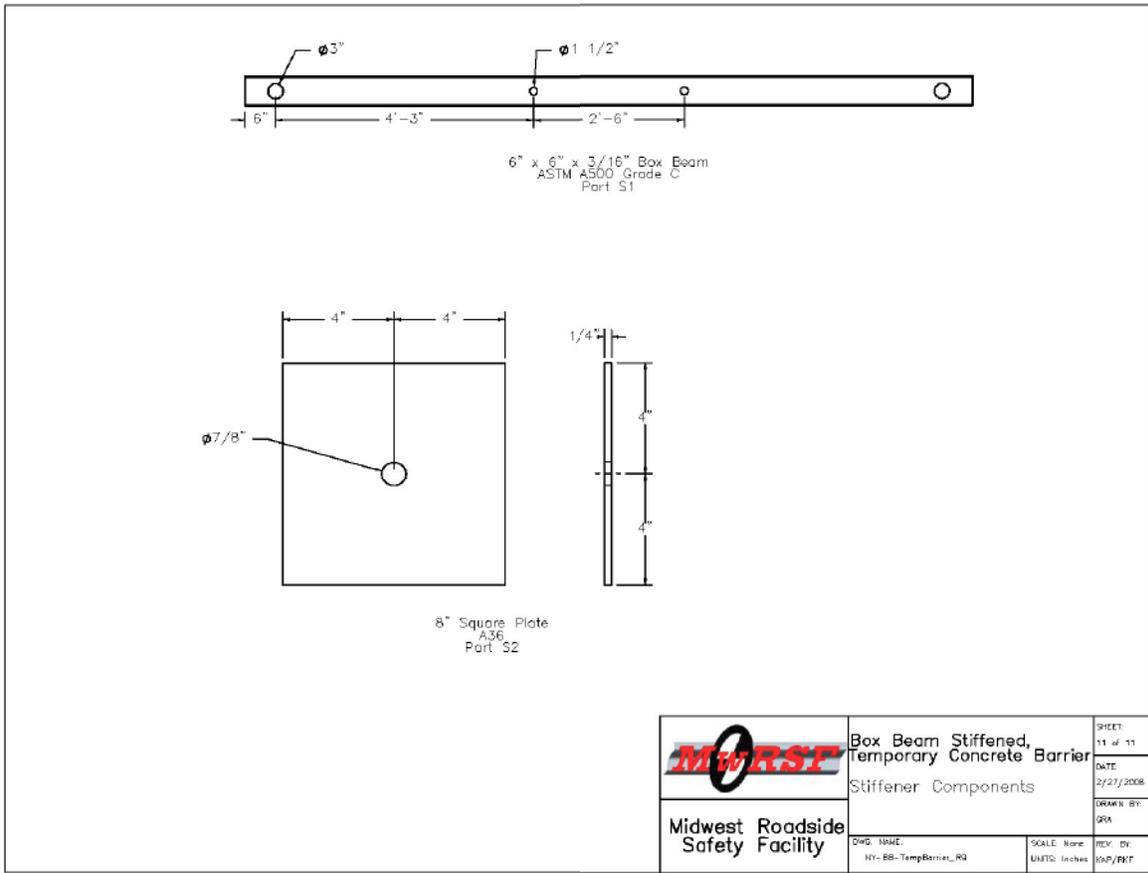


Figure A-11. Box Beam Stiffener Details (English), Test NYTCB-1

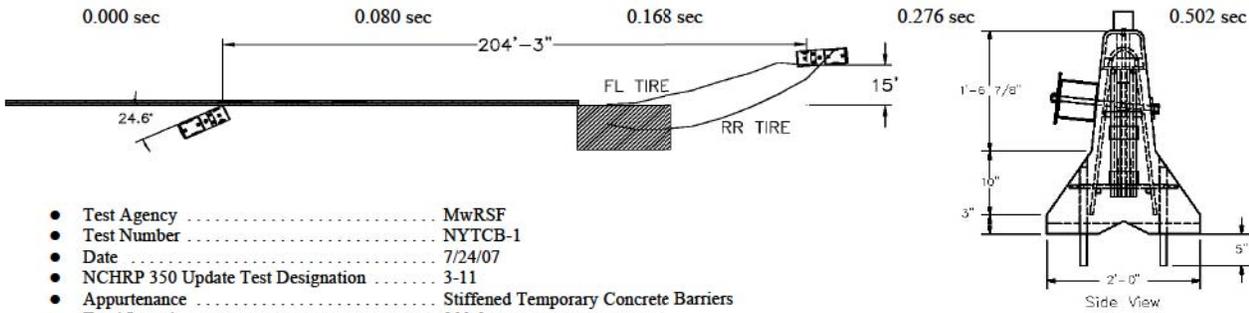
APPENDIX B

Test Summary Sheets in English Units

Figure B-1. Summary of Test Results and Sequential Photographs (English), Test NYTCB-1

Figure B-2. Summary of Test Results and Sequential Photographs (English), Test NYTCB-2

Figure B-3. Summary of Test Results and Sequential Photographs (English), Test NYTCB-3



- Test Agency MwRSF
- Test Number NYTCB-1
- Date 7/24/07
- NCHRP 350 Update Test Designation 3-11
- Appurtenance Stiffened Temporary Concrete Barriers
- Total Length 200 ft
- Key Elements - Barrier
 - Description New York TCB with Connection Keys
 - Length 20 ft
 - Base Width 24 in.
 - Height 32 in.
- Key Elements - Anchor Ends
 - Size 1 in. diameter ASTM A36 rod
 - Length 15.5 in.
 - Number per Barrier 5 traffic-side, 4 back-side
- Key Elements - Box Beam Stiffener
 - Size 6 in. x 6 in. x 0.1875 in.
 - Length 144 in.
 - Connector Rod 0.75 in. diameter x 17 in. long Grade 5
 - Plate Washer 8 in. x 8 in. x 0.5 in.
- Type of Soil N/A
- Test Vehicle
 - Type/Designation 2270P
 - Make and Model 2002 Dodge Ram 1500 Quad Cab 4x2
 - Curb 5,074 lbs
 - Test Inertial 5,016 lbs
 - Gross Static 5,016 lbs
- Impact Conditions
 - Speed 99.5 km/h
 - Angle 24.6 degrees
 - Impact Location 51.1875 in. upstream from downstream end of barrier 4
- Exit Conditions
 - Speed 39.1 mph
 - Angle 7 deg
 - Exit Box Criterion Pass
- Post-Impact Trajectory
 - Vehicle Stability Satisfactory
 - Stopping Distance 204.4 ft downstream
15.1 ft laterally behind
- Occupant Impact Velocity
 - Longitudinal -15.32 ft/s < 40 ft/s
 - Lateral 20.77 ft/s < 40 ft/s
- Occupant Ridedown Deceleration
 - Longitudinal 4.72 g's < 20.49 g's
 - Lateral 8.36 g's < 20.49 g's
- THIV (not required) 24.44 ft/s
- PHD (not required) 8.71 g's
- Test Article Damage Moderate
- Test Article Deflections
 - Permanent Set 26.0 in.
 - Dynamic 27.6 in.
 - Working Width 51.6 in.
- Vehicle Damage Moderate
 - VDS¹³ 11-LFQ-3
 - CDC¹⁴ 11-LYEN2
 - Maximum Deformation 1.5 in.
- Angular Displacements
 - Roll -10.5 deg
 - Pitch -11.4 deg
 - Yaw 28.0 deg

Figure B-1. Summary of Test Results and Sequential Photographs (English), Test NYTCB-1



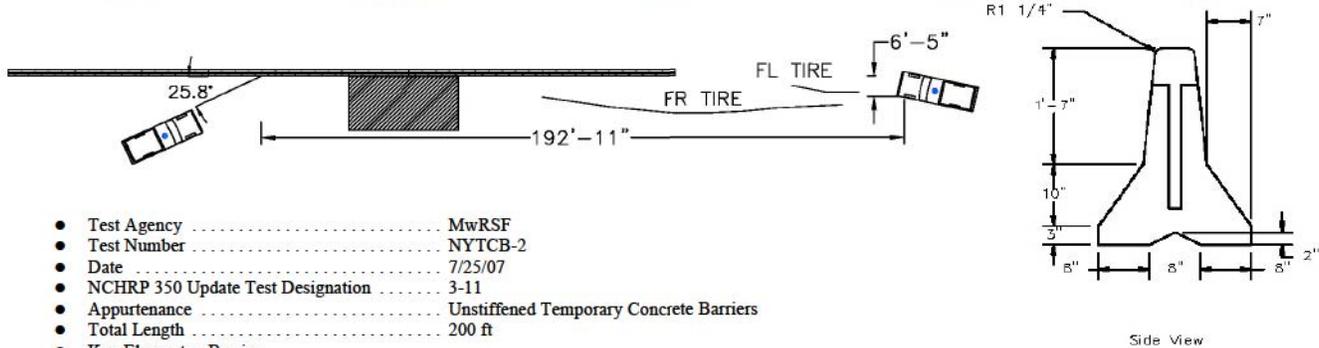
0.000 sec

0.054 sec

0.184 sec

0.358 sec

0.676 sec

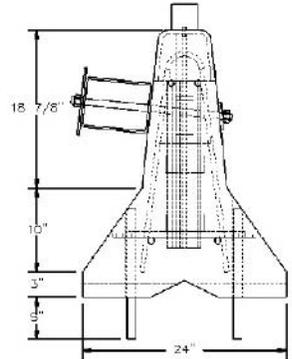
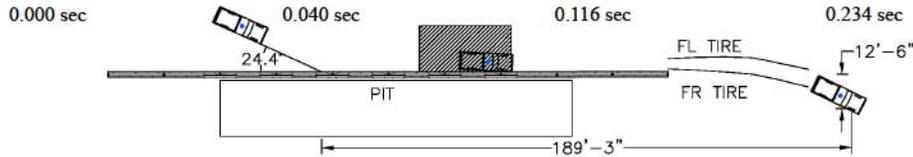


- Test Agency MwRSF
- Test Number NYTCB-2
- Date 7/25/07
- NCHRP 350 Update Test Designation 3-11
- Appurtenance Unstiffened Temporary Concrete Barriers
- Total Length 200 ft
- Key Elements - Barrier
 - Description New York TCB with Connection Keys
 - Length 20 ft
 - Base Width 24 in.
 - Height 32 in.
- Key Elements - Anchor Ends
 - Size 1 in. diameter ASTM A36 rod
 - Length 15.5 in.
 - Number per Barrier 5 traffic-side, 4 back-side
- Type of Soil N/A
- Test Vehicle
 - Type/Designation 2270P
 - Make and Model 2002 Dodge Ram 1500 Quad Cab 4x2
 - Curb 4,949 lbs
 - Test Inertial 5,024 lbs
 - Gross Static 5,024 lbs
- Impact Conditions
 - Speed 61.2 mph
 - Angle 25.8 degrees
 - Impact Location 4 ft - 3.1875 in. upstream from downstream end of barrier 4
- Exit Conditions
 - Speed 45.3 mph
 - Angle 4.7 degrees
 - Exit Box Criterion Pass

- Post-Impact Trajectory
 - Vehicle Stability Satisfactory
 - Stopping Distance 94.5 ft downstream
6.4 ft laterally away
- Occupant Impact Velocity
 - Longitudinal -15.87 ft/s < 40 ft/s
 - Lateral 20.73 ft/s < 40 ft/s
- Occupant Ridedown Deceleration
 - Longitudinal -5.44 g's < 20.49 g's
 - Lateral 8.09 g's < 20.49 g's
- THIV (not required) 24.89 ft/s
- PHD (not required) 8.19 g's
- Test Article Damage Moderate
- Test Article Deflections
 - Permanent Set 39.5 in.
 - Dynamic 40.3 in.
 - Working Width 64.2 in.
- Vehicle Damage Moderate
 - VDS¹³ 11-LFQ-3
 - CDC¹⁴ 11-LYEN4
 - Maximum Deformation 3 in.
- Angular Displacements
 - Roll -12.4 deg
 - Pitch -10.6 deg
 - Yaw 43.1 deg

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Figure B-2. Summary of Test Results and Sequential Photographs (English), Test NYTCB-2



SIDE VIEW

- Test Agency MwRSF
- Test Number NYTCB-3
- Date 8/30/07
- NCHRP 350 Update Test Designation 3-11
- Appurtenance Stiffened Temporary Concrete Barriers
- Total Length 200 ft
- Barrier Offset 12 in.
- Key Elements - Barrier
 - Description New York TCB with Connection Keys
 - Length 20 ft
 - Base Width 24 in.
 - Height 32 in.
- Key Elements - Anchor Ends
 - Size 1 in. diameter ASTM A36 rod
 - Length 15.5 in.
 - Number per Barrier 5 traffic-side, 4 back-side
- Key Elements - Box Beam Stiffener
 - Dimensions 6 in. x 8 in. x 0.25 in.
 - Length 144 in.
 - Connector Rod 0.75 in. diameter x 19 in. long Grade 5
- Type of Soil N/A
- Test Vehicle
 - Type/Designation 2270P
 - Make and Model 2003 Dodge Ram 1500 Quad Cab 4x2
 - Curb 5,078 lbs
 - Test Inertial 5,001 lbs
 - Gross Static 5,001 lbs
- Impact Conditions
 - Speed 63.5 mph
 - Angle 24.4 degrees
 - Impact Location 4 ft - 3.1875 in. upstream from downstream end of barrier no. 4
- Exit Conditions
 - Speed 54.2 mph
 - Angle 1.7 degrees
 - Exit Box Criterion Pass
- Post-Impact Trajectory
 - Vehicle Stability Satisfactory
 - Stopping Distance 189 ft - 3 in. downstream
12 ft - 6 in. laterally behind

- Occupant Impact Velocity (DTS)
 - Longitudinal -15.64 ft/s < 40 ft/s
 - Lateral 19.88 ft/s < 40 ft/s
- Occupant Ridedown Deceleration (DTS)
 - Longitudinal -7.15 g's < 20.49 g's
 - Lateral 6.64 g's < 20.49 g's
- Occupant Impact Velocity (EDR-3)
 - Longitudinal -17.44 ft/s < 40 ft/s
 - Lateral 22.50 ft/s < 40 ft/s
- Occupant Ridedown Deceleration (EDR-3)
 - Longitudinal -7.85 g's < 20.49 g's
 - Lateral 5.83 g's < 20.49 g's
- THIV (not required) 23.77 ft/s
- PHD (not required) 7.93 g's
- Test Article Damage Moderate
- Test Article Deflections
 - Permanent Set 26 in.
 - Dynamic 30.9 in.
 - Working Width 51.3 in.
- Vehicle Damage Moderate
 - VDS¹³ 1-RFQ-3
 - CDC¹⁴ 1-RVEN2
 - Maximum Deformation 3.5 in.
- Angular Displacements
 - Roll -18.2 deg
 - Pitch 9.7 deg
 - Yaw -27.5 deg

Figure B-3. Summary of Test Results and Sequential Photographs (English), Test NYTCB-3

APPENDIX C

Occupant Compartment Deformation Data

Figure C-1. Occupant Compartment Deformation Data Set 1, Test NYTCB-1

Figure C-2. Occupant Compartment Deformation Data Set 2, Test NYTCB-1

Figure C-3. Occupant Compartment Deformation Index (OCDI), Test NYTCB-1

Figure C-4. Occupant Compartment Deformation Data Set 1, Test NYTCB-2

Figure C-5. Occupant Compartment Deformation Data Set 2, Test NYTCB-2

Figure C-6. Occupant Compartment Deformation Index (OCDI), Test NYTCB-2

Figure C-7. Occupant Compartment Crush Data, Test NYTCB-3

VEHICLE PRE/POST CRUSH INFO
Set-1

TEST: NYTCB-1
VEHICLE: 2002 Dodge Ram 1500

POINT	X	Y	Z	X'	Y'	Z'	DEL X	DEL Y	DEL Z
1	29.25	-29	-1.5	28.5	-27.5	-1	-0.75	1.5	0.5
2	32.5	-19	-3.25	32	-18.25	-2.5	-0.5	0.75	0.75
3	30	-13	-1	30.25	-12.25	-1	0.25	0.75	0
4	28.25	-9.75	0	28	-9	0	-0.25	0.75	0
5	26.5	-29	-5.25	26.25	-28.5	-5.25	-0.25	0.5	0
6	27.5	-22	-5.75	27.5	-21.5	-5.5	0	0.5	0.25
7	27.75	-16	-5.5	27.75	-15	-5.25	0	1	0.25
8	25	-8.5	-2.75	25	-8.25	-2.75	0	0.25	0
9	23	-29.25	-8.25	23	-29	-8.25	0	0.25	0
10	22.75	-23.25	-8	22.75	-23.25	-7.5	0	0	0.5
11	22.75	-16.5	-8	22.75	-16.5	-7.75	0	0	0.25
12	21.5	-9	-3.75	21.5	-8.5	-3.75	0	0.5	0
13	18.25	-31	-10.5	18.5	-30.75	-10.5	0.25	0.25	0
14	18.5	-21.25	-9.75	18.5	-21.25	-9.5	0	0	0.25
15	19	-10.5	-8.5	18.75	-10	-8.25	-0.25	0.5	0.25
16	15	-4	-1.75	15	-4	-1.75	0	0	0
17	13.5	-30.75	-10.25	13.5	-30.75	-10.5	0	0	-0.25
18	14	-22	-9.5	14	-22	-9.25	0	0	0.25
19	14.25	-11.25	-9.25	14.25	-11	-9.25	0	0.25	0
20	11.5	-3.25	-2	11.5	-3.25	-2	0	0	0
21	6.75	-30.5	-9.75	6.75	-30.5	-9.75	0	0	0
22	8	-21	-9.25	8	-20.75	-9.25	0	0.25	0
23	7.5	-10.25	-8.25	7.5	-10.25	-8.25	0	0	0
24	7	-1.5	-1.75	6.75	-1.5	-2	-0.25	0	-0.25
25	0.75	-28.5	-5.75	0.75	-28.5	-5.75	0	0	0
26	0.5	-21.25	-5	0.5	-21.25	-5.25	0	0	-0.25
27	0.5	-12.5	-4.75	0.5	-12.25	-5	0	0.25	-0.25
28	0.5	-2.75	-1.5	0.5	-2.75	-1.75	0	0	-0.25
29							0	0	0
30							0	0	0
31							0	0	0
32							0	0	0
33							0	0	0
34							0	0	0
35							0	0	0

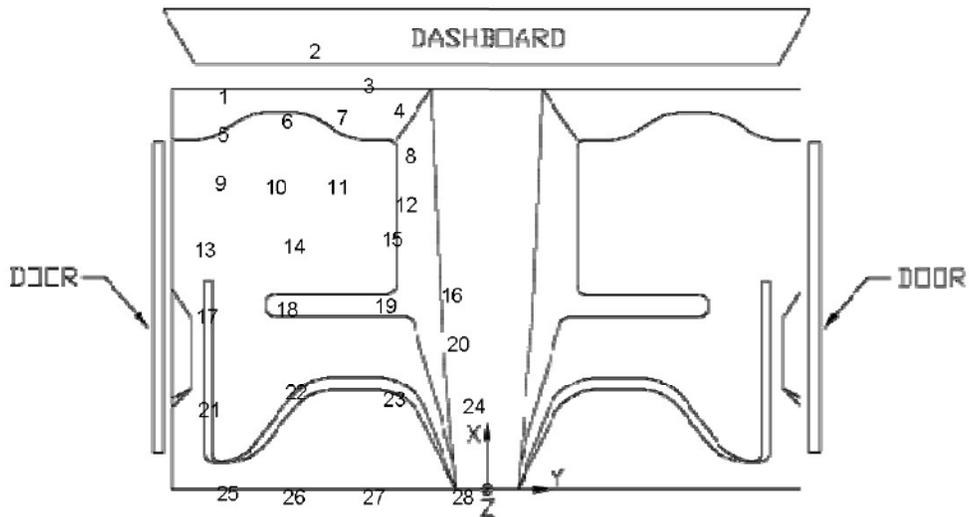


Figure C-4. Occupant Compartment Deformation Data Set 1, Test NYTCB-1

VEHICLE PRE/POST CRUSH INFO
Set-2

TEST: NYTCB-1
VEHICLE: 2002 Dodge Ram 1500

POINT	X	Y	Z	X'	Y'	Z'	DEL X	DEL Y	DEL Z
1	52.75	-26	-0.75	52	-24.5	0.25	-0.75	1.5	1
2	55	-18	-3.5	55.5	-15.25	-2.25	-0.5	0.75	1.25
3	53.5	-10	-1.5	53.75	-9.25	-1.25	0.25	0.75	0.25
4	51.75	-6.75	-1	51.5	-6	-0.75	-0.25	0.75	0.25
5	50	-26	-4.25	49.75	-26.5	-4	-0.25	0.5	0.25
6	51	-19	-5.75	51	-18.5	-4.75	0	0.5	1
7	51.25	-13	-6	51.25	-12	-5.5	0	1	0.5
8	48.5	-5.5	-3.75	48.5	-5.25	-3.5	0	0.25	0.25
9	46.5	-26.25	-7	46.5	-26	-7	0	0.25	0
10	46.25	-20.25	-7.5	46.25	-20.25	-7	0	0	0.5
11	46.25	-13.5	-6	46.25	-13.5	-7.75	0	0	0.25
12	45	-6	-4.75	45	-5.5	-4.5	0	0.5	0.25
13	41.75	-28	-9	42	-27.75	-9	0.25	0.25	0
14	42	-18.25	-9.25	42	-18.25	-9	0	0	0.25
15	42.5	-7.5	-9	42.25	-7	-9	-0.25	0.5	0
16	38.5	-1	-3	39.5	-1	-3	0	0	0
17	37	-27.75	-8.75	37	-27.75	-8.75	0	0	0
18	37.5	-19	-9	37.5	-19	-8.5	0	0	0.5
19	37.75	-8.25	-9.75	37.75	-8	-9.5	0	0.25	0.25
20	35	-0.25	-3.5	35	-0.25	-3.25	0	0	0.25
21	30.25	-27.5	-7.75	30.25	-27.5	-7.75	0	0	0
22	31.5	-18	-7.5	31.5	-17.75	-8.5	0	0.25	-1
23	31	-7.25	-8.75	31	-7.25	-8.75	0	0	0
24	30.5	1.5	-3.5	30.25	1.5	-3.25	-0.25	0	0.25
25	24.25	-25.5	-4	24.25	-25.5	-4	0	0	0
26	24	-18.25	-4.5	24	-18.25	-4.5	0	0	0
27	24	-9.5	-5	24	-9.25	-5	0	0.25	0
28	24	0.25	-3	24	0.25	-2.75	0	0	0.25
29							0	0	0
30							0	0	0
31							0	0	0
32							0	0	0
33							0	0	0
34							0	0	0
35							0	0	0

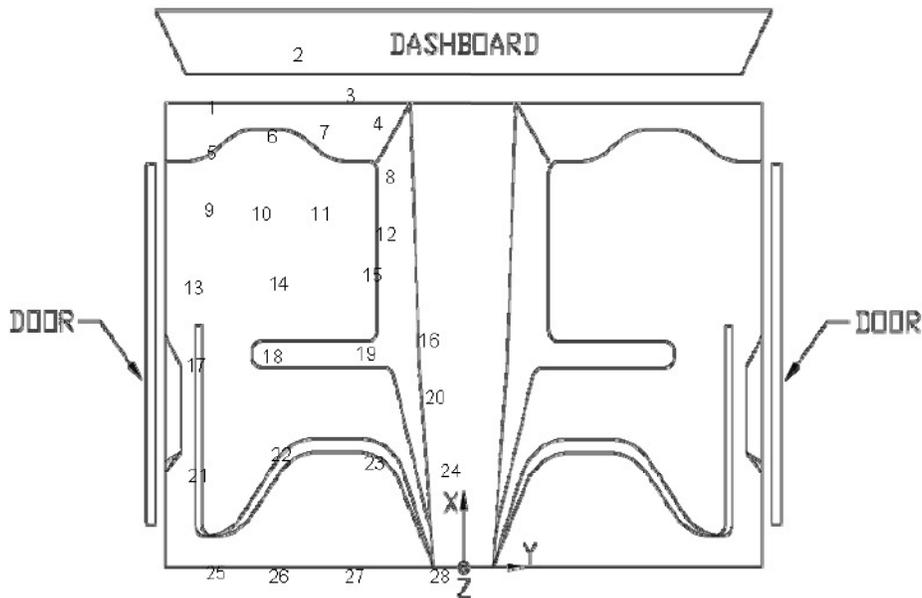


Figure C-5. Occupant Compartment Deformation Data Set 2, Test NYTCB-1

Occupant Compartment Deformation Index (OCDI)

Test No. NYTCB-1
 Vehicle Type: 2002 Dodge Ram 1500

OCDI = XXABCDEFGHI

XX = location of occupant compartment deformation

A = distance between the dashboard and a reference point at the rear of the occupant compartment, such as the top of the rear seat or the rear of the cab on a pickup

B = distance between the roof and the floor panel

C = distance between a reference point at the rear of the occupant compartment and the motor panel

D = distance between the lower dashboard and the floor panel

E = interior width

F = distance between the lower edge of right window and the upper edge of left window

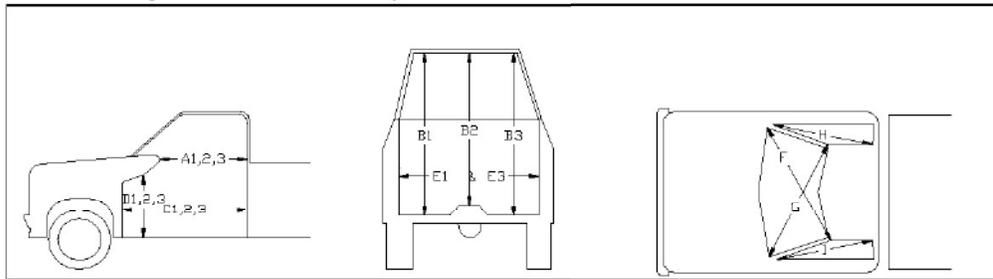
G = distance between the lower edge of left window and the upper edge of right window

H = distance between bottom front corner and top rear corner of the passenger side window

I = distance between bottom front corner and top rear corner of the driver side window

Severity Indices

- 0 - if the reduction is less than 3%
- 1 - if the reduction is greater than 3% and less than or equal to 10 %
- 2 - if the reduction is greater than 10% and less than or equal to 20 %
- 3 - if the reduction is greater than 20% and less than or equal to 30 %
- 4 - if the reduction is greater than 30% and less than or equal to 40 %



where,
 1 = Passenger Side
 2 = Middle
 3 = Driver Side

Location:

Measurement	Pre-Test (in.)	Post-Test (in.)	Change (in.)	% Difference	Severity Index
A1	56.25	56.50	0.25	0.44	0
A2	54.00	54.00	0.00	0.00	0
A3	55.00	55.00	0.00	0.00	0
B1	43.75	44.00	0.25	0.57	0
B2	42.50	42.50	0.00	0.00	0
B3	46.75	47.00	0.25	0.53	0
C1	67.00	65.50	-1.50	-2.24	0
C2	48.00	48.00	0.00	0.00	0
C3	65.50	65.25	-0.25	-0.38	0
D1	23.50	24.00	0.50	2.13	0
D2	13.75	14.00	0.25	1.82	0
D3	22.50	22.50	0.00	0.00	0
E1	65.50	65.50	0.00	0.00	0
E3	64.75	64.75	0.00	0.00	0
F	58.00	58.00	0.00	0.00	0
G	57.50	57.50	0.00	0.00	0
H	36.75	36.75	0.00	0.00	0
I	38.25	38.50	0.25	0.65	0

Note: Maximum severity index for each variable (A-I) is used for determination of final OCDI value

Final OCDI: XXABCDEFGHI
 LF 0 0 0 0 0 0 0 0 0

Figure C-6. Occupant Compartment Deformation Index (OCDI), Test NYTCB-1

VEHICLE PRE/POST CRUSH INFO
Set-1

TEST: NYTCB-2
VEHICLE: 2003 Dodge Ram 1500

POINT	23			3			DEL X	DEL Y	DEL Z
	X	Y	Z	X'	Y'	Z'			
1	30	-28.75	0	28.5	-28	1.5	-1.5	0.75	1.5
2	32.5	-24	-0.75	29.5	-23.25	2	-3	0.75	2.75
3	33.5	-18	-1	32	-17	1	-1.5	1	2
4	29.5	-11	1	30	-11.75	1.5	0.5	-0.75	0.5
5	26.5	-29	-4.75	26	-29	-4	-0.5	0	0.75
6	28	-24.25	-5.25	27.5	-24.25	-4.5	-0.5	0	0.75
7	29	-17	-5	28	-16.75	-4	-1	0.25	1
8	28.5	-10.25	-2.5	28.5	-10.5	-2.5	0	-0.25	0
9	23.5	-30.25	-7.5	23.25	-30.5	-7.5	-0.25	-0.25	0
10	23.25	-23	-7.5	22.75	-23.5	-7	-0.5	-0.5	0.5
11	23.25	-17.25	-7.5	23	-17	-7.25	-0.25	0.25	0.25
12	23.25	-11.5	-7.75	23.5	-11	-7.5	0.25	0.5	0.25
13	21	-8	-2.75	20.75	-8.25	-2.5	-0.25	-0.25	0.25
14	17.75	-29.25	-9	17.5	-28.5	-9	-0.25	0.75	0
15	18	-21.5	-9	18	-21	-9	0	0.5	0
16	18	-13.75	-9.25	17.75	-13	-9.5	-0.25	0.75	-0.25
17	15.25	-7.25	-2.5	15.25	-7.25	-2.75	0	0	-0.25
18	15	-2	-2.5	15.25	-2	-2.5	0.25	0	0
19	11	-29	-8.5	10.5	-28.25	-8.5	-0.5	0.75	0
20	11	-22	-8.5	10.75	-21	-8.5	-0.25	1	0
21	10.75	-15.25	-8.75	10.75	-15.25	-8.75	0	0	0
22	8.25	-7.5	-3	8.5	-7.5	-3	0.25	0	0
23	8.5	-1.5	-2.75	8.5	-1.5	-2.5	0	0	0.25
24	1	-29	-5	1	-29	-5	0	0	0
25	1	-22	-4.5	1	-22	-4.5	0	0	0
26	0.75	-15.25	-5	0.75	-15.25	-5	0	0	0
27	1.25	-8	-2.5	1.25	-8	-2.5	0	0	0
28	1	-1.75	-2.5	1	-1.75	-2.5	0	0	0
29							0	0	0
30							0	0	0
31							0	0	0
32							0	0	0
33							0	0	0
34							0	0	0
35							0	0	0

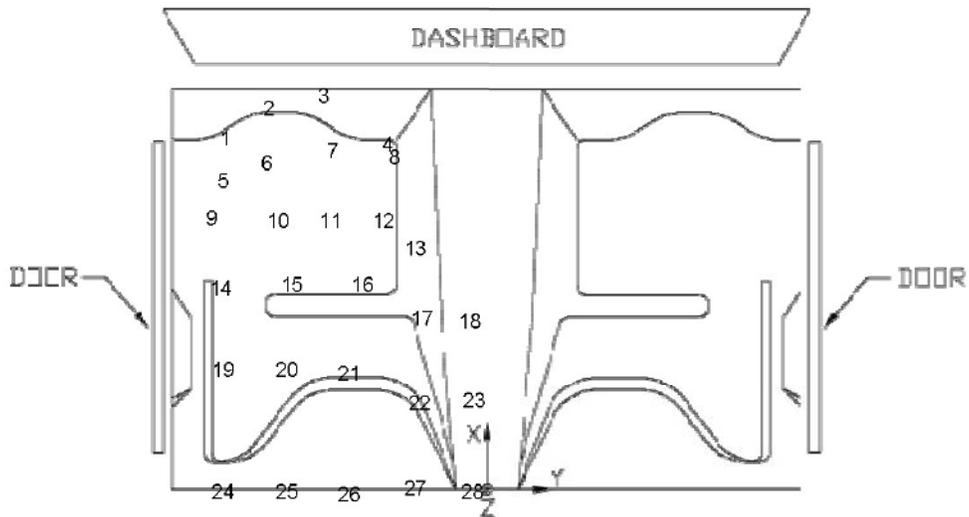


Figure C-7. Occupant Compartment Deformation Data Set 1, Test NYTCB-2

VEHICLE PRE/POST CRUSH INFO

Set-2

TEST: NYTCB-2
 VEHICLE: 2003 Dodge Ram 1500

POINT	X	Y	Z	X'	Y'	Z'	DEL X	DEL Y	DEL Z
1	53	-25.75	-2.75	51.5	-25	-2	-1.5	0.75	0.75
2	55.5	-21	-3	52.5	-20.25	-1	-3	0.75	2
3	56.5	-15	-3	55	-14	-1.25	-1.5	1	1.75
4	52.5	-8	0	53	-8.75	0	0.5	-0.75	0
5	49.5	-26	-7.25	49	-26	-6.75	-0.5	0	0.5
6	51	-21.25	-7.5	50.5	-21.25	-6.75	-0.5	0	0.75
7	52	-14	-6.5	51	-13.75	-5	-1	0.25	1.5
8	51.5	-7.25	-3.5	51.5	-7.5	-3.25	0	-0.25	0.25
9	46.5	-27.25	-10	46.25	-27.5	-10	-0.25	-0.25	0
10	46.25	-20	-9.5	45.75	-20.5	-8.75	0	-0.5	0.75
11	46.25	-14.25	-9.25	46	-14	-6.5	-0.25	0.25	0.75
12	46.25	-8.5	-8.75	46.5	-8	-8.5	0.25	0.5	0.25
13	44	-5	-3.5	43.75	-5.25	-3	-0.25	-0.25	0.5
14	40.75	-26.25	-11.5	40.5	-25.5	-11.25	-0.25	0.75	0.25
15	41	-18.5	-11	41	-18	-10.75	0	0.5	0.25
16	41	-10.75	-10.5	40.75	-10	-10.5	-0.25	0.75	0
17	38.25	-4.25	-3.25	38.25	-4.25	-3.25	0	0	0
18	38	1	-2.5	38.25	1	-2.5	0.25	0	0
19	34	-26	-10.75	33.5	-25.25	-11	-0.5	0.75	-0.25
20	34	-18	-10.5	33.75	-18	-10.5	-0.25	1	0
21	33.75	-12.25	-10.25	33.75	-12.25	-10	0	0	0.25
22	31.25	-4.5	-3.25	31.5	-4.5	-3.5	0.25	0	-0.25
23	31.5	1.5	-2.75	31.5	1.5	-2.75	0	0	0
24	24	-26	-7.25	24	-26	-7.25	0	0	0
25	24	-19	-6.25	24	-19	-6.25	0	0	0
26	23.75	-12.25	-6	23.75	-12.25	-6	0	0	0
27	24.25	-5	-3.25	24.25	-5	-3.25	0	0	0
28	24	1.25	-2.75	24	1.25	-2.5	0	0	0.25
29							0	0	0
30							0	0	0
31							0	0	0
32							0	0	0
33							0	0	0
34							0	0	0
35							0	0	0

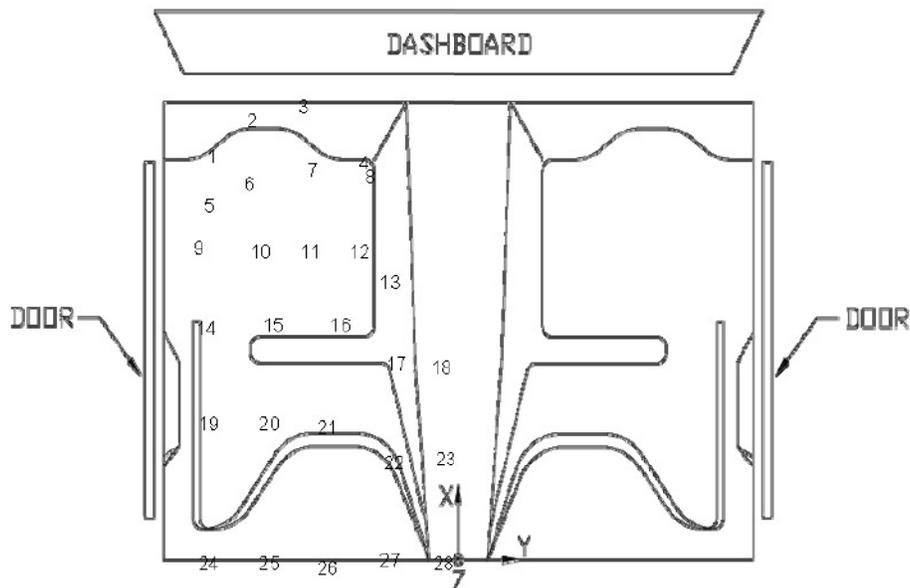


Figure C-8. Occupant Compartment Deformation Data Set 2, Test NYTCB-2

Occupant Compartment Deformation Index (OCDI)

Test No. NYTCB-2
 Vehicle Type: 2003 Dodge Ram 1500

OCDI = XXABCDEFGHI

XX = location of occupant compartment deformation

A = distance between the dashboard and a reference point at the rear of the occupant compartment, such as the top of the rear seat or the rear of the cab on a pickup

B = distance between the roof and the floor panel

C = distance between a reference point at the rear of the occupant compartment and the motor panel

D = distance between the lower dashboard and the floor panel

E = interior width

F = distance between the lower edge of right window and the upper edge of left window

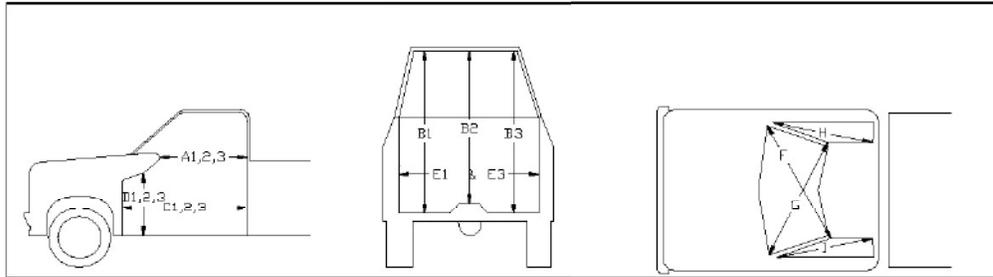
G = distance between the lower edge of left window and the upper edge of right window

H = distance between bottom front corner and top rear corner of the passenger side window

I = distance between bottom front corner and top rear corner of the driver side window

Severity Indices

- 0 - if the reduction is less than 3%
- 1 - if the reduction is greater than 3% and less than or equal to 10 %
- 2 - if the reduction is greater than 10% and less than or equal to 20 %
- 3 - if the reduction is greater than 20% and less than or equal to 30 %
- 4 - if the reduction is greater than 30% and less than or equal to 40 %



where,
 1 = Passenger Side
 2 = Middle
 3 = Driver Side

Location:

Measurement	Pre-Test (in.)	Post-Test (in.)	Change (in.)	% Difference	Severity Index
A1	53.75	53.50	-0.25	-0.47	0
A2	50.25	50.25	0.00	0.00	0
A3	53.75	54.00	0.25	0.47	0
B1	47.75	47.75	0.00	0.00	0
B2	42.25	42.25	0.00	0.00	0
B3	47.50	47.50	0.00	0.00	0
C1	64.75	63.25	-1.50	-2.32	0
C2	46.75	47.00	0.25	0.53	0
C3	65.00	65.00	0.00	0.00	0
D1	23.50	23.50	0.00	0.00	0
D2	14.00	14.00	0.00	0.00	0
D3	22.50	22.50	0.00	0.00	0
E1	65.50	65.50	0.00	0.00	0
E3	64.75	64.75	0.00	0.00	0
F	58.00	58.00	0.00	0.00	0
G	58.25	58.25	0.00	0.00	0
H	37.50	37.50	0.00	0.00	0
I	38.00	38.00	0.00	0.00	0

Note: Maximum severity index for each variable (A-I) is used for determination of final OCDI value

Final OCDI: XX A B C D E F G H I
 RF 0 0 0 0 0 0 0 0 0

Figure C-9. Occupant Compartment Deformation Index (OCDI), Test NYTCB-2

NYTCB-3

Comparison interior crush measurements

Lateral measurements taken from left door seam to right door seam.
 Longitudinal measurements taken from b-pillar string line (see photo)

Direction:		
Lateral	1	67.5
Lateral	2	69.1875
Lateral	3	69
Lateral	4	69.5
Lateral	5	68
Longitudinal	6	49.875
Longitudinal	7	46.25
Longitudinal	8	48.25

Reference Vehicle (no damage)

1	68.125	Front of door
2	69.75	Midspan (front of door to front of seat)
3	69.25	Front of seat
4	68.75	Front of seat belt
5	68	Back of door
6	50	MIN. CRUSH
7	49.75	MAX. CRUSH
8	49.25	MIN. CRUSH

Total crush at each point.

1	0.625	Front of door
2	0.5625	Midspan (front of door to front of seat)
3	0.25	Front of seat
4	0.25	Front of seat belt
5	0	Back of door
6	0.125	MIN. CRUSH
7	3.5	MAX. CRUSH
8	1	MIN. CRUSH

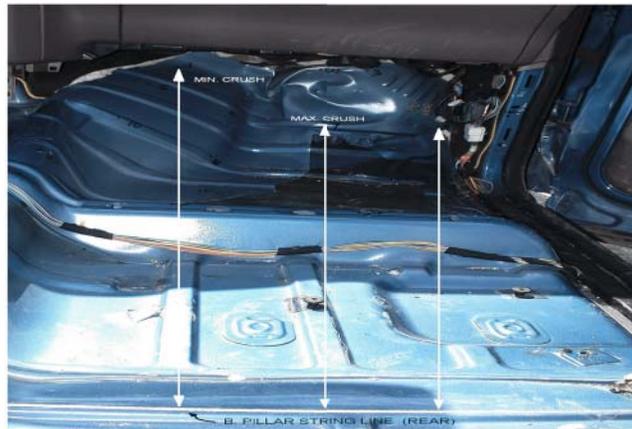
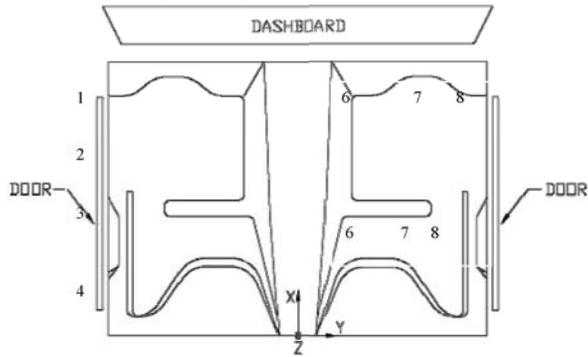


Figure C-10. Occupant Compartment Crush Data, Test NYTCB-3

APPENDIX D

Accelerometer and Rate Transducer Data Analysis, Test NYTCB-1

Figure D-1. Graph of Longitudinal Deceleration, Test NYTCB-1

Figure D-2. Graph of Longitudinal Occupant Impact Velocity, Test NYTCB-1

Figure D-3. Graph of Longitudinal Occupant Displacement, Test NYTCB-1

Figure D-4. Graph of Lateral Deceleration, Test NYTCB-1

Figure D-5. Graph of Lateral Occupant Impact Velocity, Test NYTCB-1

Figure D-6. Graph of Lateral Occupant Displacement, Test NYTCB-1

Figure D-7. Graph of Roll, Pitch, and Yaw Angular Displacements, Test NYTCB-1

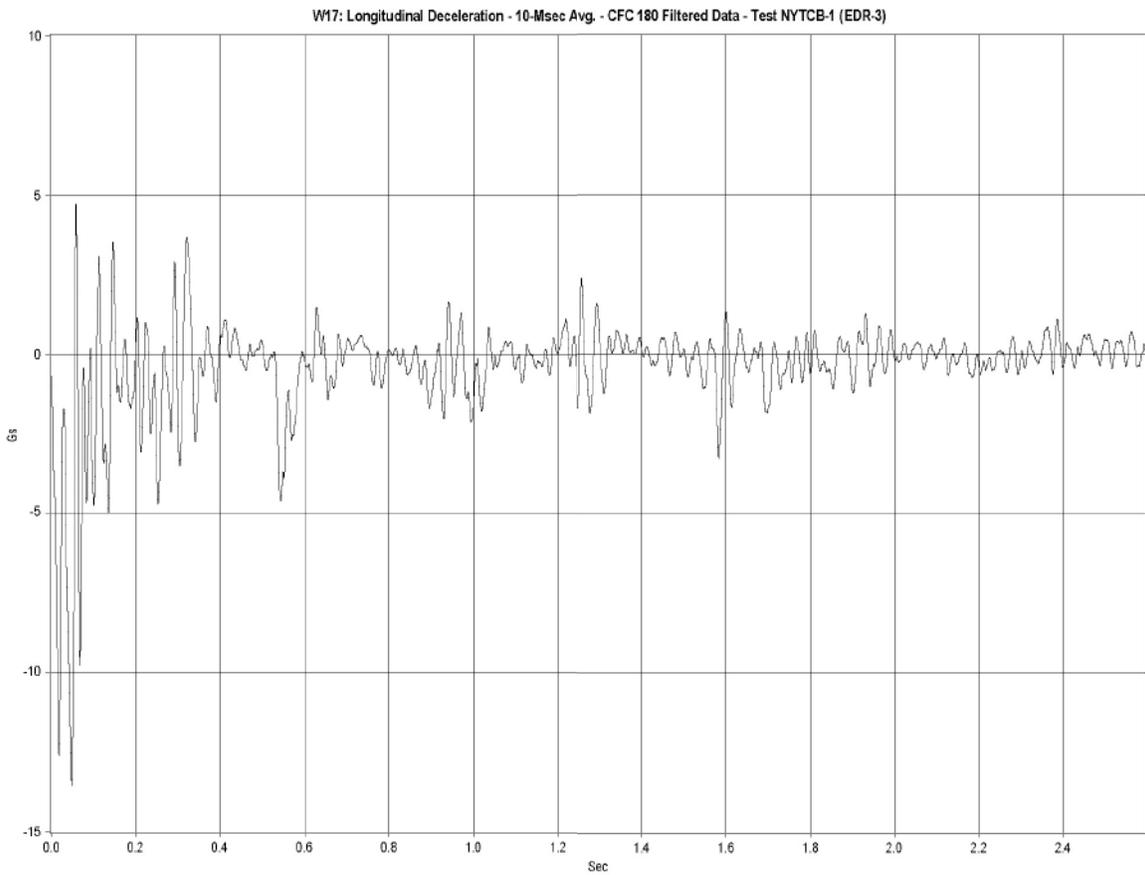


Figure D-1. Graph of Longitudinal Deceleration, Test NYTCB-1

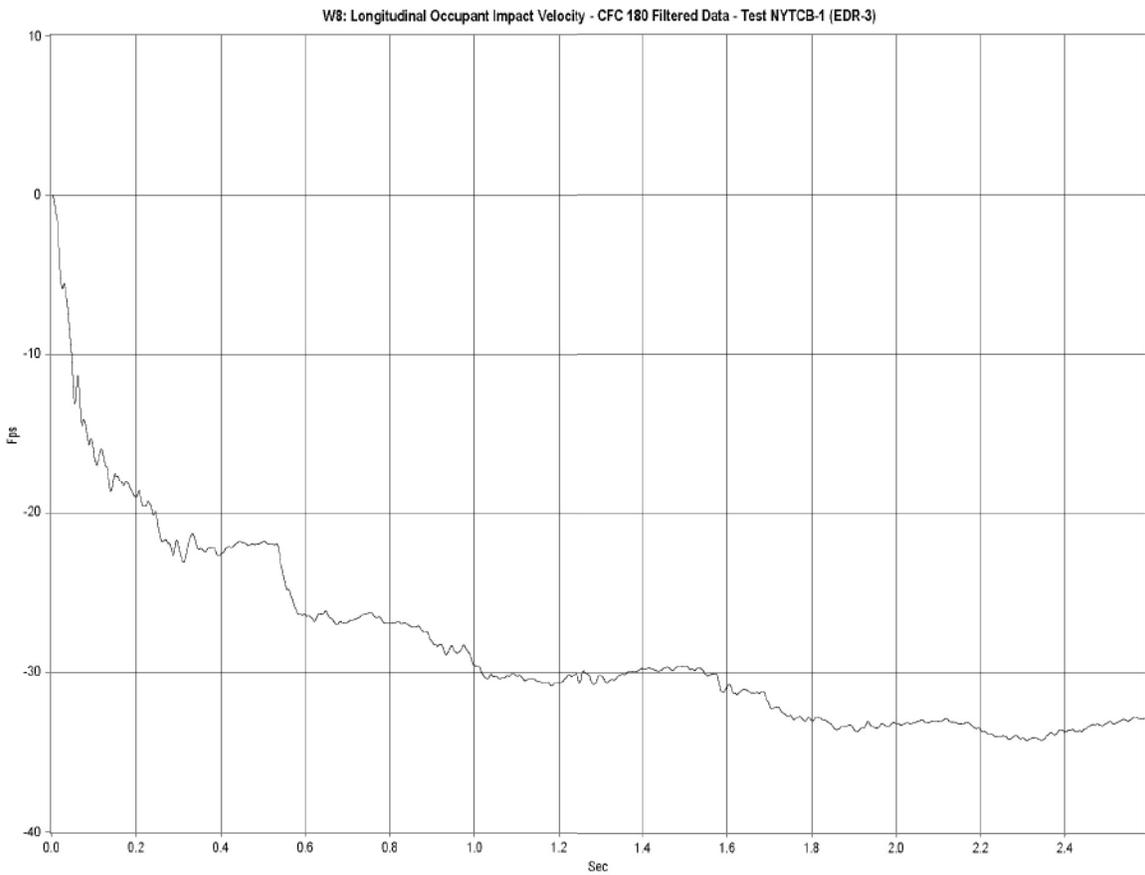


Figure D-2. Graph of Longitudinal Occupant Impact Velocity, Test NYTCB-1

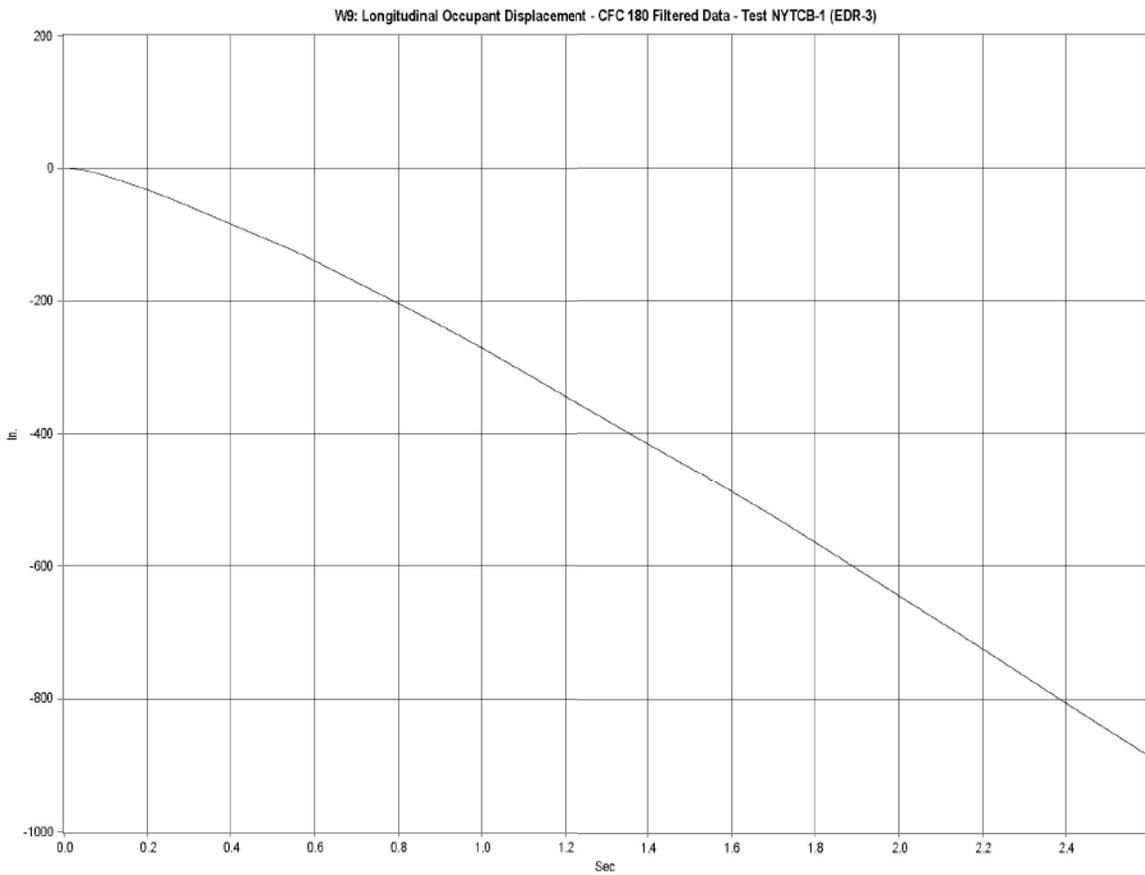


Figure D-3. Graph of Longitudinal Occupant Displacement, Test NYTCB-1

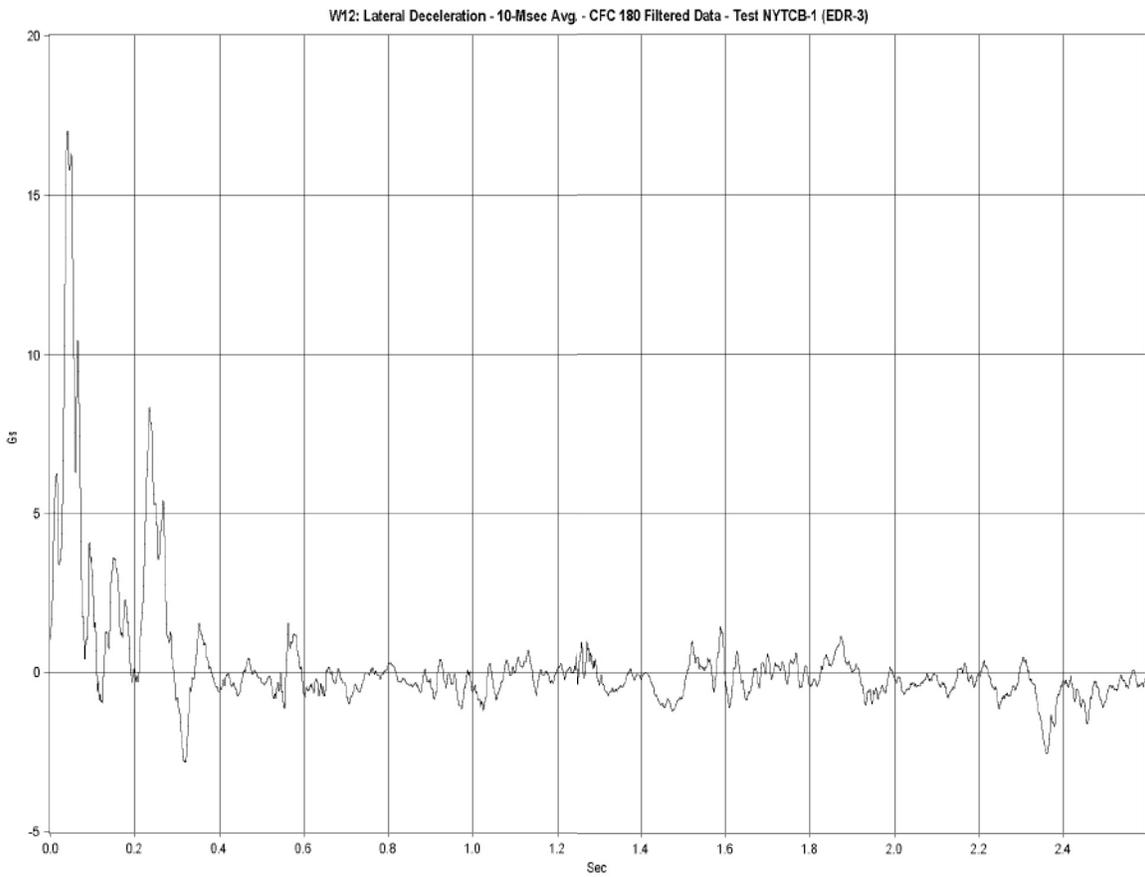


Figure D-4. Graph of Lateral Deceleration, Test NYTCB-1

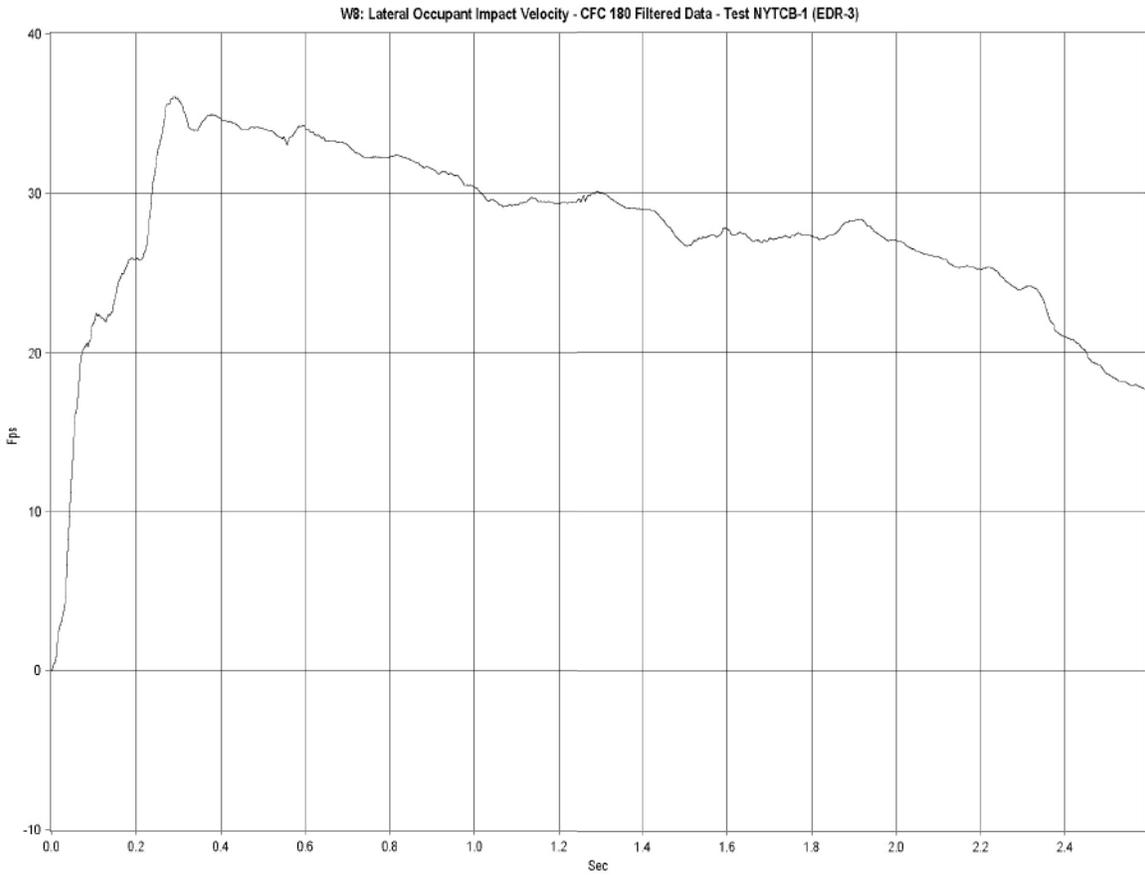


Figure D-5. Graph of Lateral Occupant Impact Velocity, Test NYTCB-1

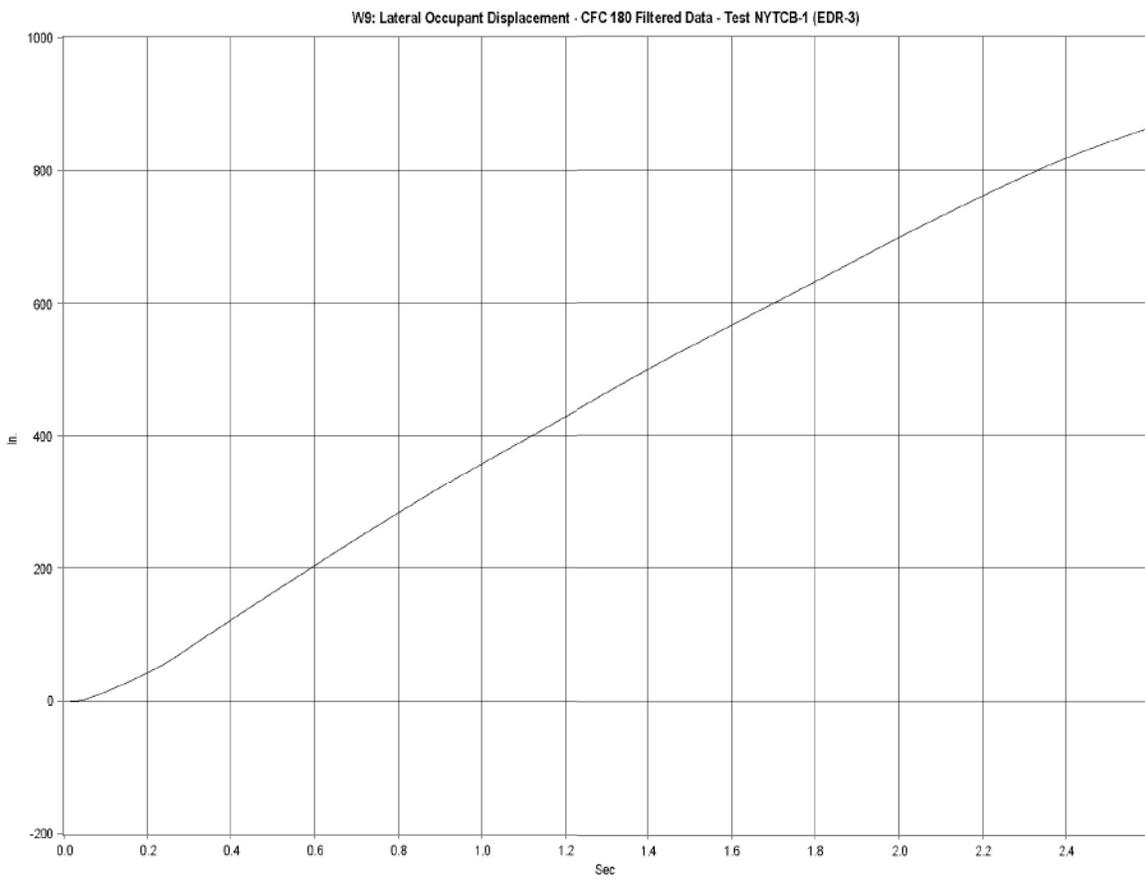


Figure D-6. Graph of Lateral Occupant Displacement, Test NYTCB-1

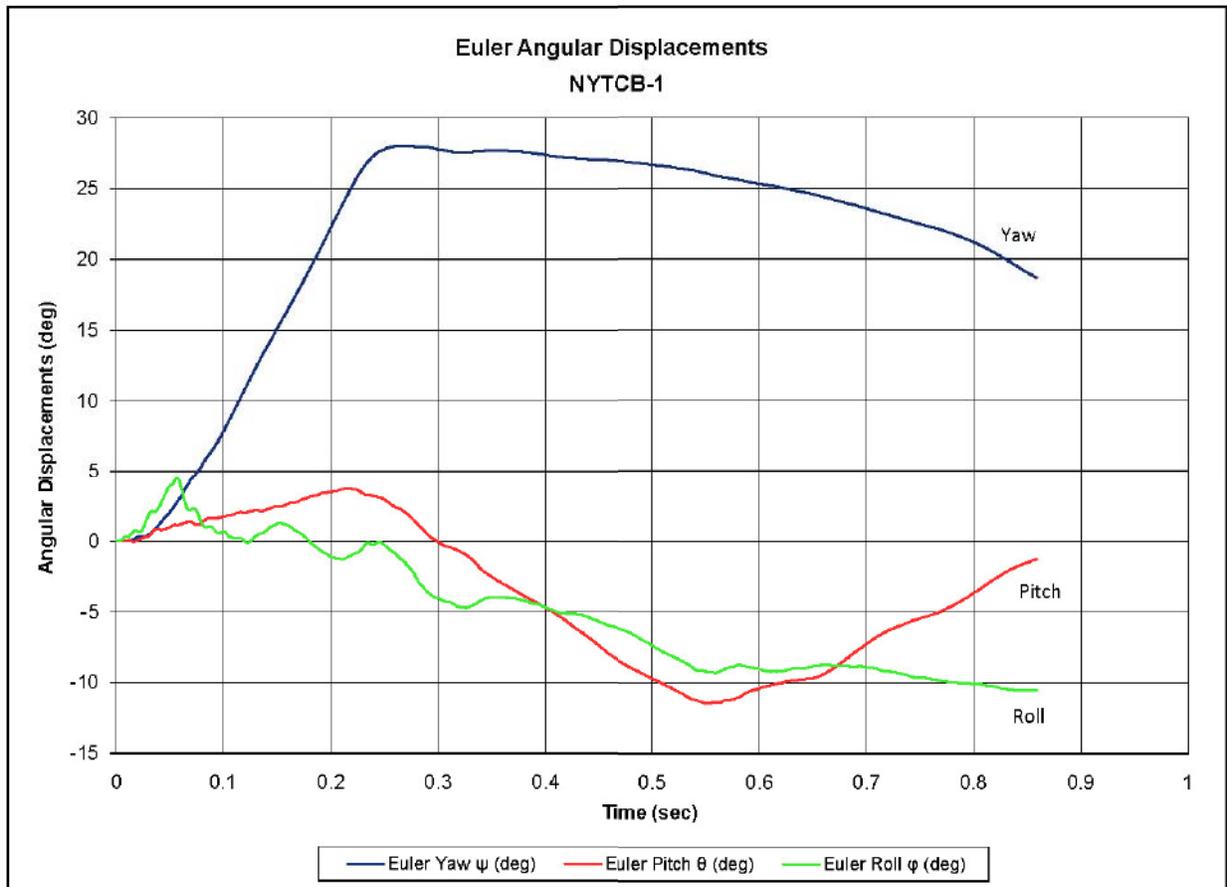


Figure D-7. Graph of Roll, Pitch, and Yaw Angular Displacements, Test NYTCB-1

APPENDIX E

Metric- and English-Unit System Drawings, Test NYTCB-2

Figure E-1. Unstiffened Temporary Concrete Barrier System Layout, Test NYTCB-2

Figure E-2. Temporary Concrete Barrier Details, Test NYTCB-2

Figure E-3. Temporary Concrete Barrier Reinforcement Details, Test NYTCB-2

Figure E-4. Bill of Bars, Test NYTCB-2

Figure E-5. Temporary Concrete Barrier Connection Details, Test NYTCB-2

Figure E-6. Connection Key Assembly Details, Test NYTCB-2

Figure E-7. Connection Key Assembly Details, Test NYTCB-2

Figure E-8. Temporary Concrete Barrier Connector Assembly Details, Test NYTCB-2

Figure E-9. Unstiffened Temporary Concrete Barrier System Layout (English), Test NYTCB-2

Figure E-10. Temporary Concrete Barrier Details (English), Test NYTCB-2

Figure E-11. Temporary Concrete Barrier Reinforcement Details (English), Test NYTCB-2

Figure E-12. Bill of Bars (English), Test NYTCB-2

Figure E-13. Temporary Concrete Barrier Connection Details (English), Test NYTCB-2

Figure E-14. Connection Key Assembly Details (English), Test NYTCB-2

Figure E-15. Connection Key Assembly Details (English), Test NYTCB-2

Figure E-16. Temporary Concrete Barrier Connector Assembly Details (English), Test NYTCB-2

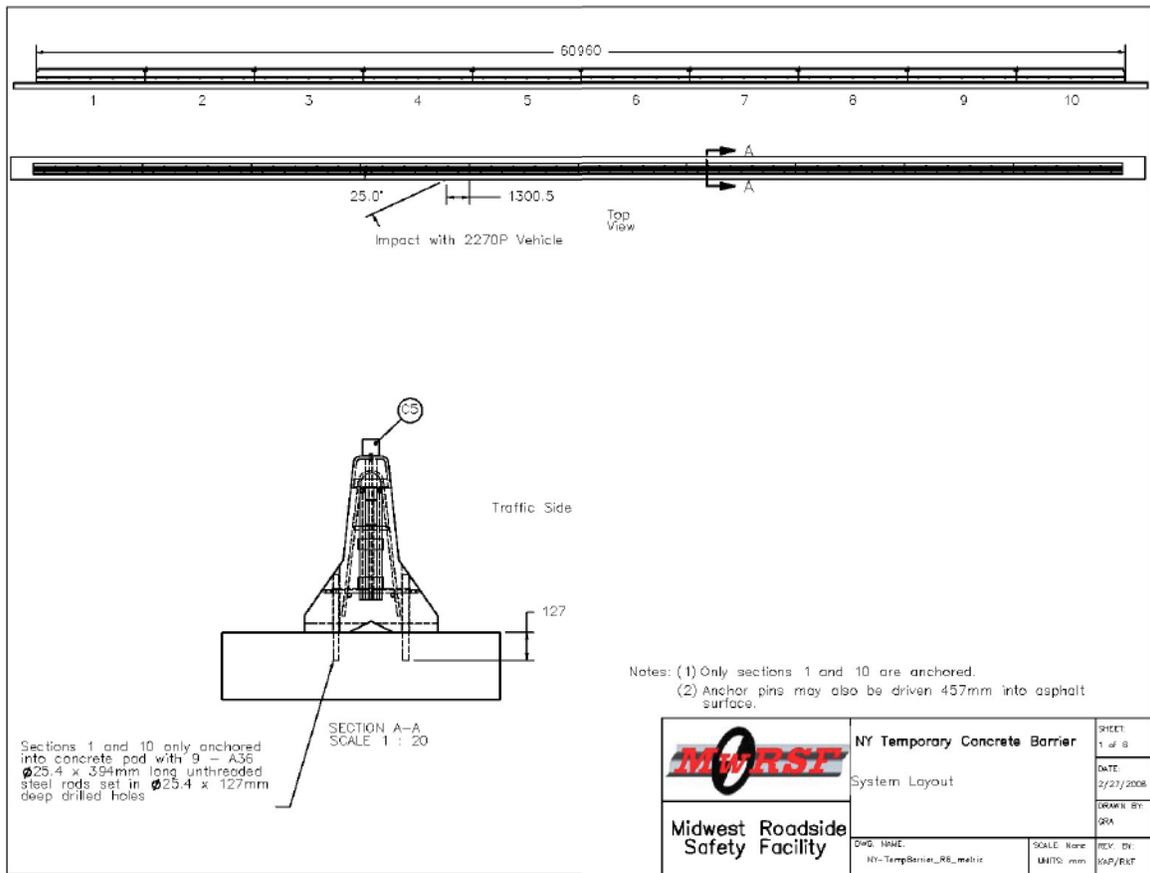


Figure E-1. Unstiffened Temporary Concrete Barrier System Layout, Test NYTCB-2

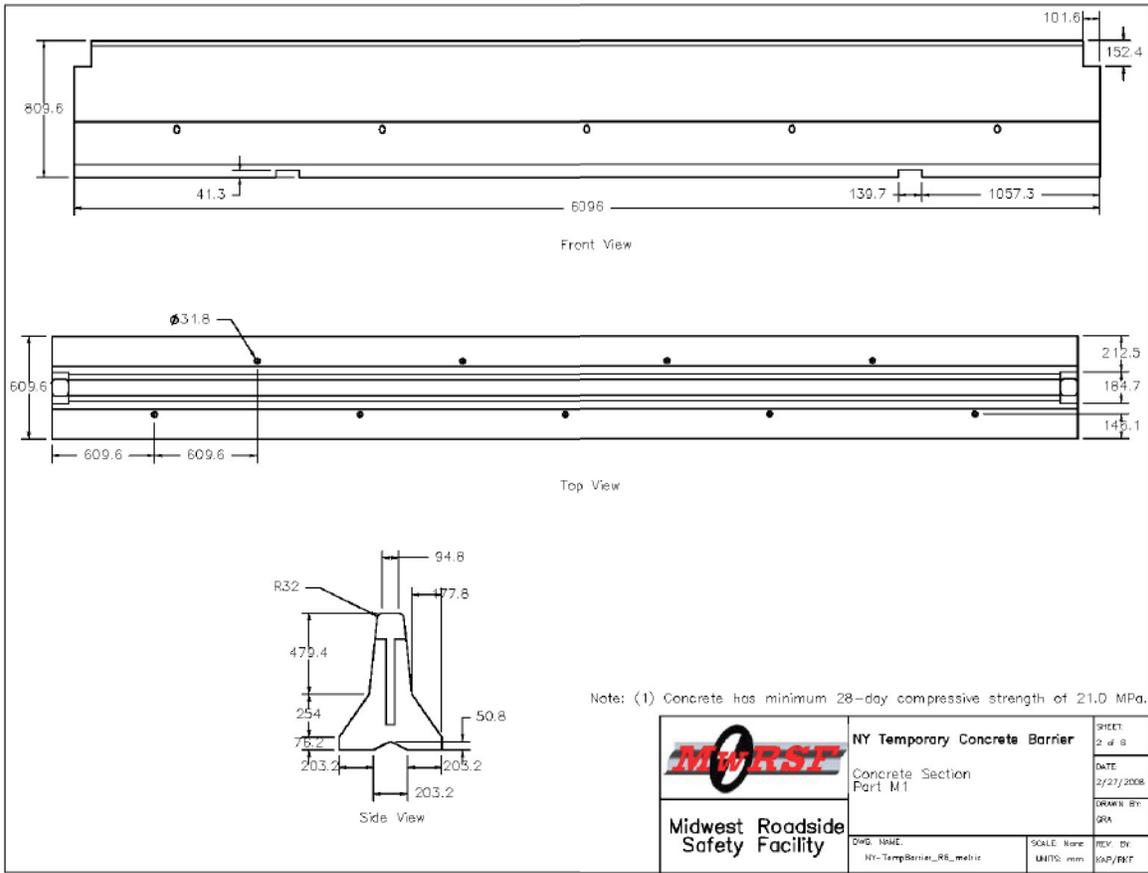


Figure E-2. Temporary Concrete Barrier Details, Test NYTCB-2

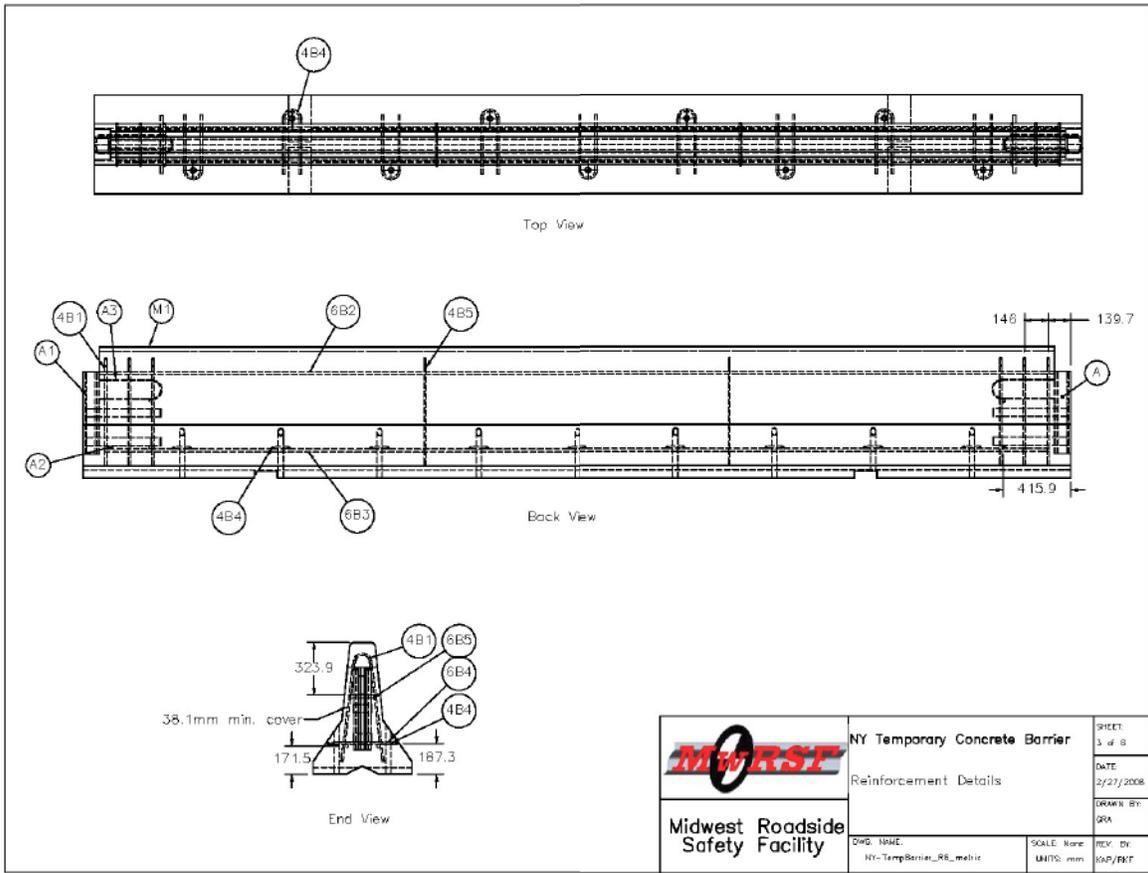


Figure E-3. Temporary Concrete Barrier Reinforcement Details, Test NYTCB-2

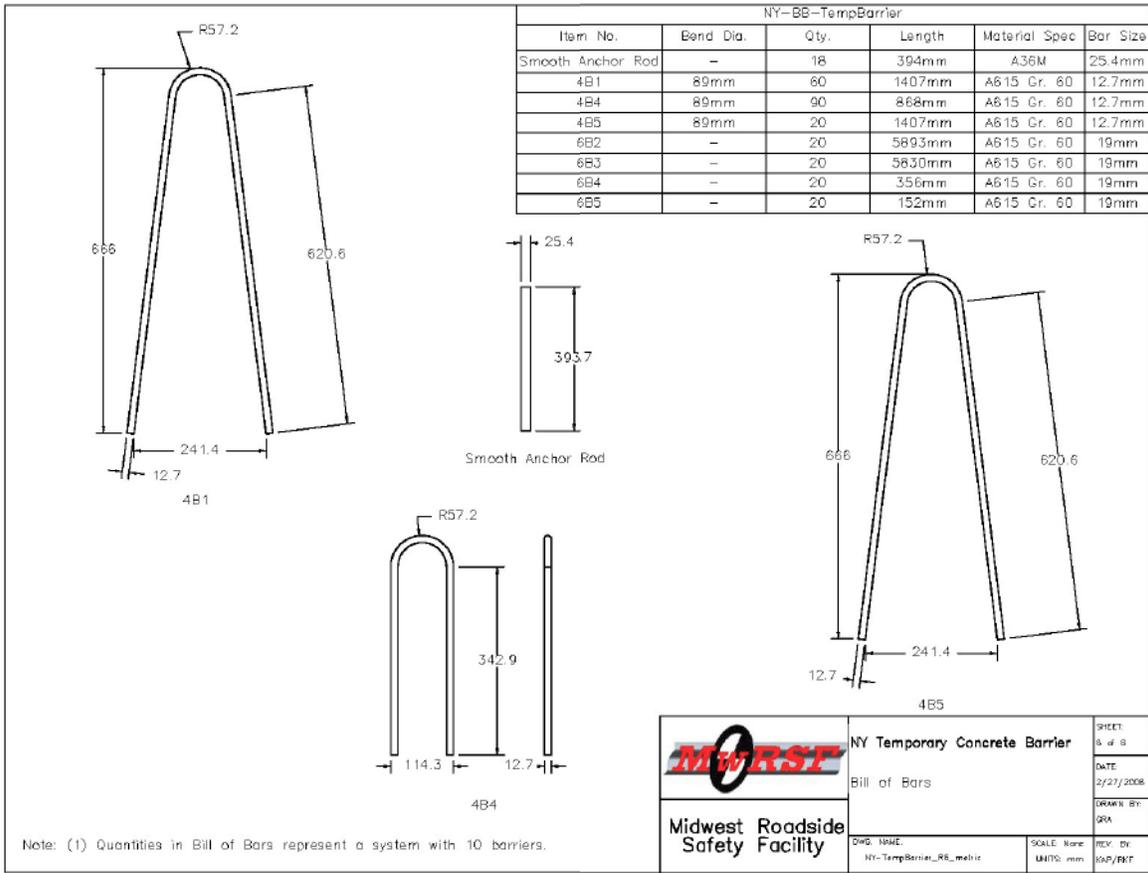


Figure E-4. Bill of Bars, Test NYTCB-2

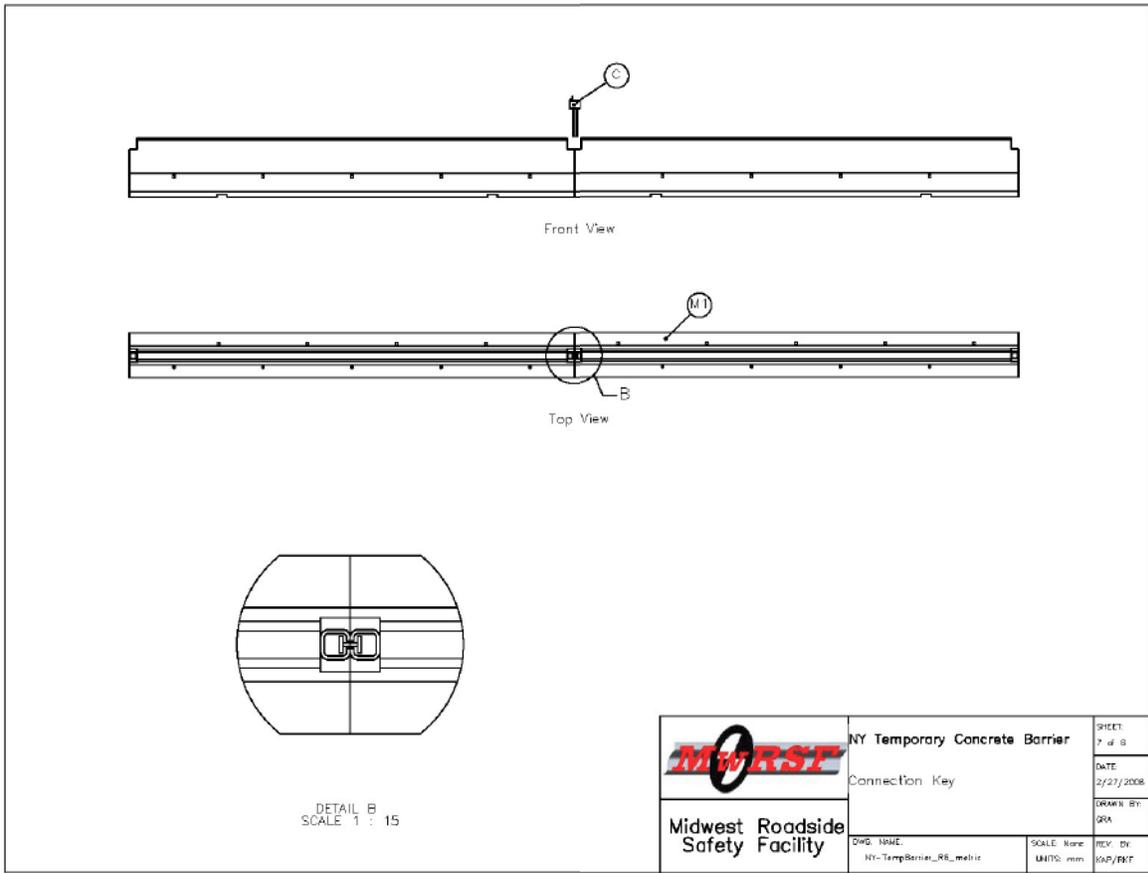


Figure E-5. Temporary Concrete Barrier Connection Details, Test NYTCB-2

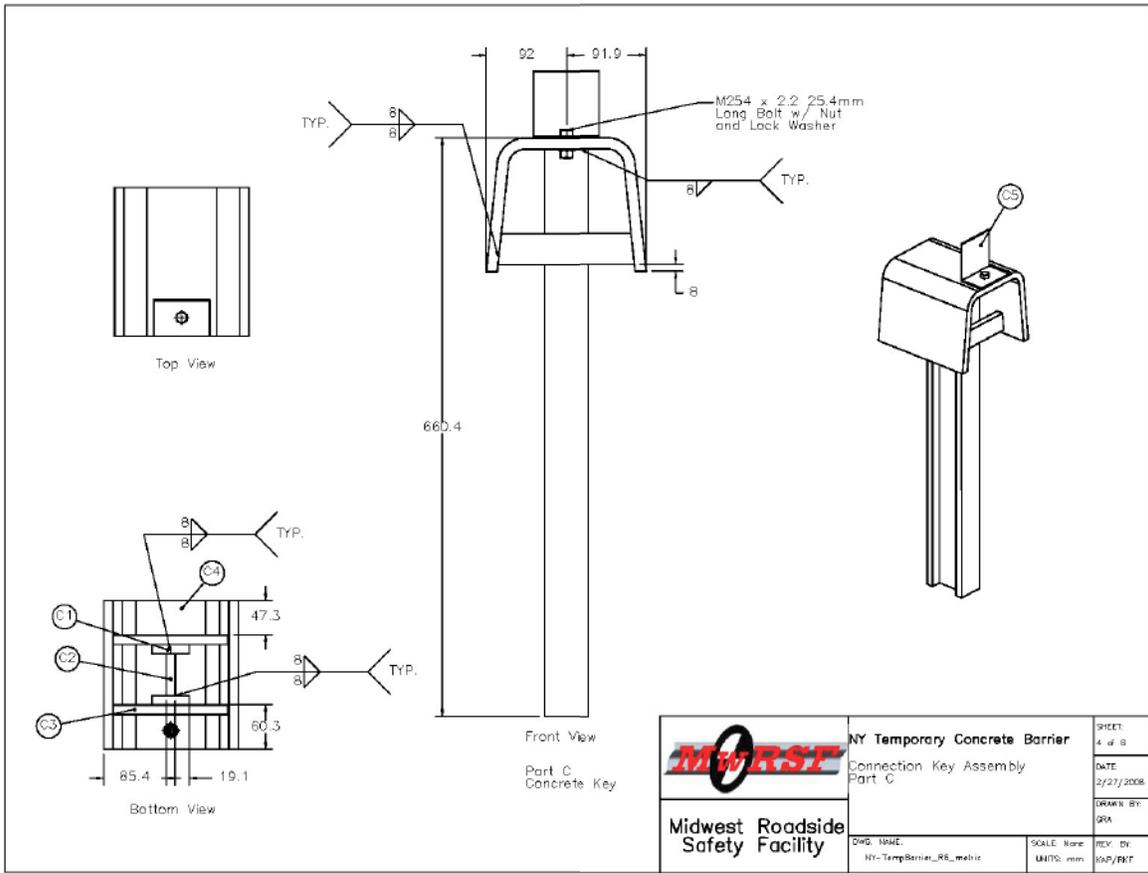


Figure E-6. Connection Key Assembly Details, Test NYTCB-2

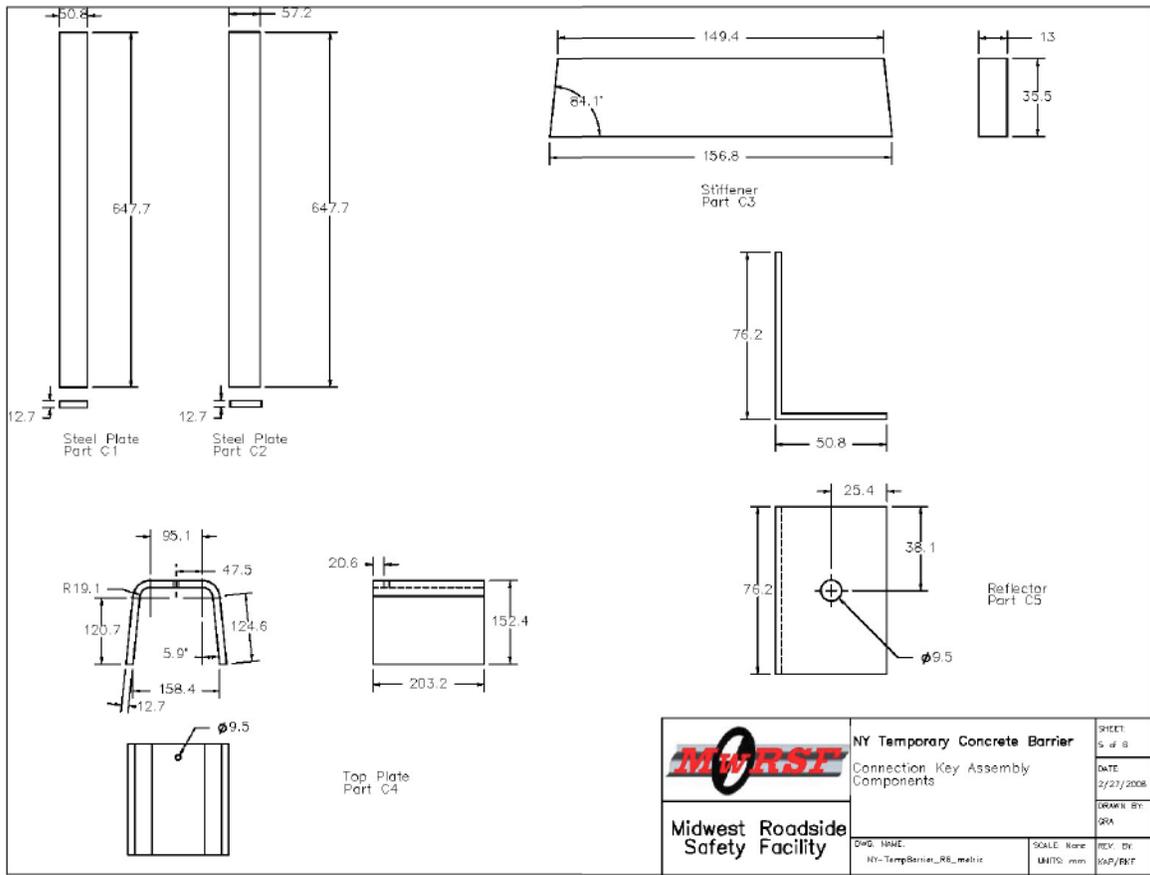


Figure E-7. Connection Key Assembly Details, Test NYTCB-2

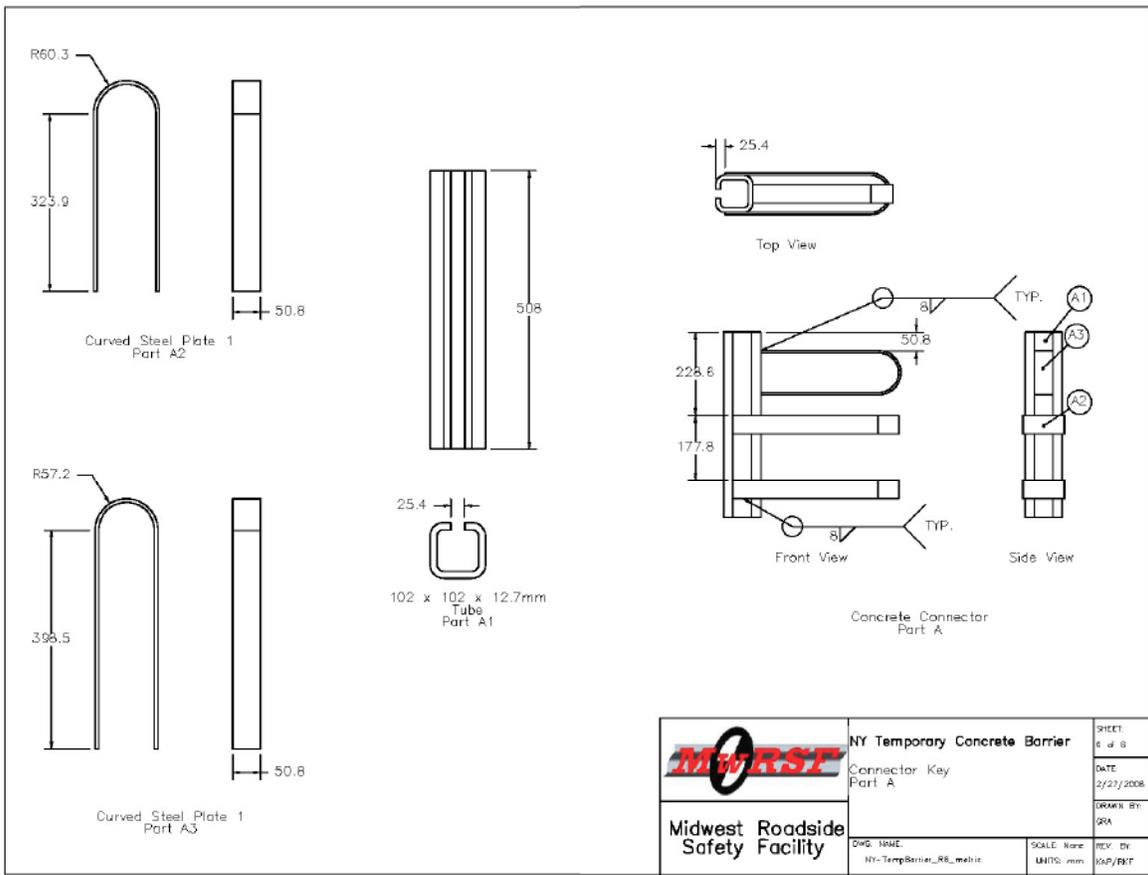


Figure E-8. Temporary Concrete Barrier Connector Assembly Details, Test NYTCB-2

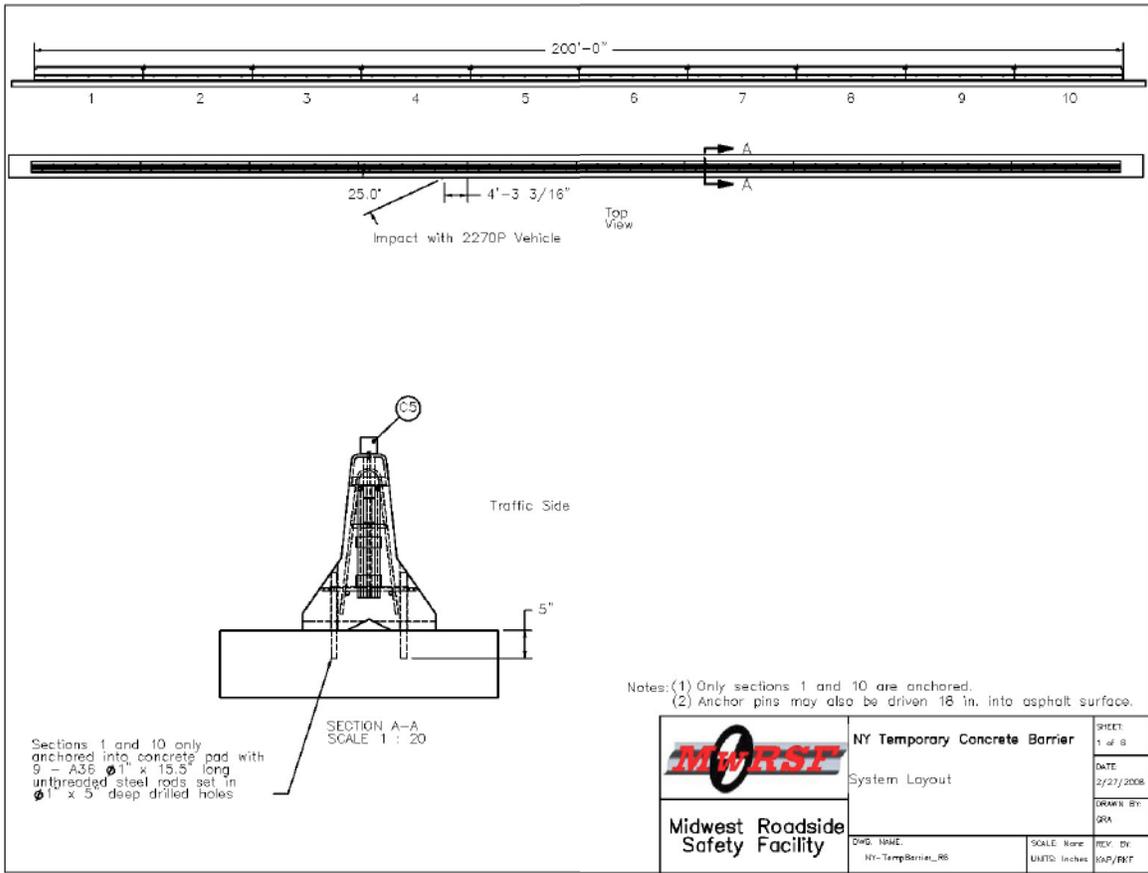


Figure E-9. Unstiffened Temporary Concrete Barrier System Layout (English), Test NYTCB-2

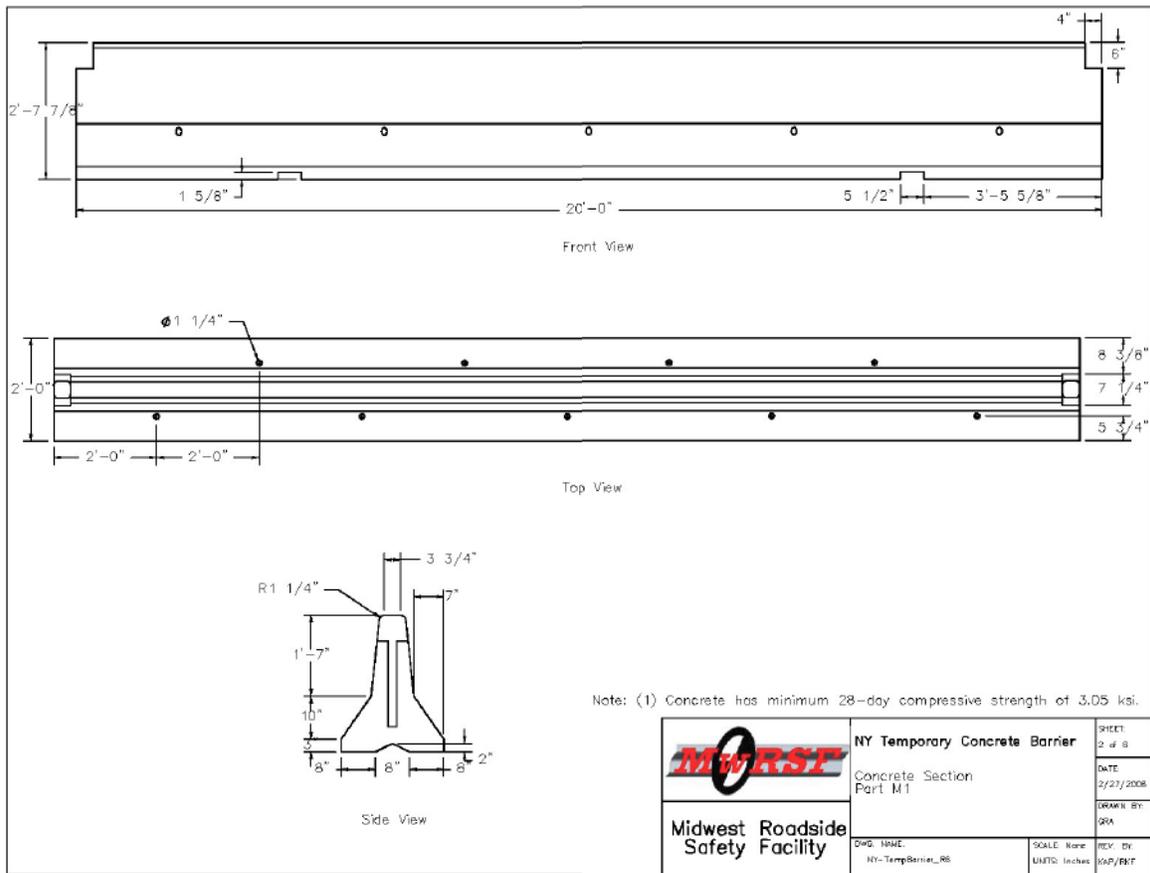


Figure E-10. Temporary Concrete Barrier Details (English), Test NYTCB-2

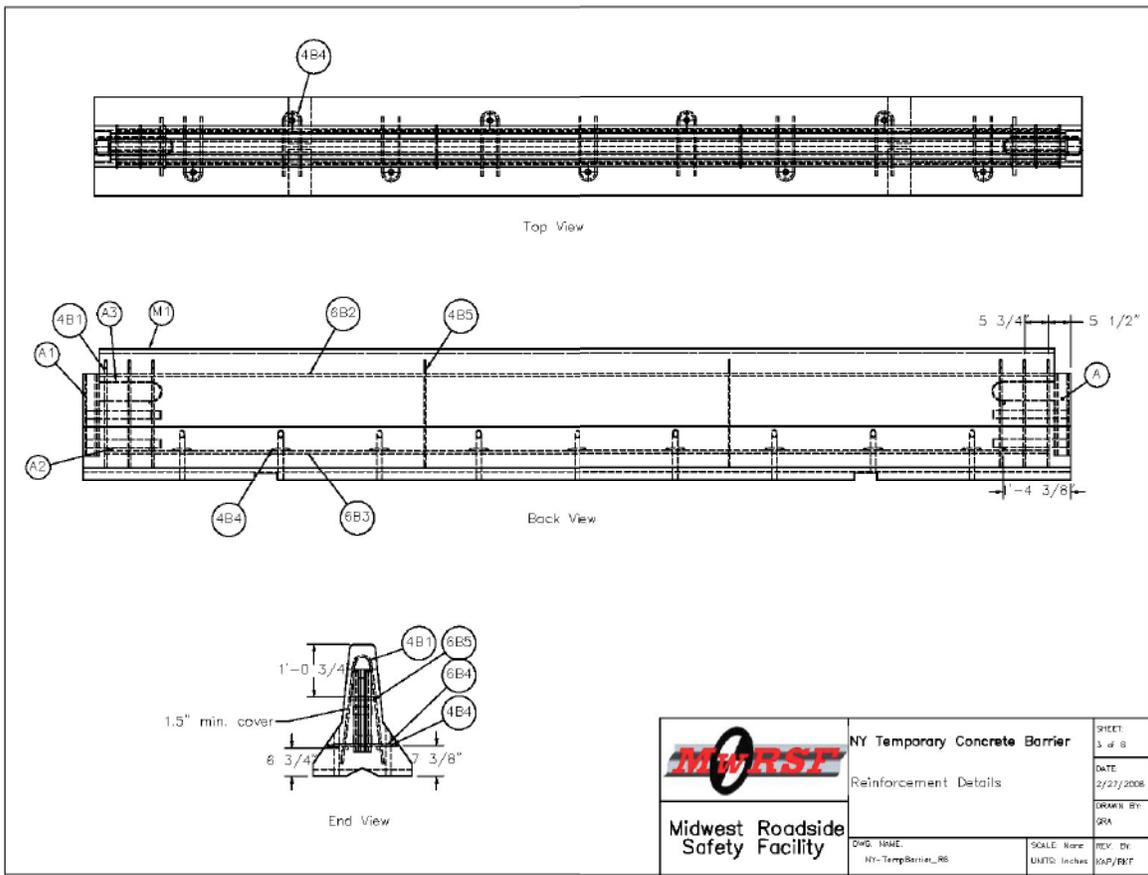


Figure E-11. Temporary Concrete Barrier Reinforcement Details (English), Test NYTCB-2

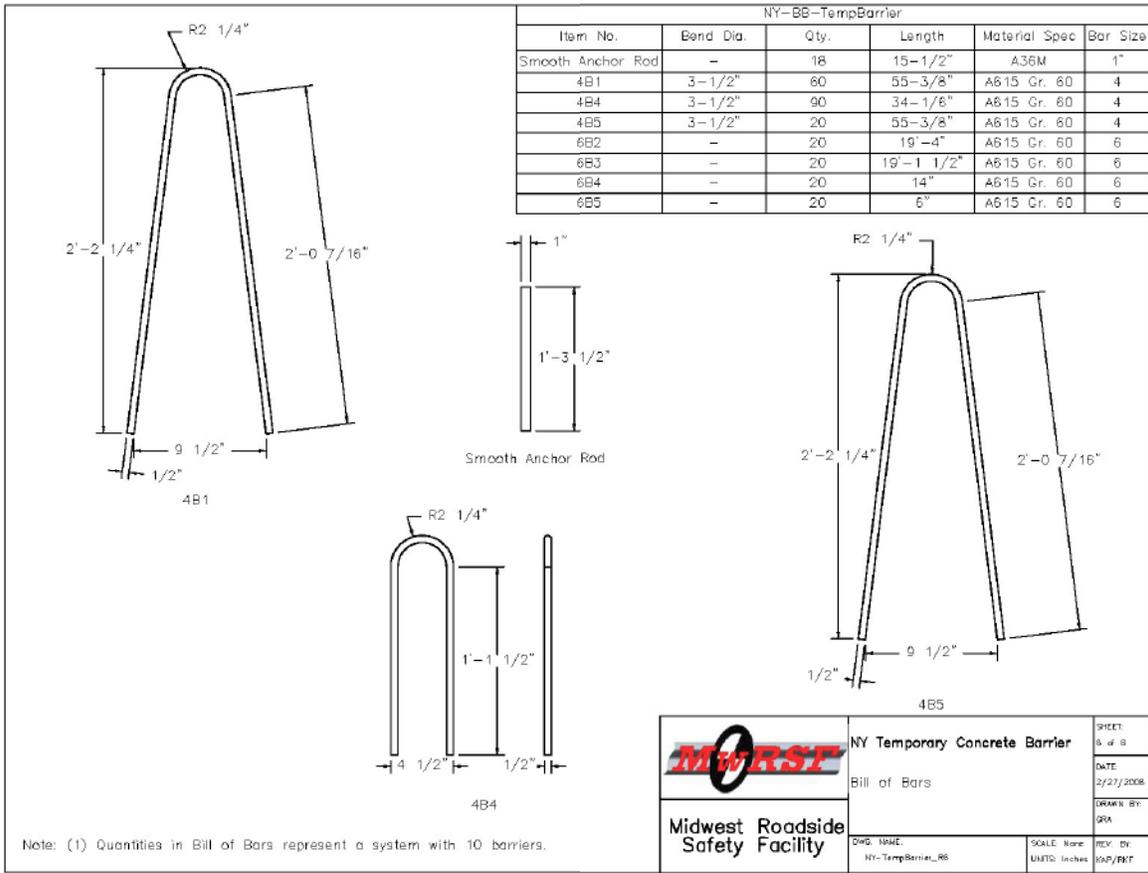


Figure E-12. Bill of Bars (English), Test NYTCB-2

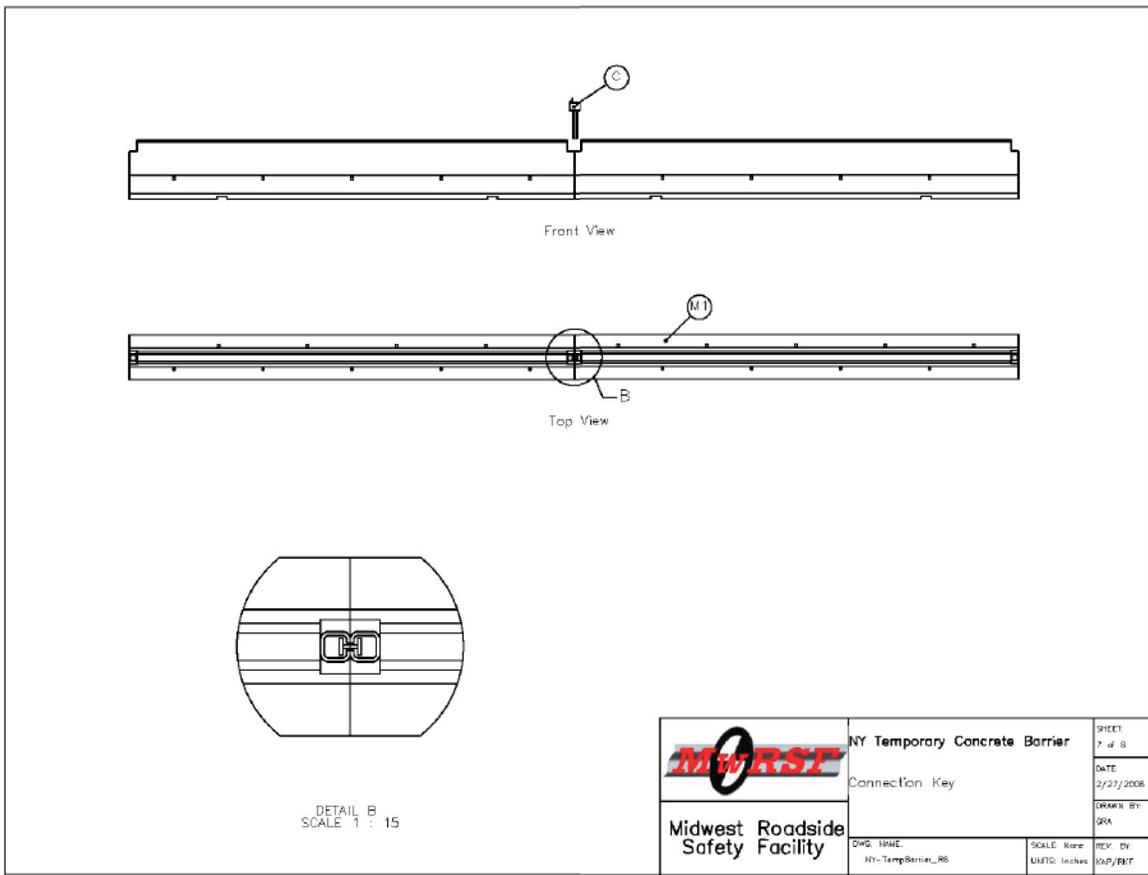


Figure E-13. Temporary Concrete Barrier Connection Details (English), Test NYTCB-2

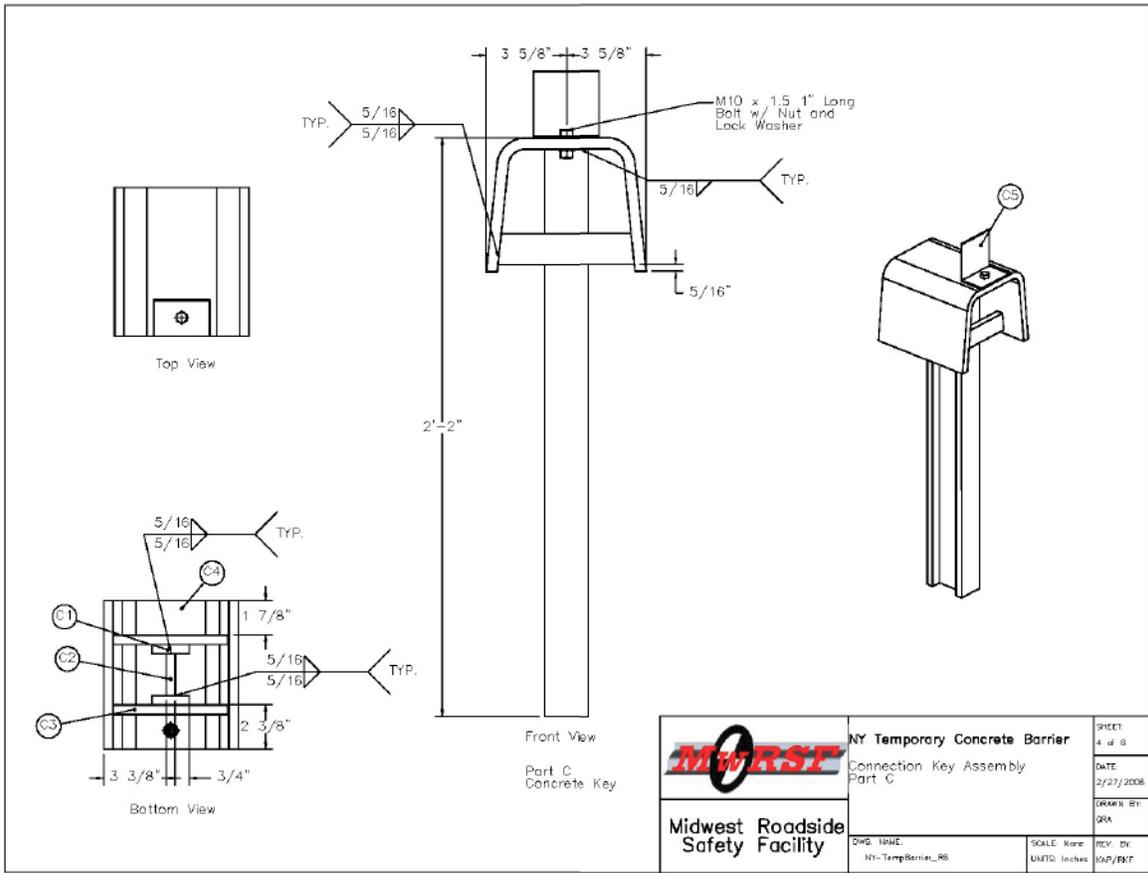


Figure E-14. Connection Key Assembly Details (English), Test NYTCB-2

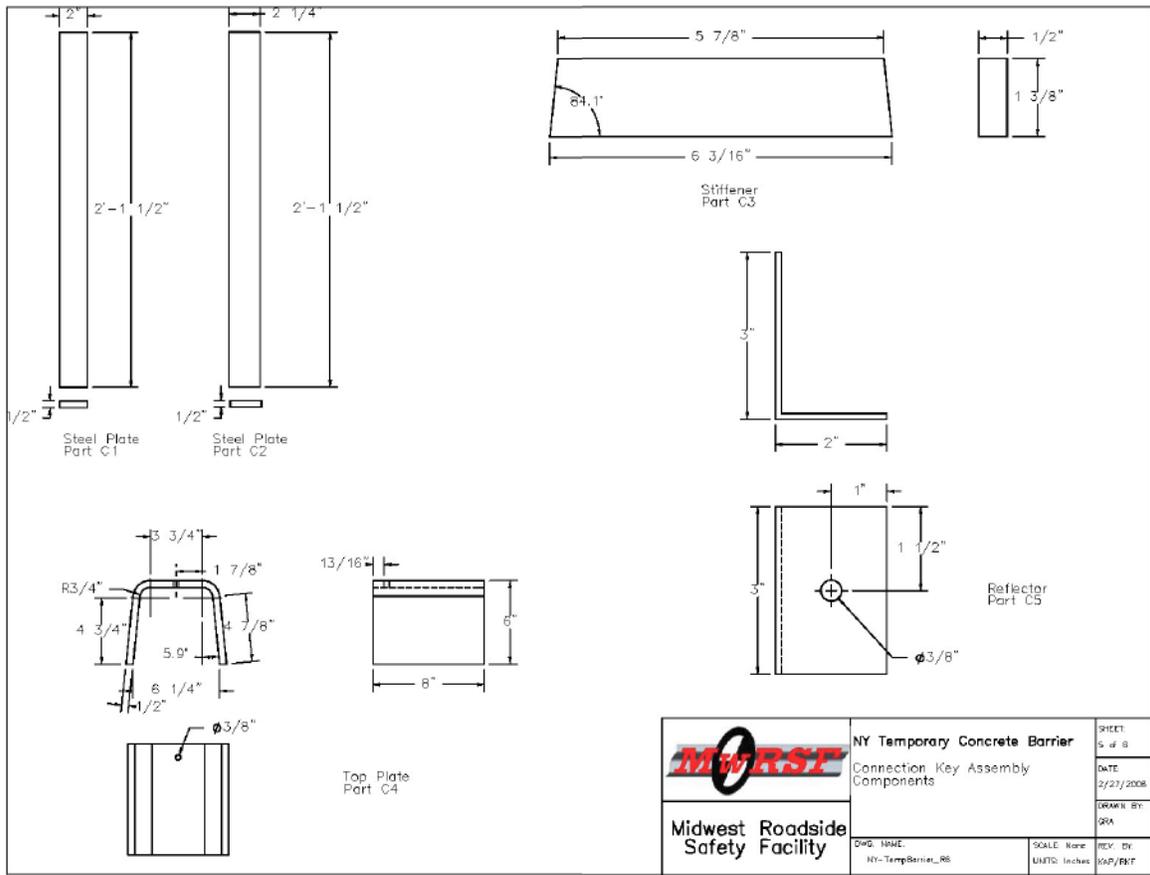


Figure E-15. Connection Key Assembly Details (English), Test NYTCB-2

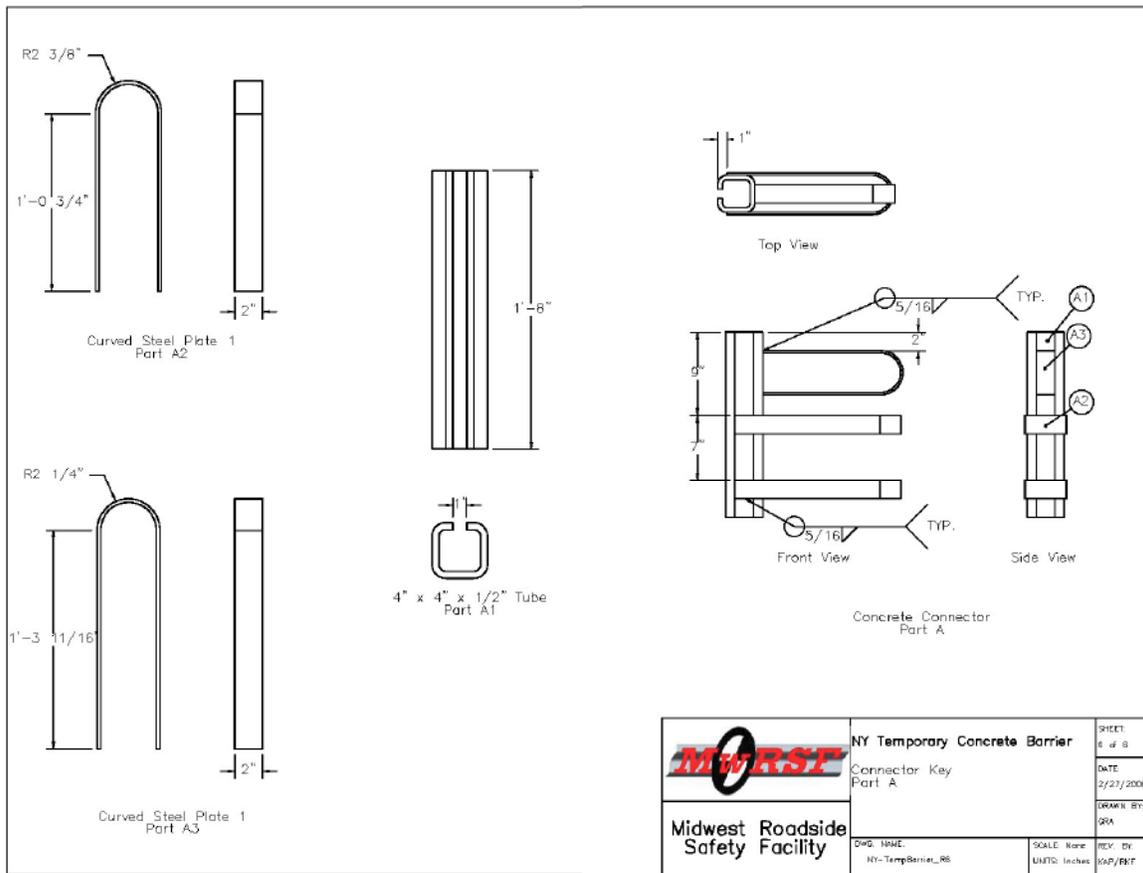


Figure E-16. Temporary Concrete Barrier Connector Assembly Details (English), Test NYTCB-2

APPENDIX F

Accelerometer and Rate Transducer Data Analysis, Test NYTCB-2

Figure F-1. Graph of Longitudinal Deceleration, Test NYTCB-2

Figure F-2. Graph of Longitudinal Occupant Impact Velocity, Test NYTCB-2

Figure F-3. Graph of Longitudinal Occupant Displacement, Test NYTCB-2

Figure F-4. Graph of Lateral Deceleration, Test NYTCB-2

Figure F-5. Graph of Lateral Occupant Impact Velocity, Test NYTCB-2

Figure F-6. Graph of Lateral Occupant Displacement, Test NYTCB-2

Figure F-7. Graph of Roll, Pitch, and Yaw Angular Displacements, Test NYTCB-2

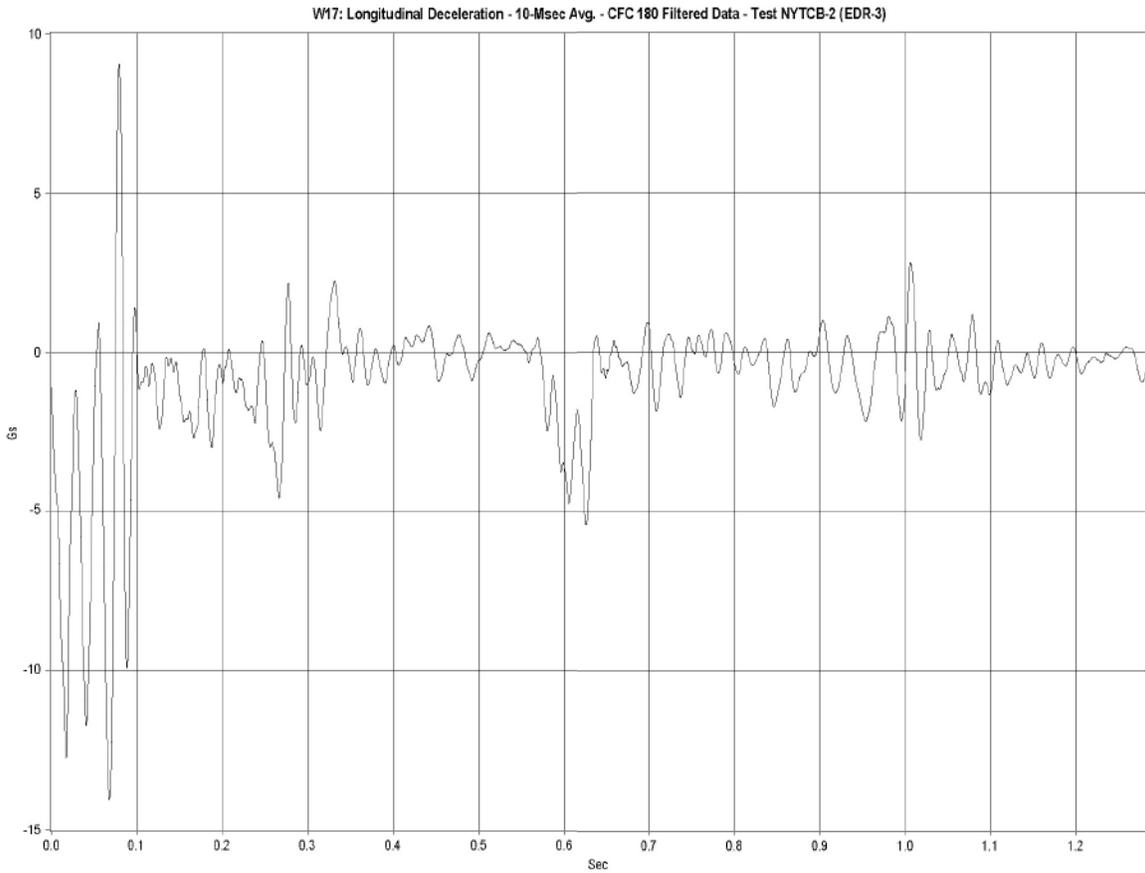


Figure F-1. Graph of Longitudinal Deceleration, Test NYTCB-2

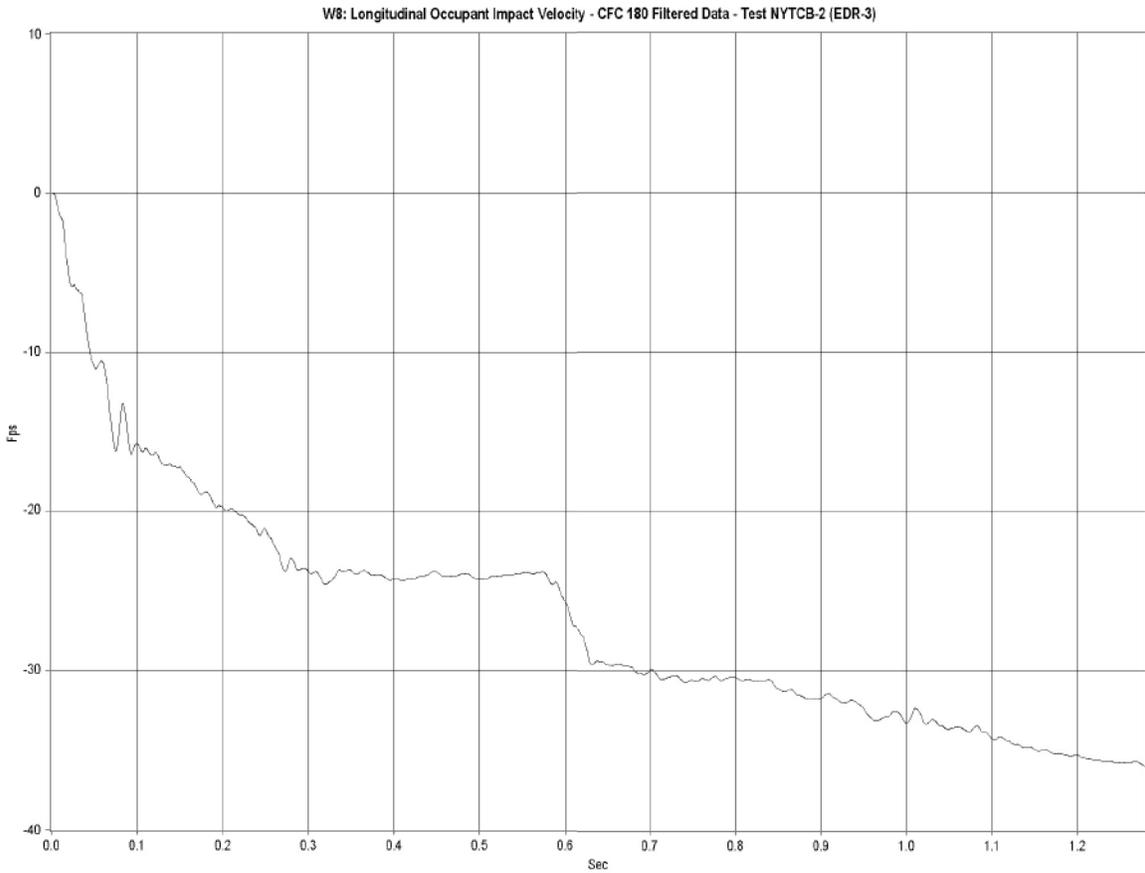


Figure F-2. Graph of Longitudinal Impact Velocity, Test NYTCB-2

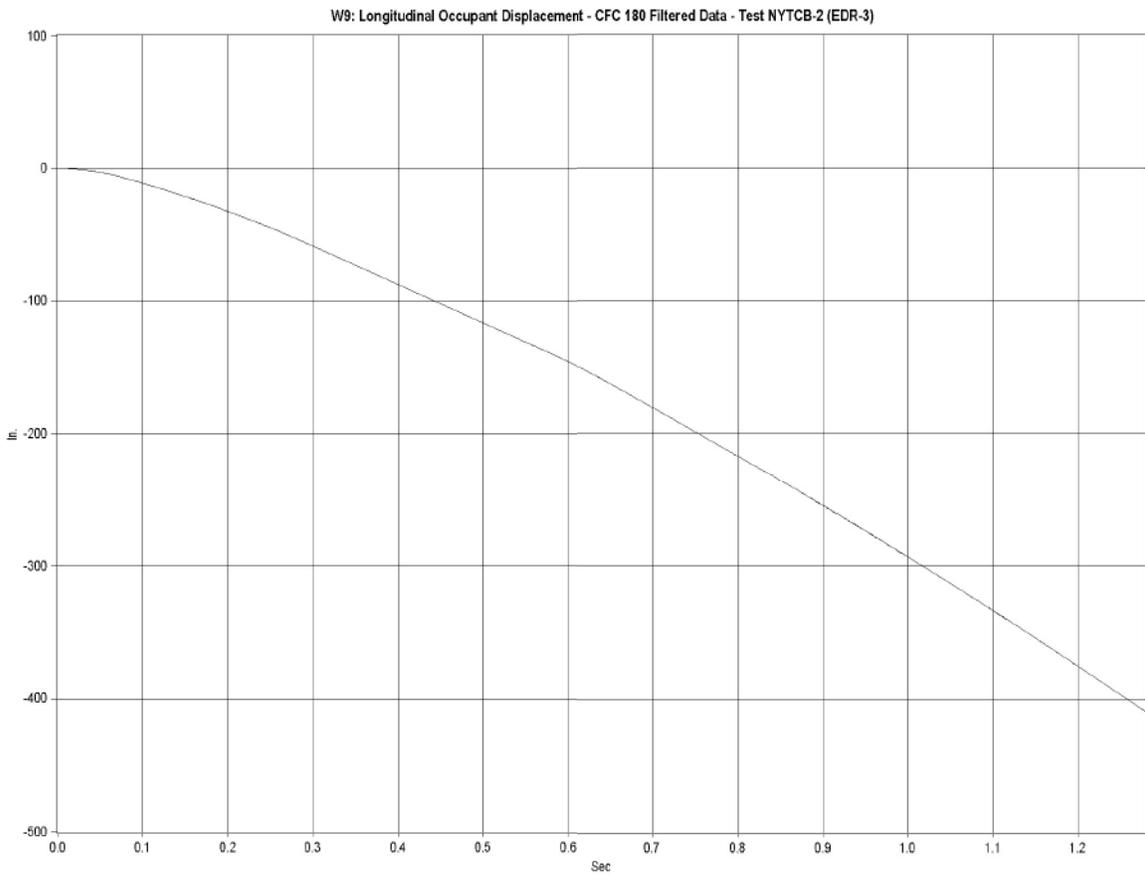


Figure F-3. Graph of Longitudinal Occupant Displacement, Test NYTCB-2

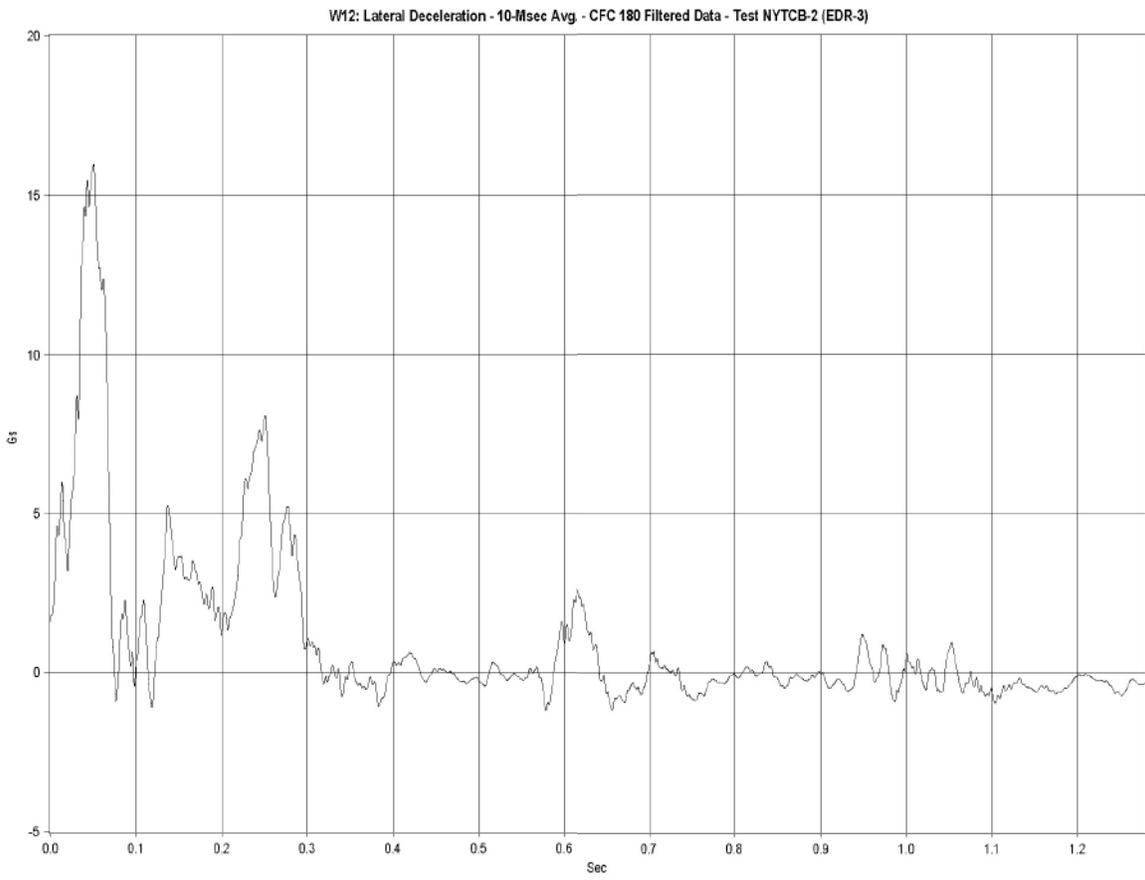


Figure F-4. Graph of Lateral Deceleration, Test NYTCB-2

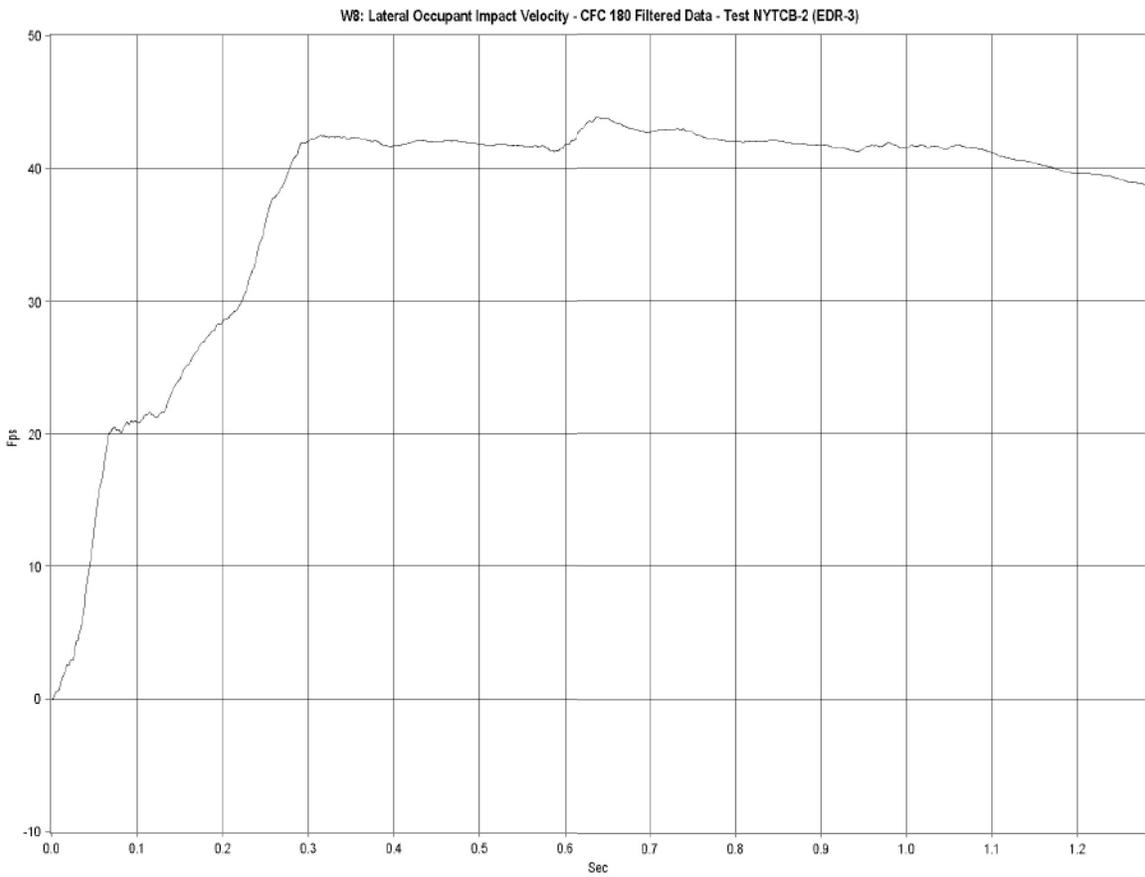


Figure F-5. Graph of Lateral Occupant Impact Velocity, Test NYTCB-2

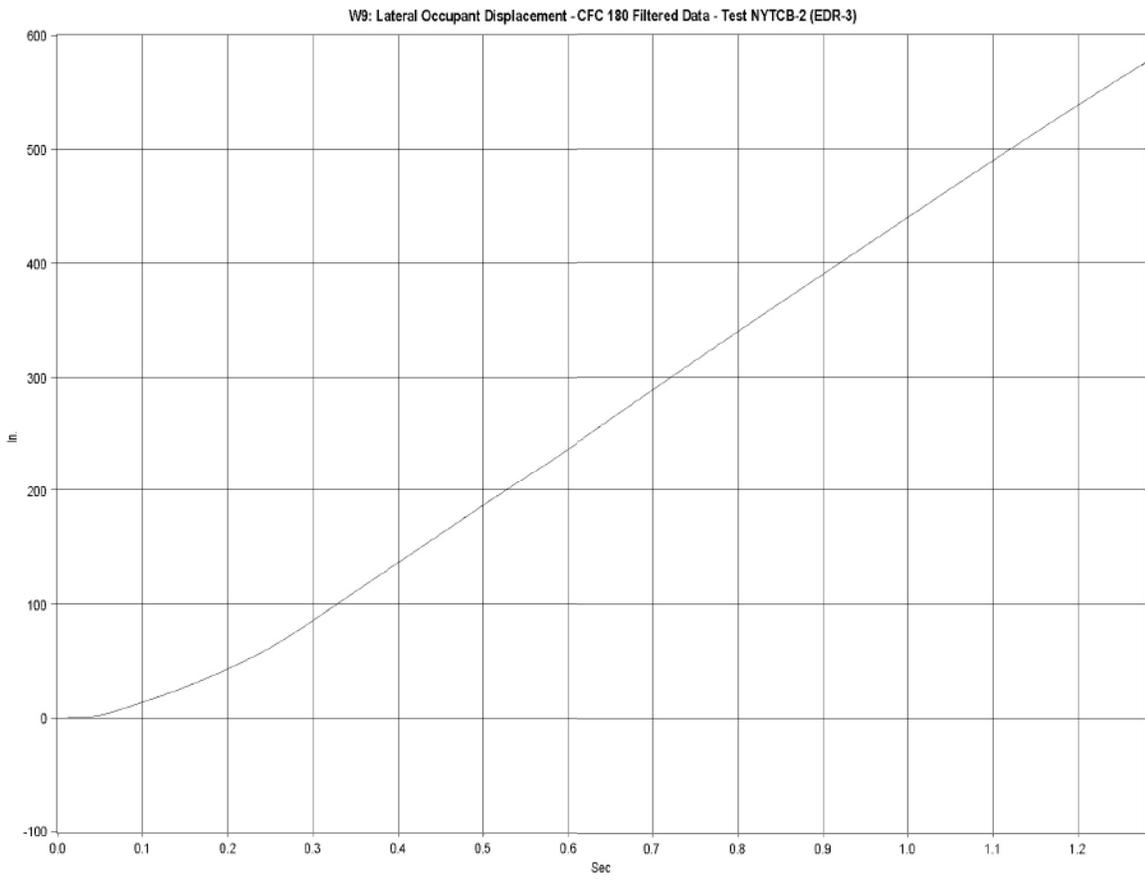


Figure F-6. Graph of Lateral Occupant Displacement, Test NYTCB-2

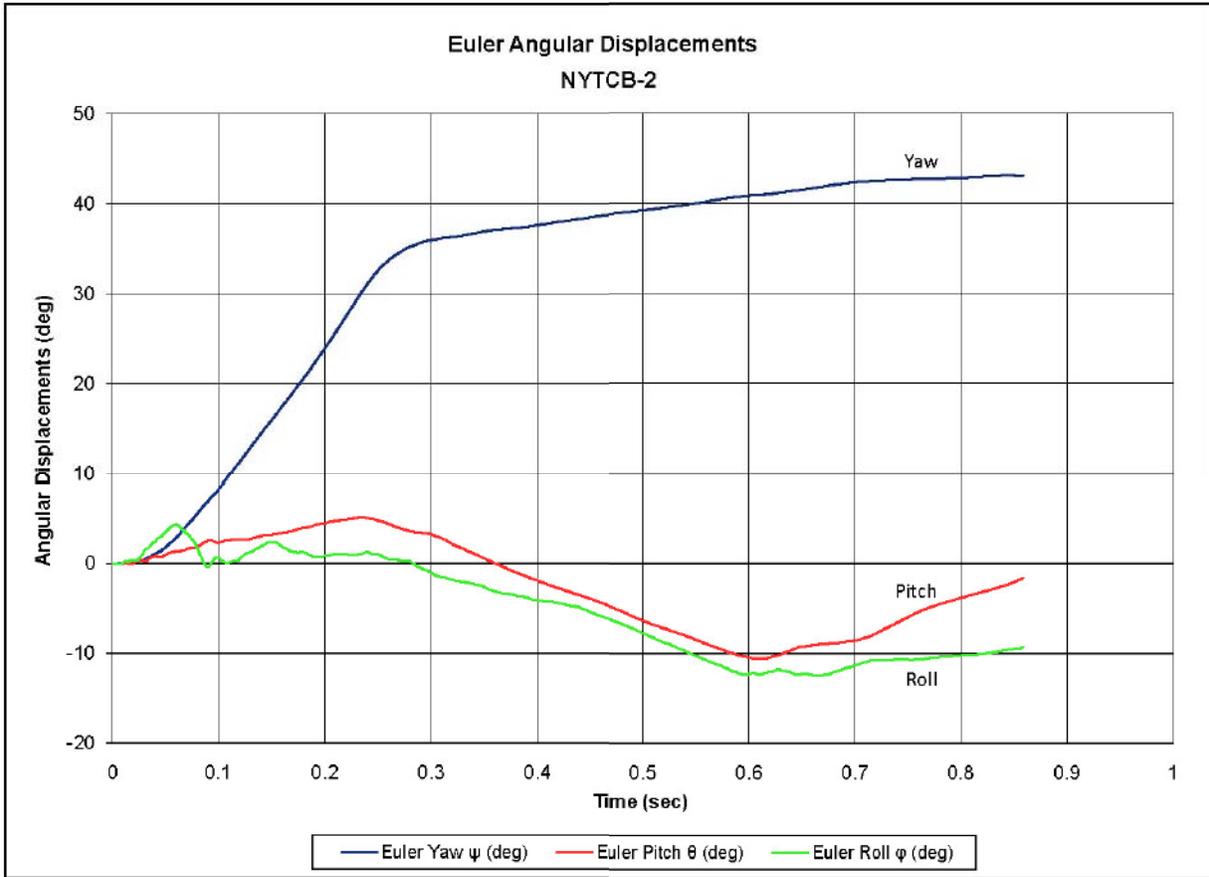


Figure F-7. Graph of Roll, Pitch, and Yaw Angular Displacements, Test NYTCB-2

APPENDIX G

Metric- and English-Unit System Drawings, Test NYTCB-3

Figure G-1. Stiffened Temporary Concrete Barrier System Layout, Test NYTCB-3

Figure G-2. Temporary Concrete Barrier Details, Test NYTCB-3

Figure G-3. Temporary Concrete Barrier Reinforcement Details, Test NYTCB-3

Figure G-4. Bill of Bars, Test NYTCB-3

Figure G-5. Temporary Concrete Barrier Connection Details, Test NYTCB-3

Figure G-6. Connection Key Assembly Details, Test NYTCB-3

Figure G-7. Connection Key Assembly Details, Test NYTCB-3

Figure G-8. Temporary Concrete Barrier Connector Assembly Details, Test NYTCB-3

Figure G-9. Box Beam Stiffener Details, Test NYTCB-3

Figure G-10. Temporary Concrete Barrier Stiffener Hole Details, Test NYTCB-3

Figure G-11. Box Beam Stiffener Details, Test NYTCB-3

Figure G-12. Stiffened Temporary Concrete Barrier System Layout (English), Test NYTCB-3

Figure G-13. Temporary Concrete Barrier Details (English), Test NYTCB-3

Figure G-14. Temporary Concrete Barrier Reinforcement Details (English), Test NYTCB-3

Figure G-15. Bill of Bars (English), Test NYTCB-3

Figure G-16. Temporary Concrete Barrier Connection Details (English), Test NYTCB-3

Figure G-17. Connection Key Assembly Details (English), Test NYTCB-3

Figure G-18. Connection Key Assembly Details (English), Test NYTCB-3

Figure G-19. Temporary Concrete Barrier Connector Assembly Details (English), Test NYTCB-3

Figure G-20. Box Beam Stiffener Details (English), Test NYTCB-3

Figure G-21. Temporary Concrete Barrier Stiffener Hole Details (English), Test NYTCB-3

Figure G-22. Box Beam Stiffener Details (English), Test NYTCB-3

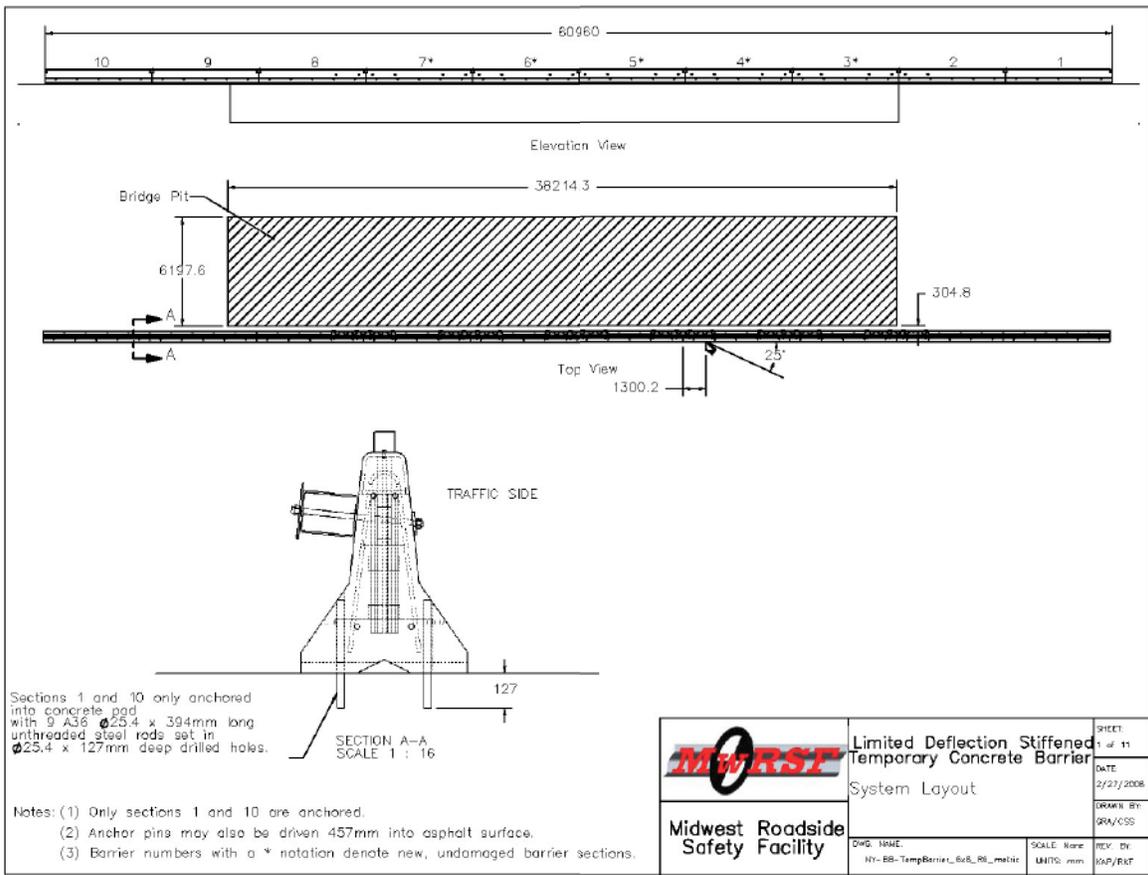


Figure G-1. Stiffened Temporary Concrete Barrier System Layout, Test NYTCB-3

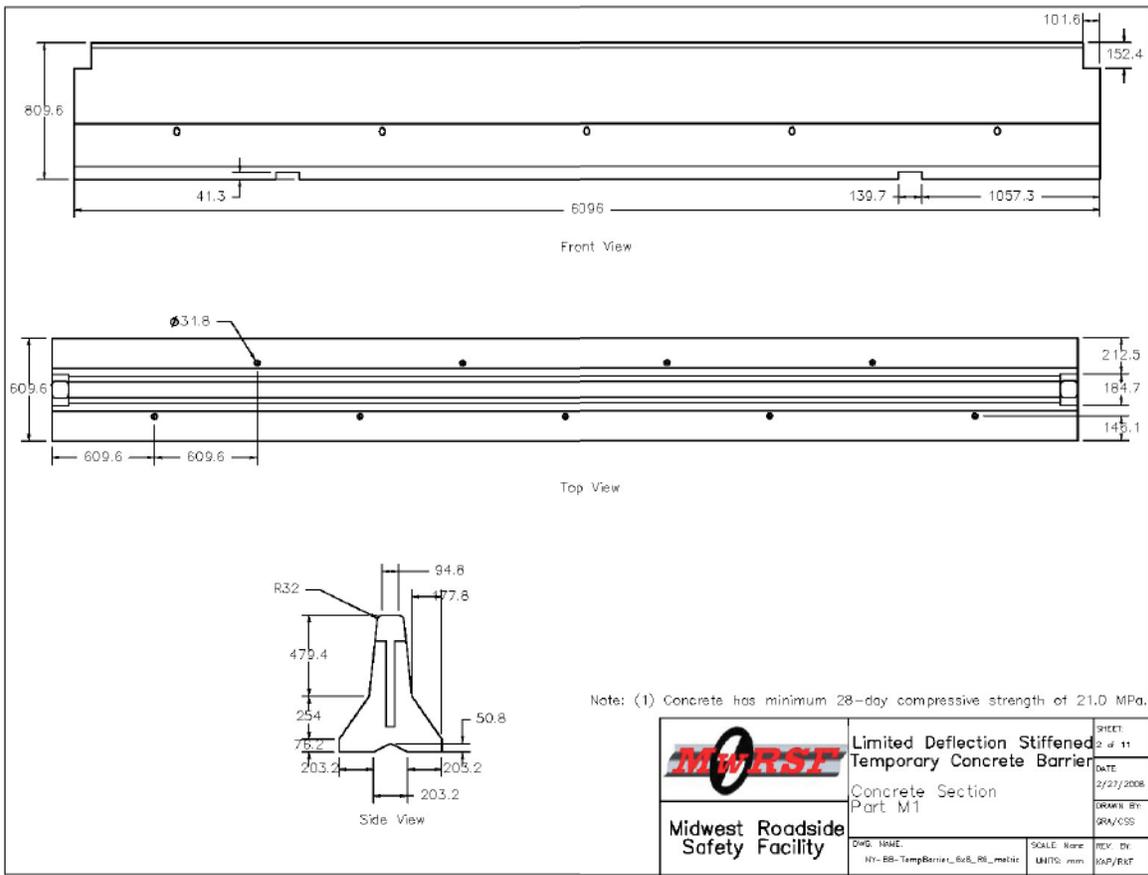


Figure G-2. Temporary Concrete Barrier Details, Test NYTCB-3

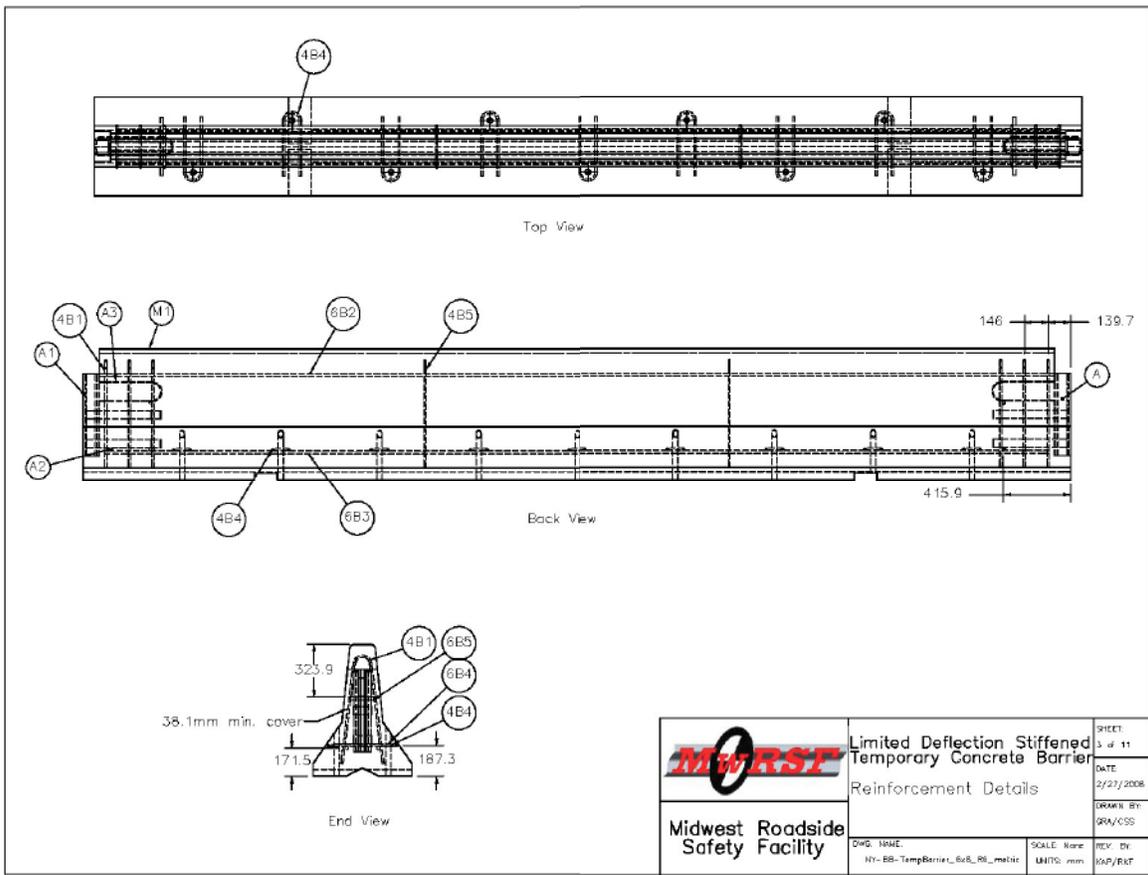


Figure G-3. Temporary Concrete Barrier Reinforcement Details, Test NYTCB-3

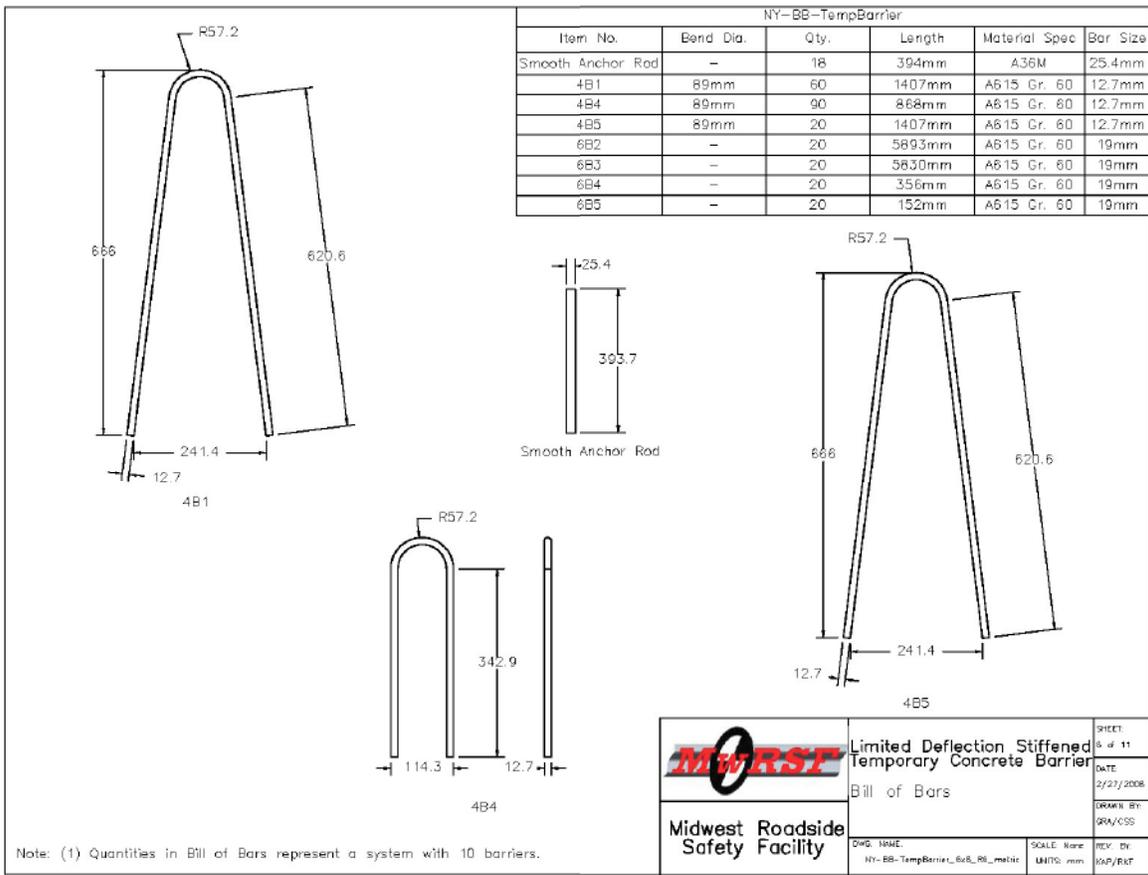


Figure G-4. Bill of Bars, Test NYTCB-3

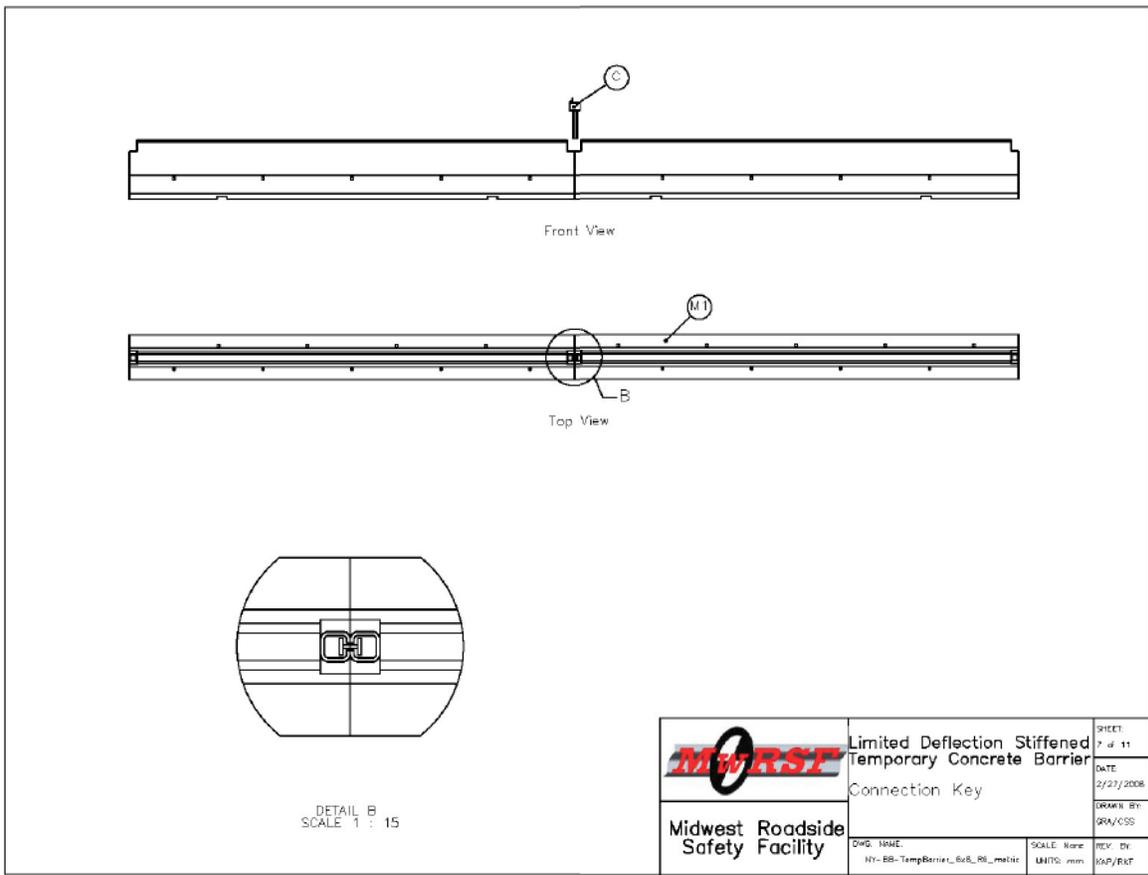


Figure G-5. Temporary Concrete Barrier Connection Details, Test NYTCB-3

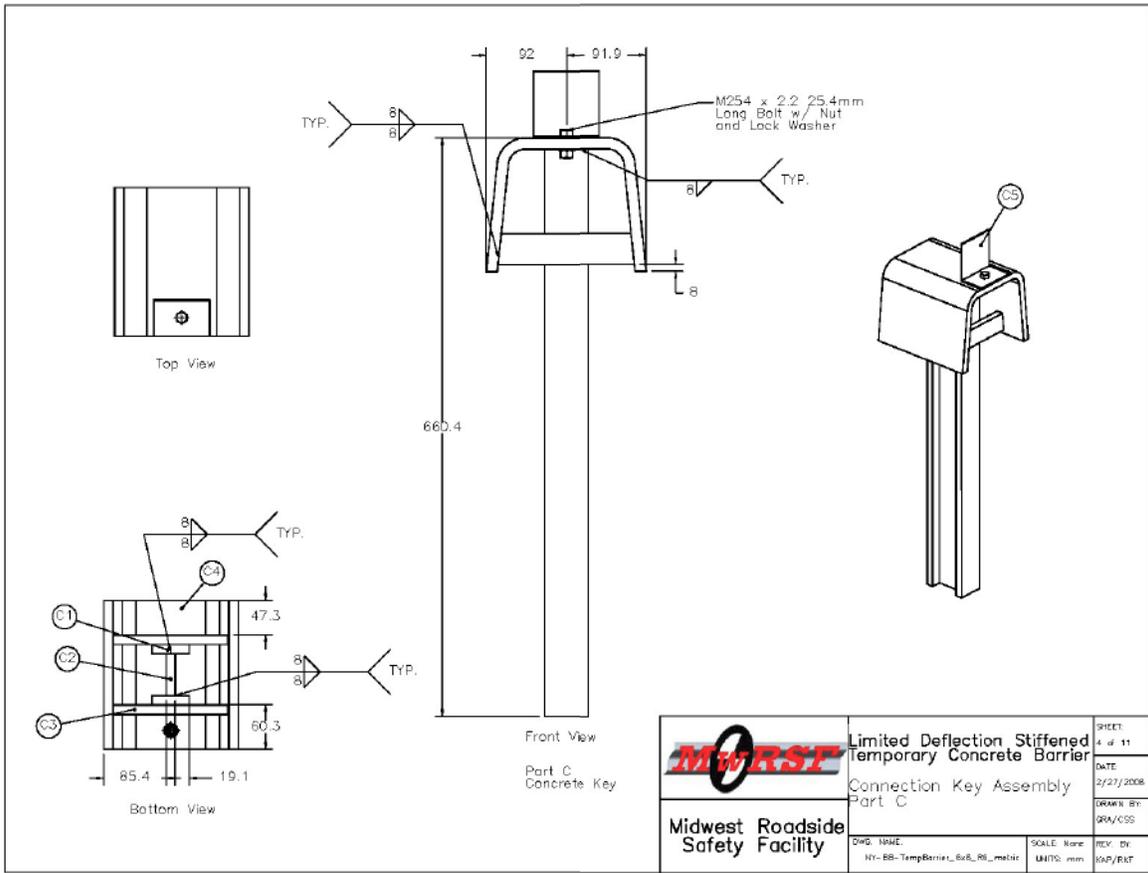


Figure G-6. Connection Key Assembly Details, Test NYTCB-3

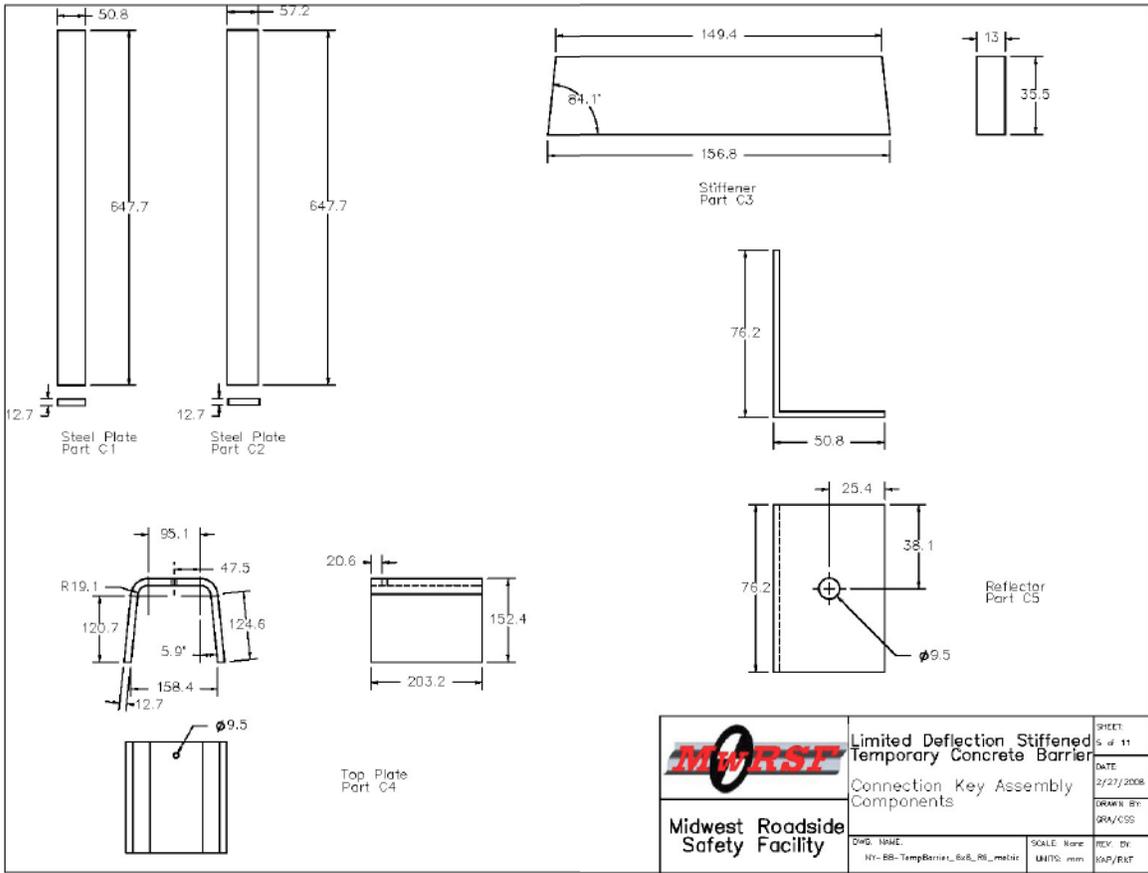


Figure G-7. Connection Key Assembly Details, Test NYTCB-3

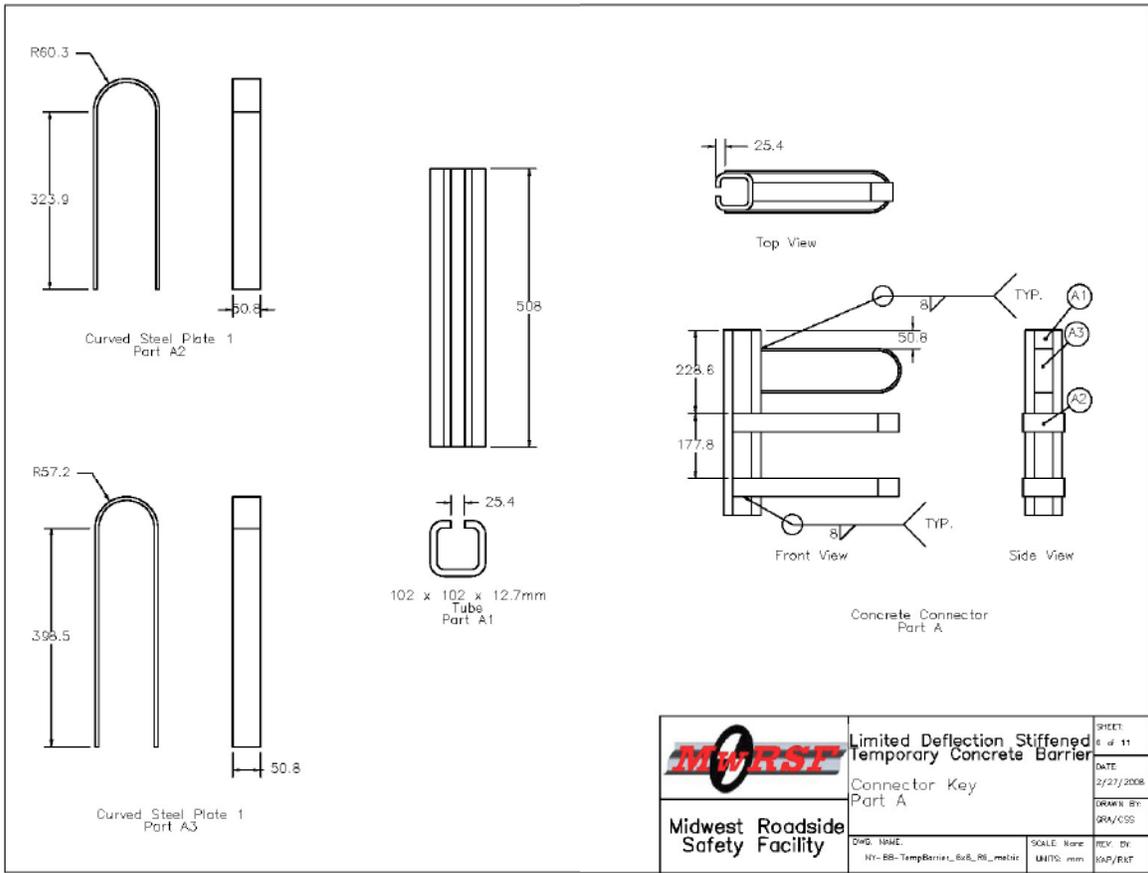


Figure G-8. Temporary Concrete Barrier Connector Assembly Details, Test NYTCB-3

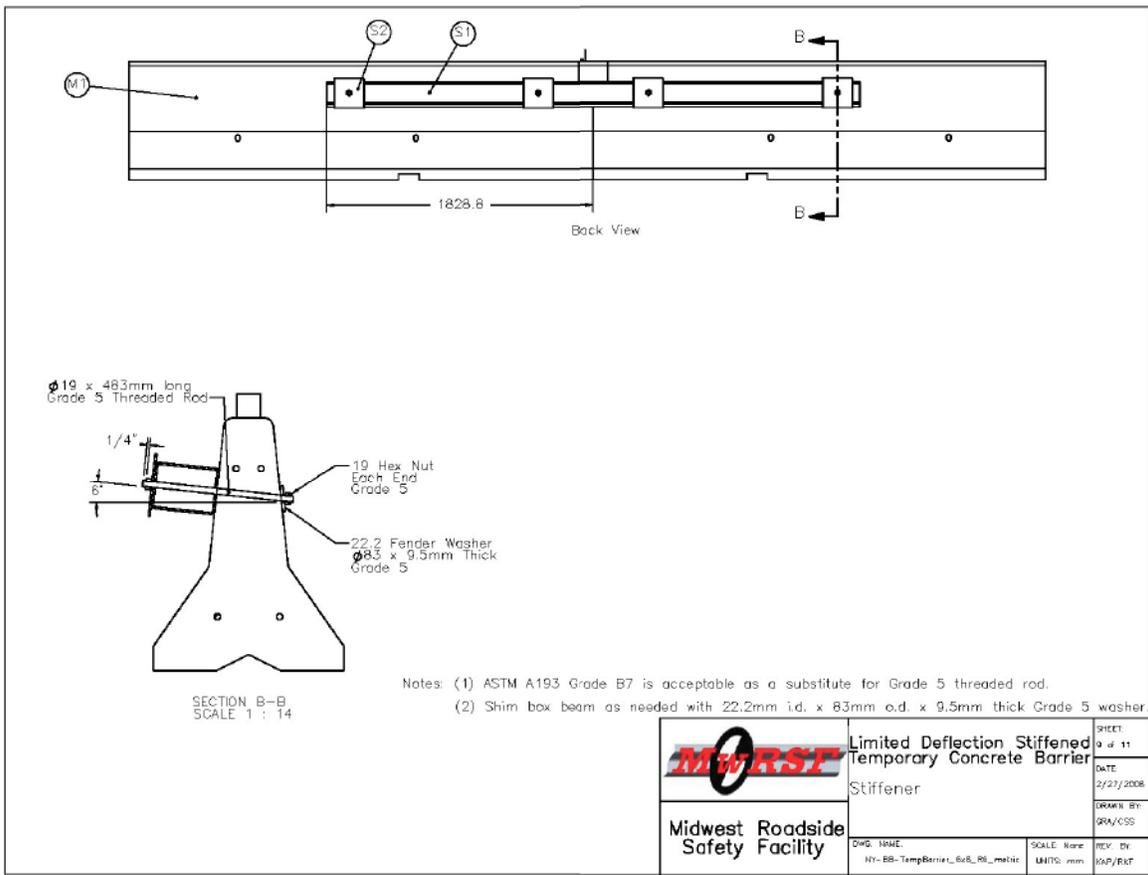


Figure G-9. Box Beam Stiffener Details, Test NYTCB-3

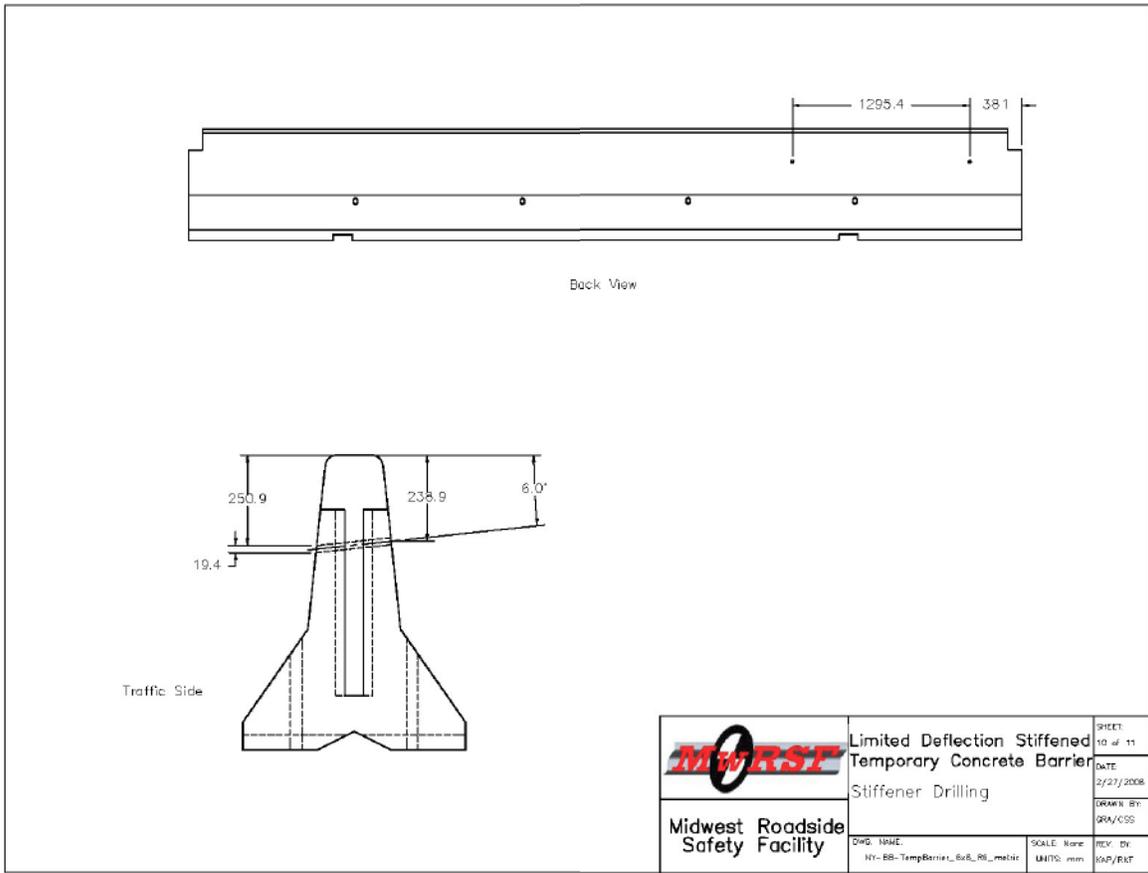


Figure G-10. Temporary Concrete Barrier Stiffener Hole Details, Test NYTCB-3

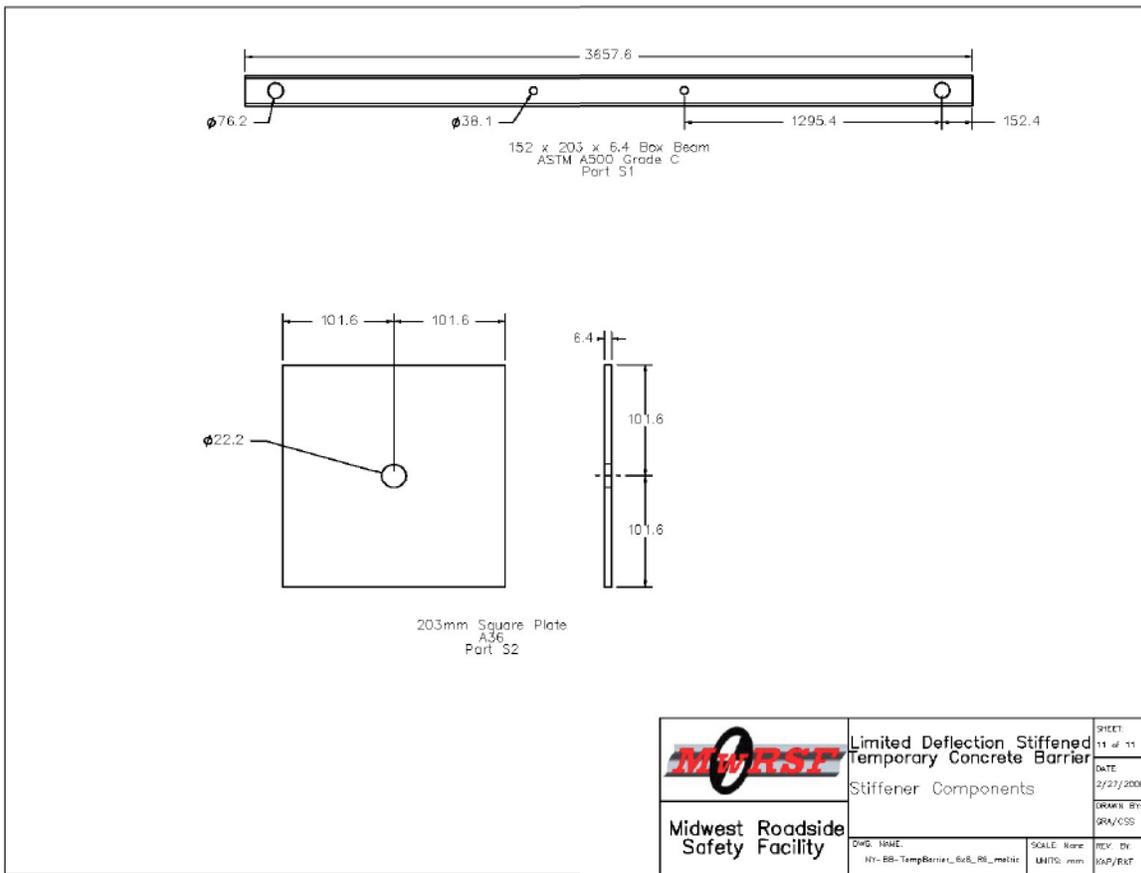


Figure G-11. Box Beam Stiffener Details, Test NYTCB-3

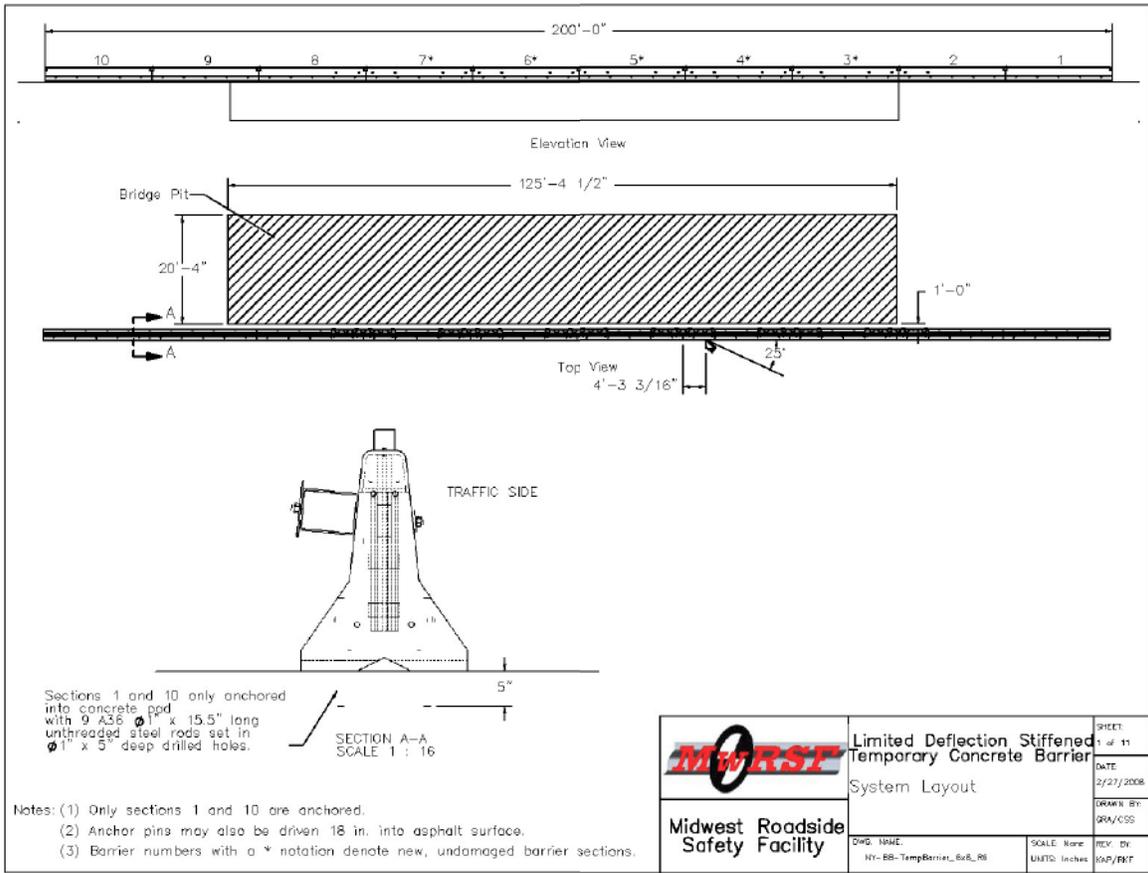


Figure G-12. Stiffened Temporary Concrete Barrier System Layout (English), Test NYTCB-3

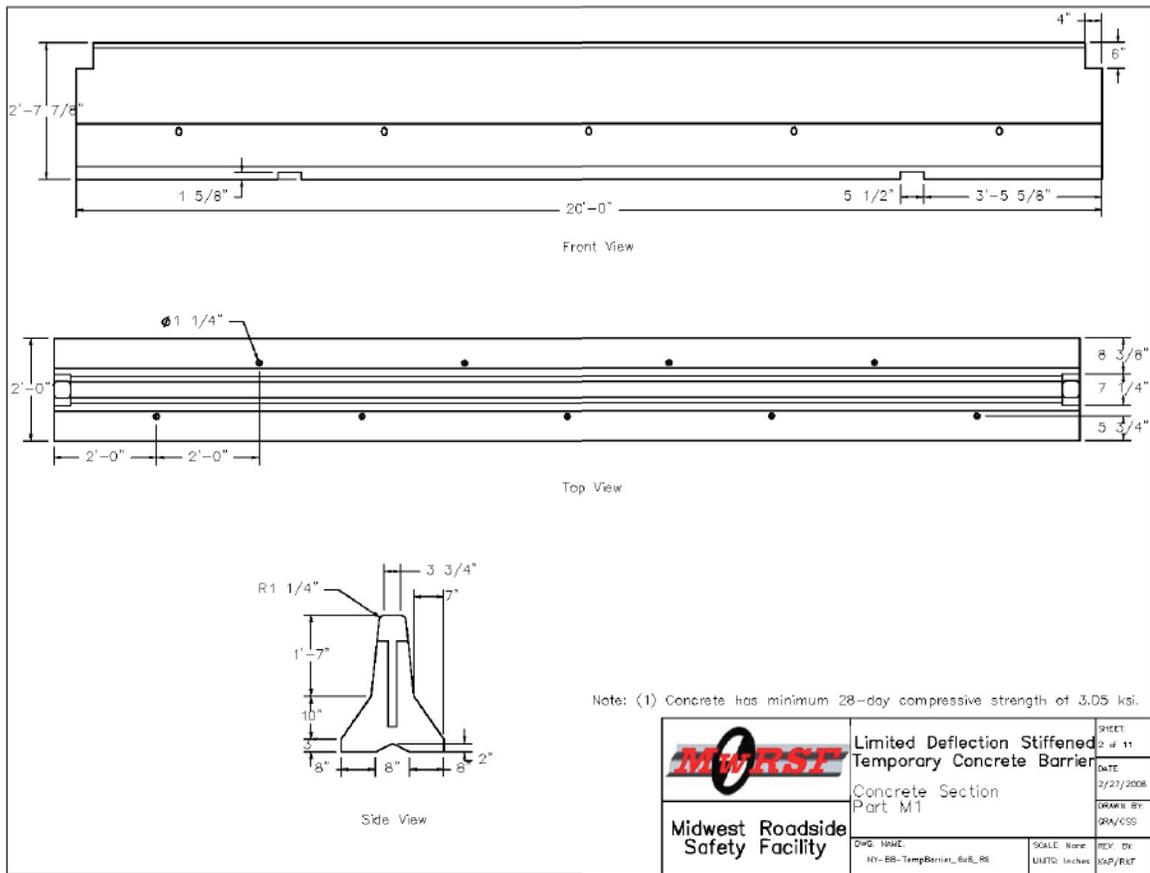


Figure G-13. Temporary Concrete Barrier Details (English), Test NYTCB-3

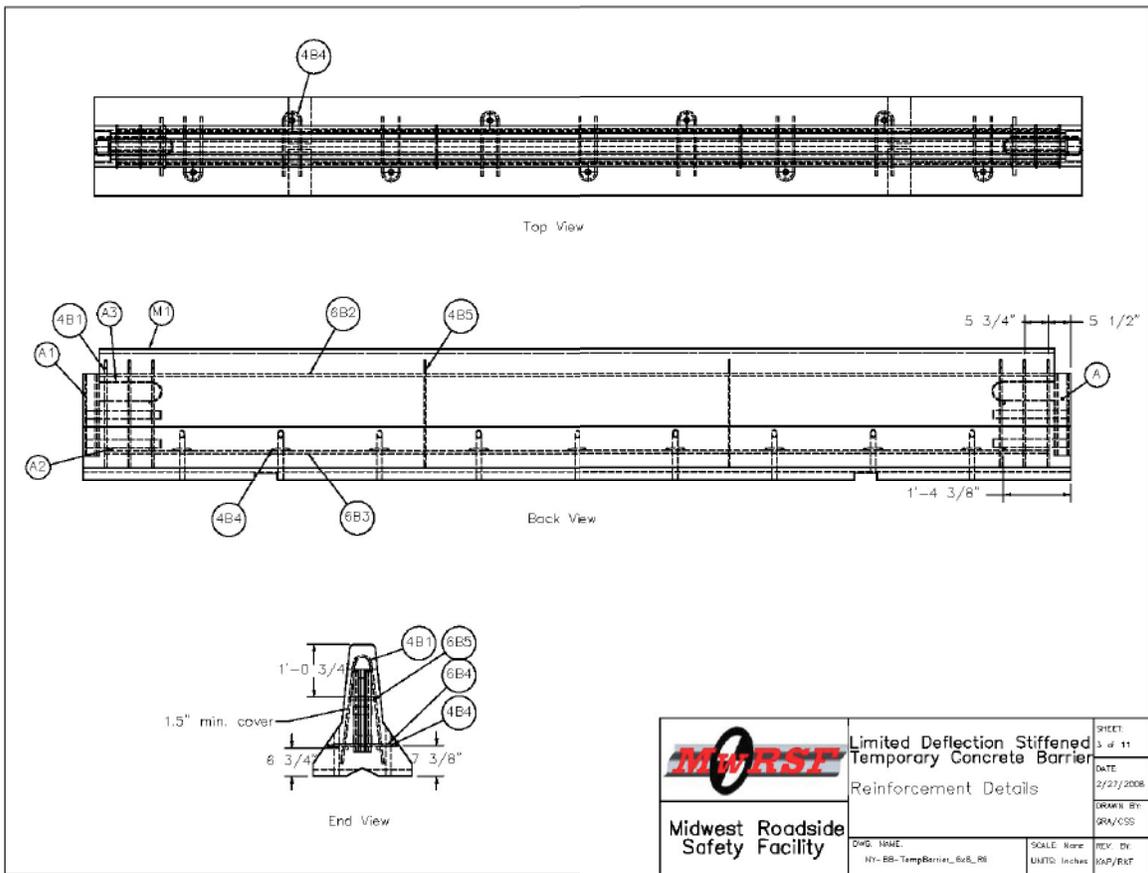


Figure G-14. Temporary Concrete Barrier Reinforcement Details (English), Test NYTCB-3

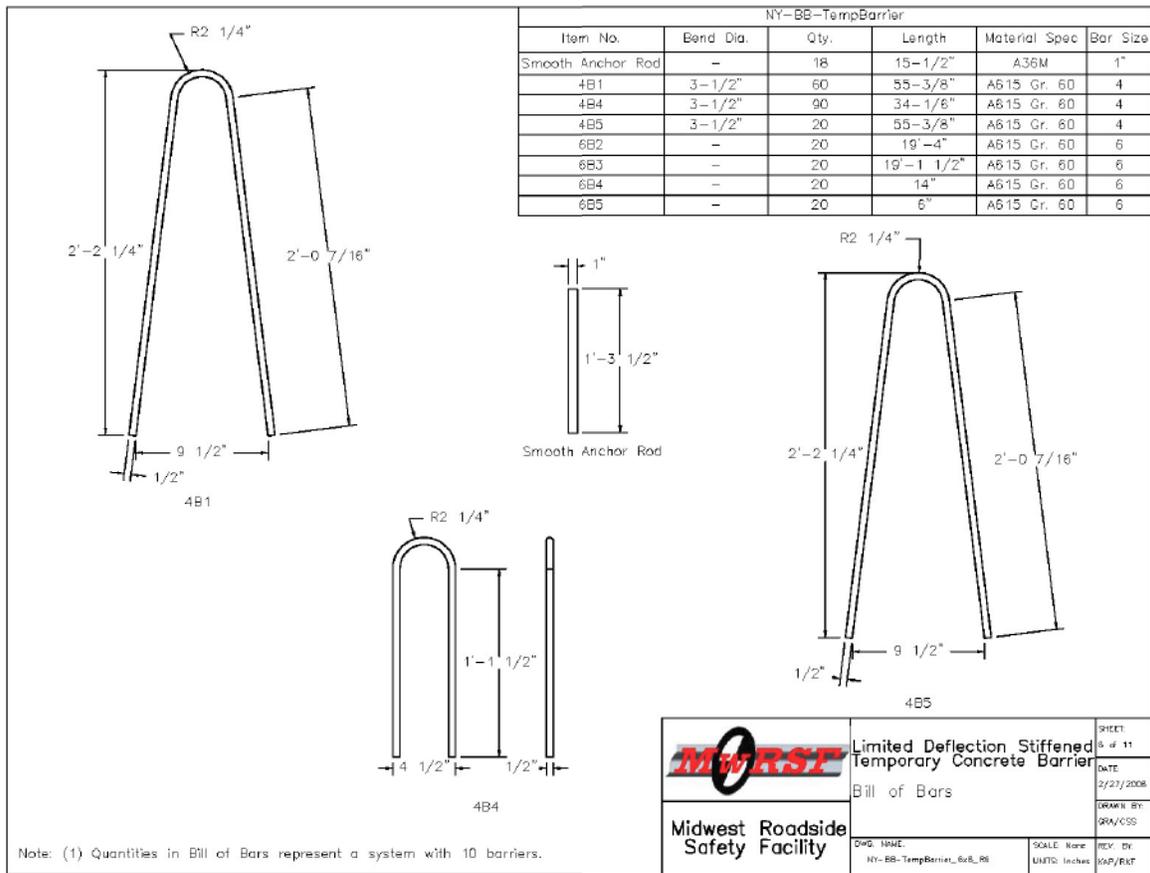


Figure G-15. Bill of Bars (English), Test NYTCB-3

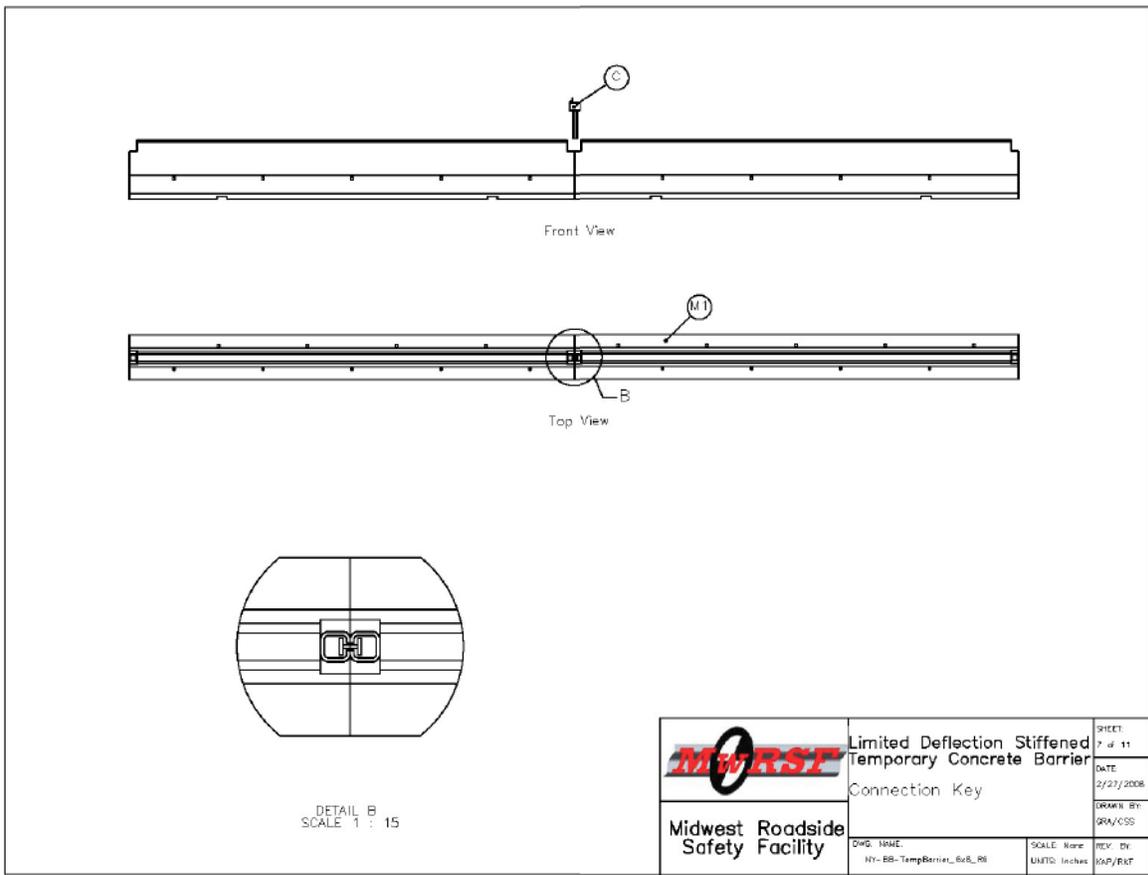
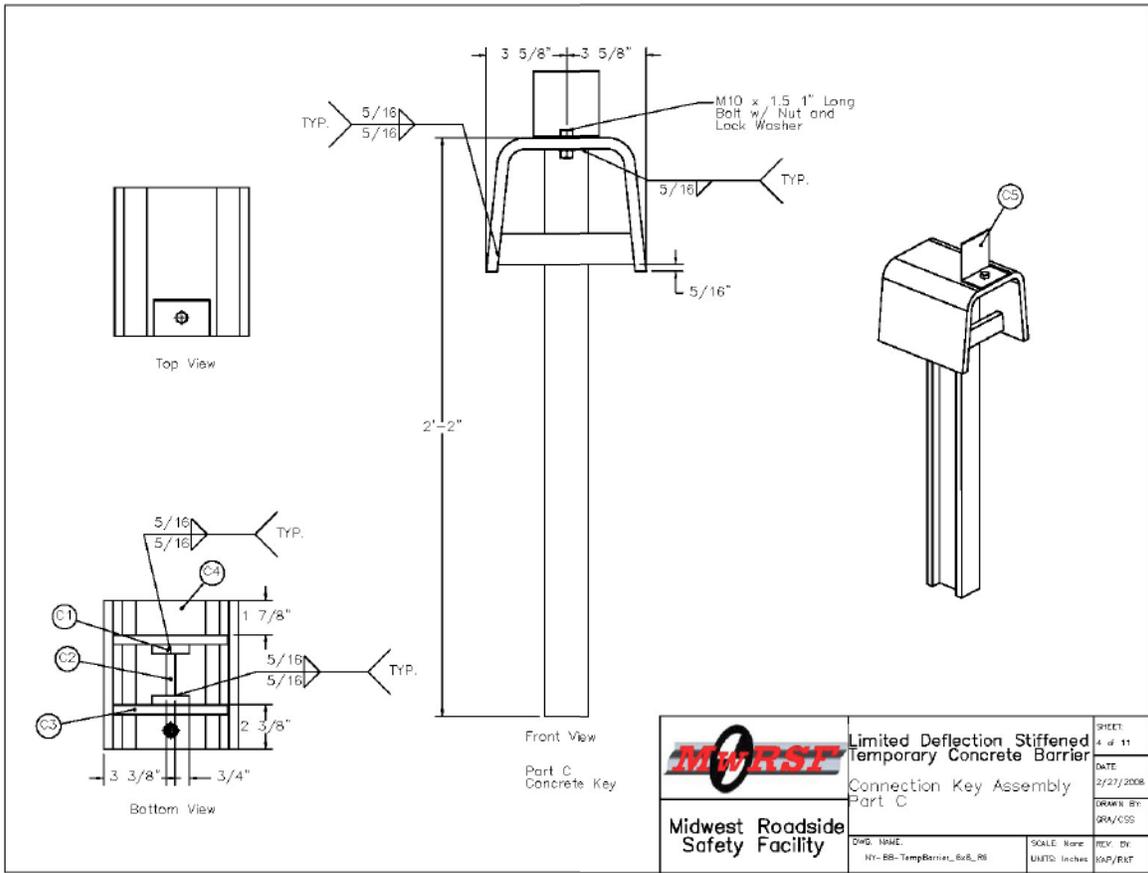


Figure G-16. Temporary Concrete Barrier Connection Details (English), Test NYTCB-3



	Limited Deflection Stiffened Temporary Concrete Barrier	SHEET: 4 of 11
	Connection Key Assembly Part C	DATE: 2/27/2008
Midwest Roadside Safety Facility	DWG. NAME: NY-BB-TempBarrier_6x8_R6	DRAWN BY: BRN/CSS
	SCALE: None UNITS: Inches	REV. BY: GAP/BKT

Figure G-17. Connection Key Assembly Details (English), Test NYTCB-3

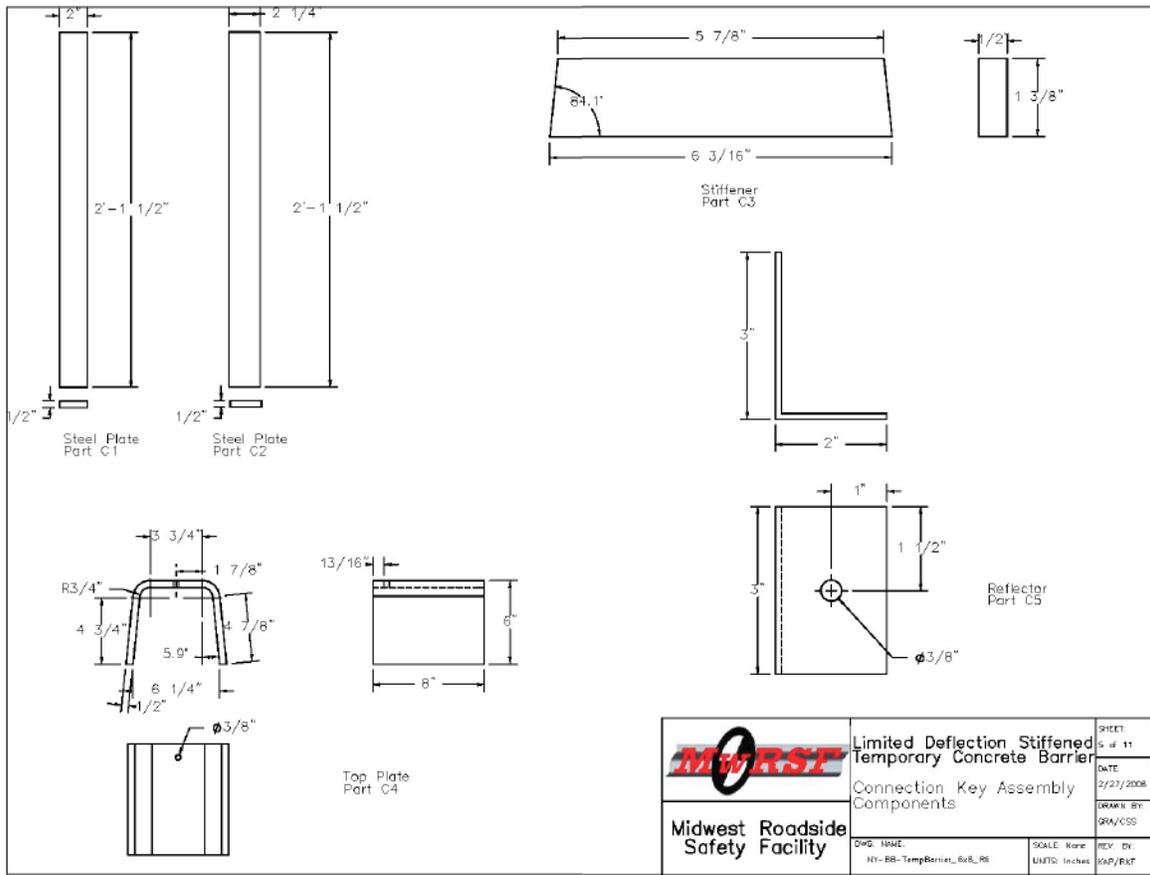


Figure G-18. Connection Key Assembly Details (English), Test NYTCB-3

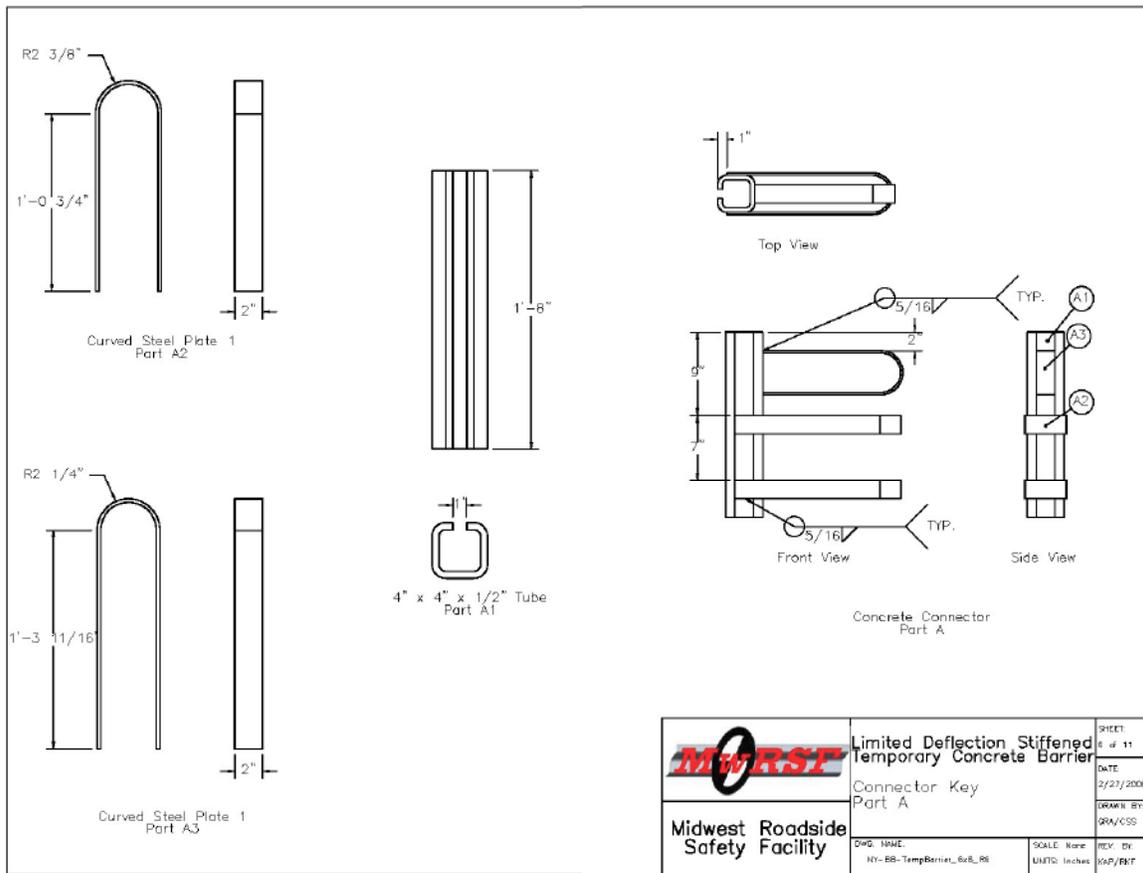


Figure G-19. Temporary Concrete Barrier Connector Assembly Details (English), Test NYTCB-3

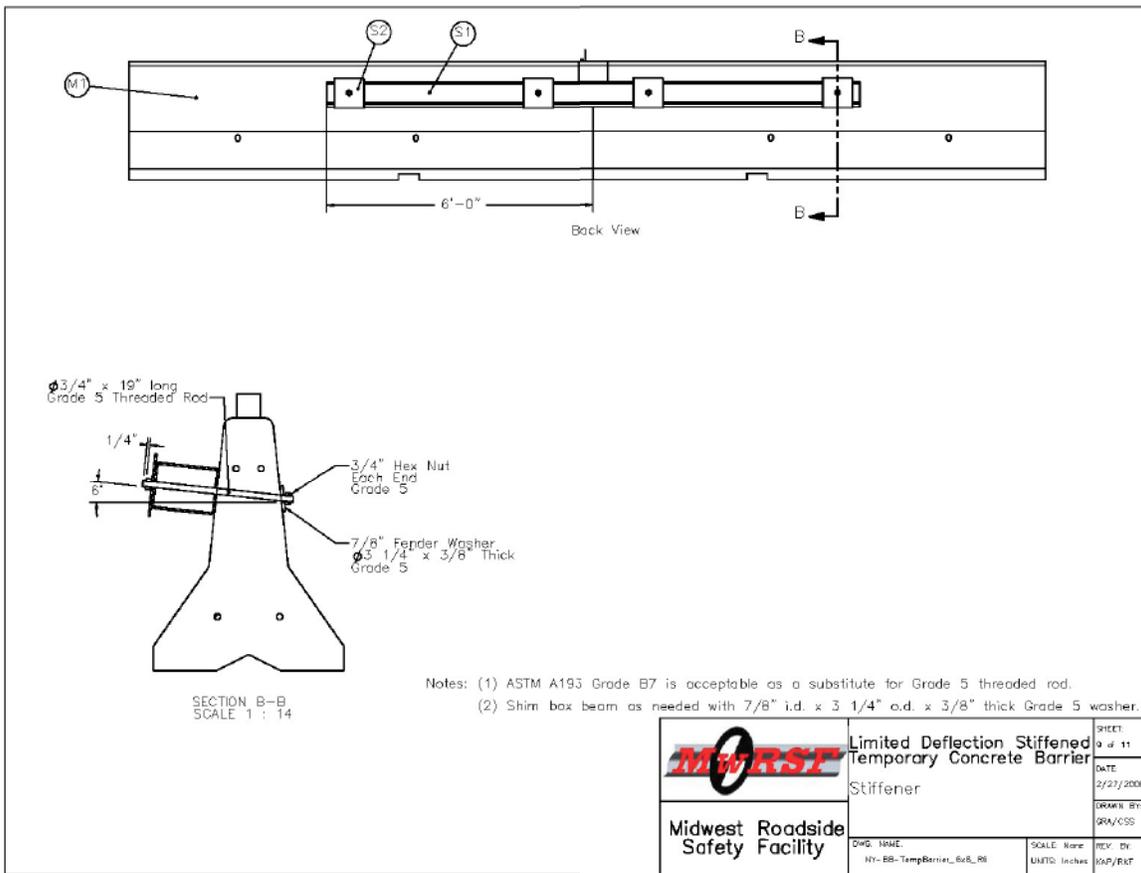


Figure G-20. Box Beam Stiffener Details (English), Test NYTCB-3

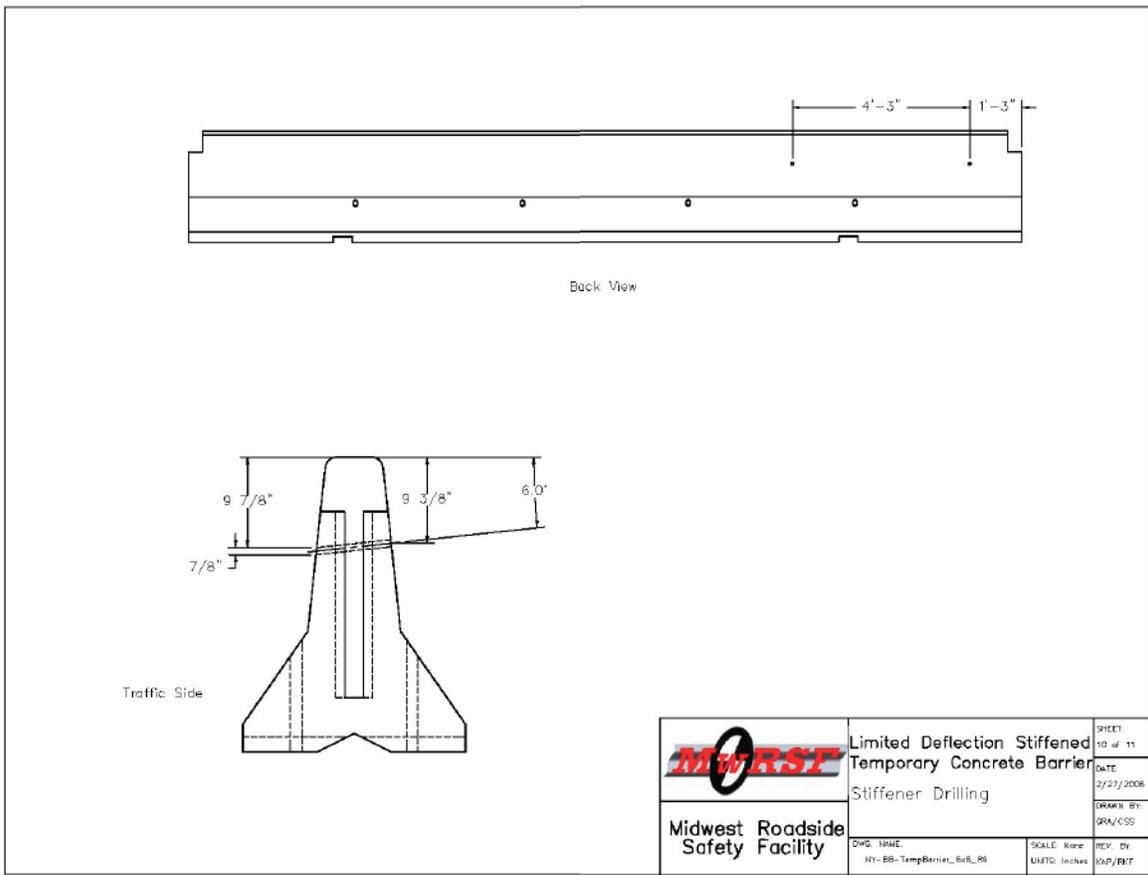
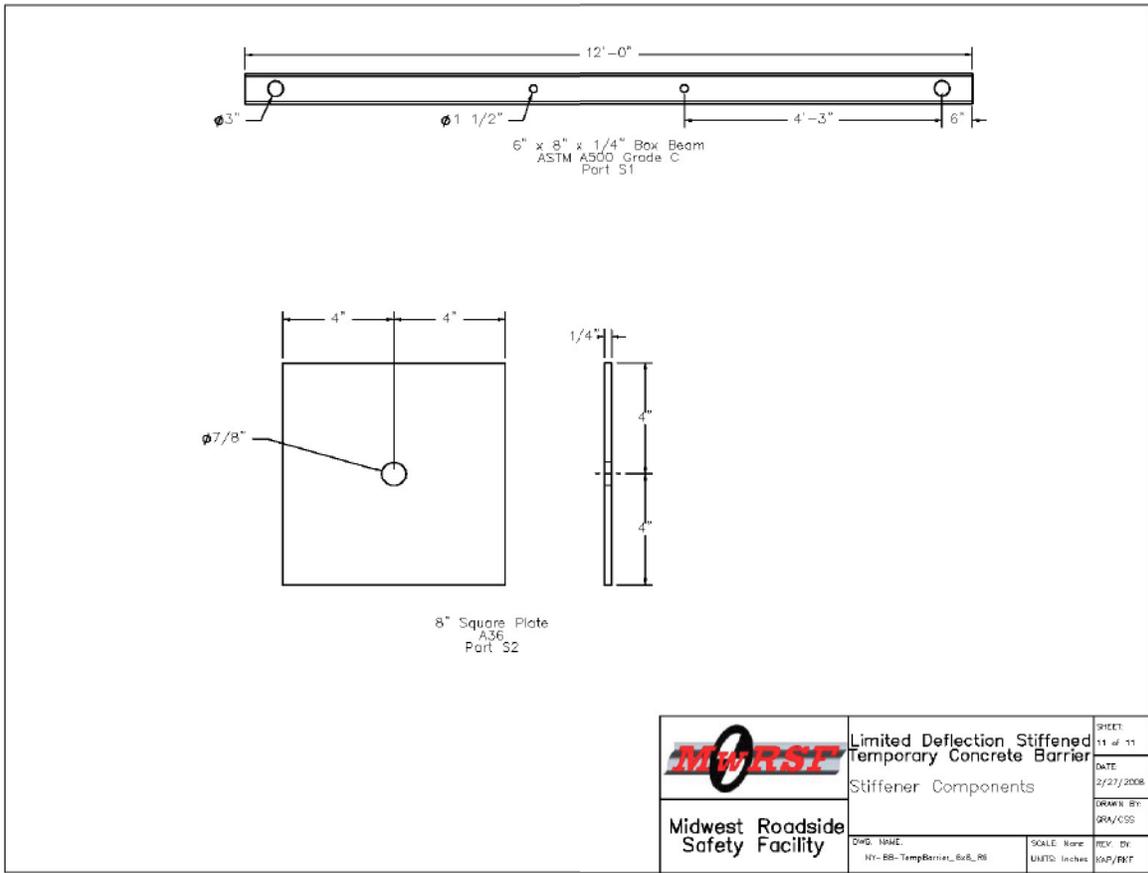


Figure G-21. Temporary Concrete Barrier Stiffener Hole Details (English), Test NYTCB-3



 Midwest Roadside Safety Facility	Limited Deflection Stiffened Temporary Concrete Barrier Stiffener Components	SHEET: 11 of 11
		DATE: 2/27/2008
		DRAWN BY: GRA/CSS
	DWG. NAME: NY-BB-TempBarrier_6x8_R8	SCALE: None UNITS: Inches
		REV. BY: GSP/BJT

Figure G-22. Box Beam Stiffener Details (English), Test NYTCB-3

APPENDIX H

Accelerometer and Rate Transducer Data Analysis, Test NYTCB-3

Figure H-1. Graph of Longitudinal Deceleration, Test NYTCB-3

Figure H-2. Graph of Longitudinal Occupant Impact Velocity, Test NYTCB-3

Figure H-3. Graph of Longitudinal Occupant Displacement, Test NYTCB-3

Figure H-4. Graph of Lateral Deceleration, Test NYTCB-3

Figure H-5. Graph of Lateral Occupant Impact Velocity, Test NYTCB-3

Figure H-6. Graph of Lateral Occupant Displacement, Test NYTCB-3

Figure H-7. Graph of Roll, Pitch, and Yaw Angular Displacements, Test NYTCB-3

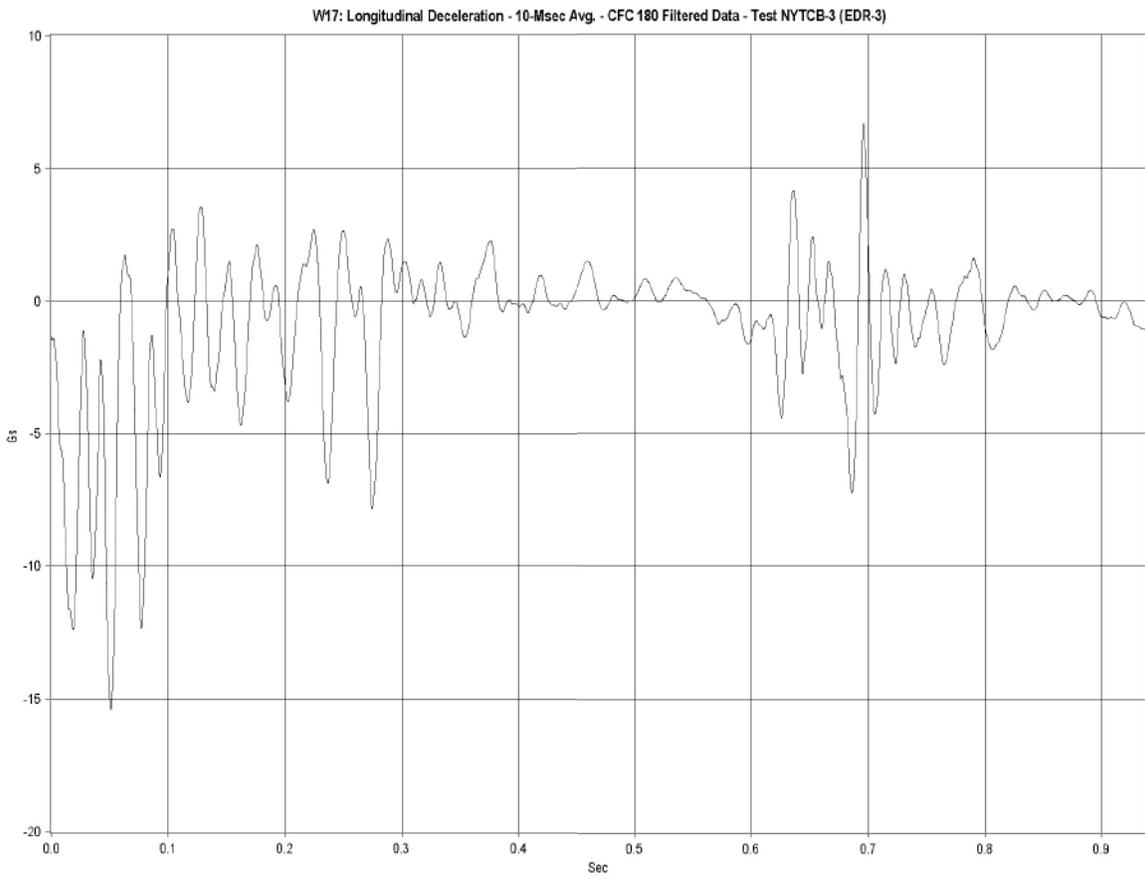


Figure H-1. Graph of Longitudinal Deceleration, Test NYTCB-3

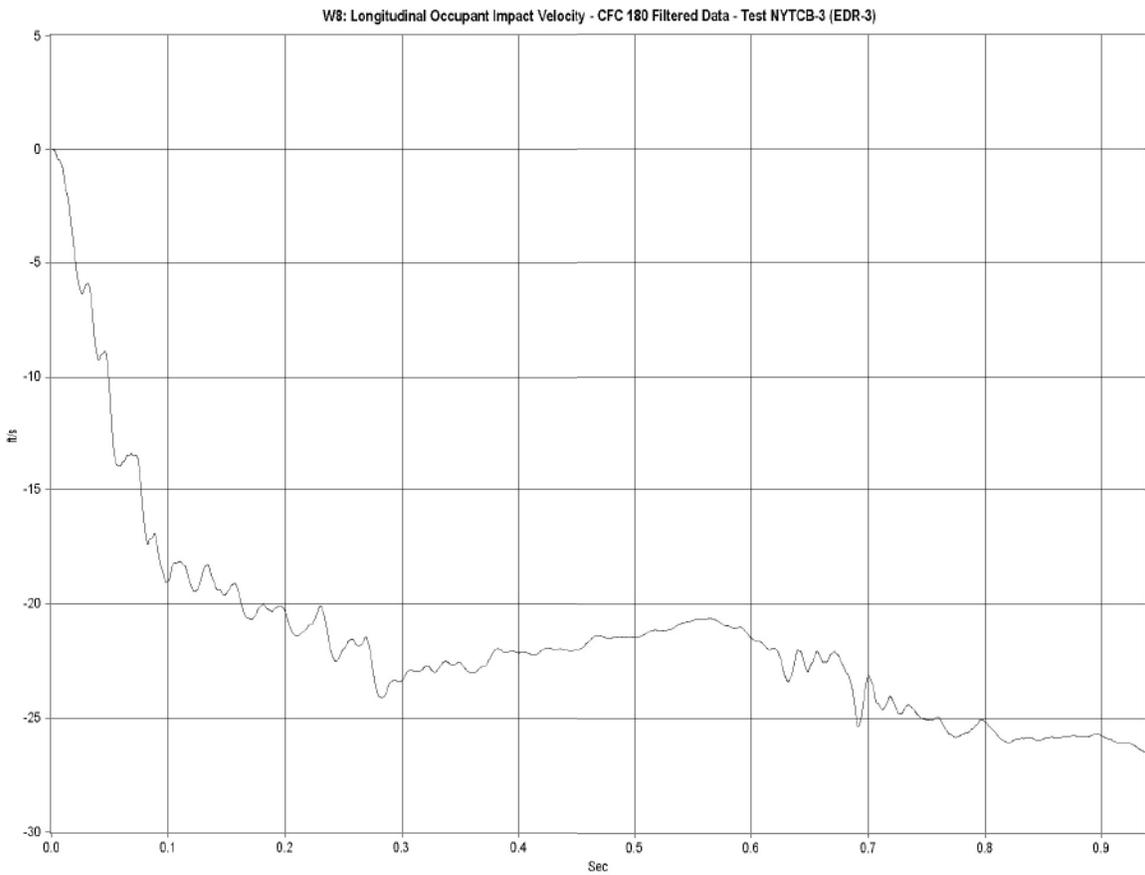


Figure H-2. Graph of Longitudinal Impact Velocity, Test NYTCB-3

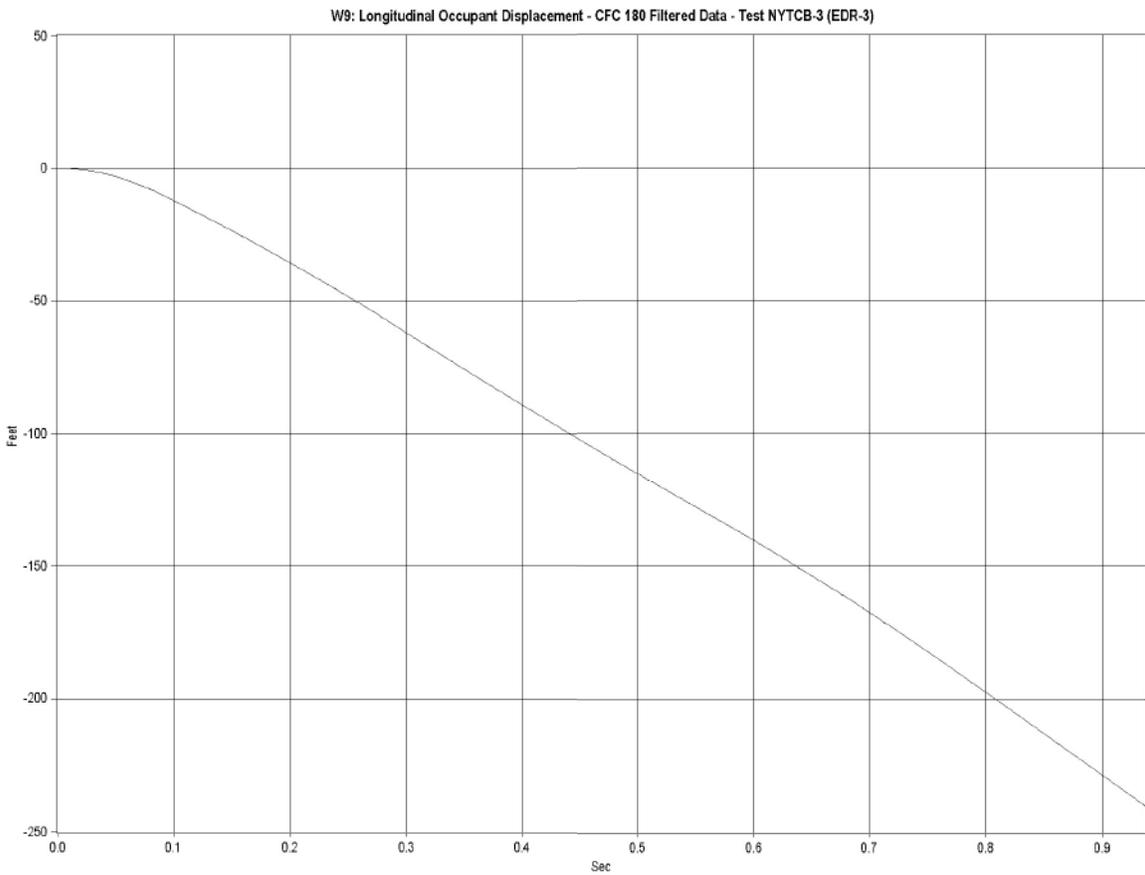


Figure H-3. Graph of Longitudinal Impact Displacement, Test NYTCB-3

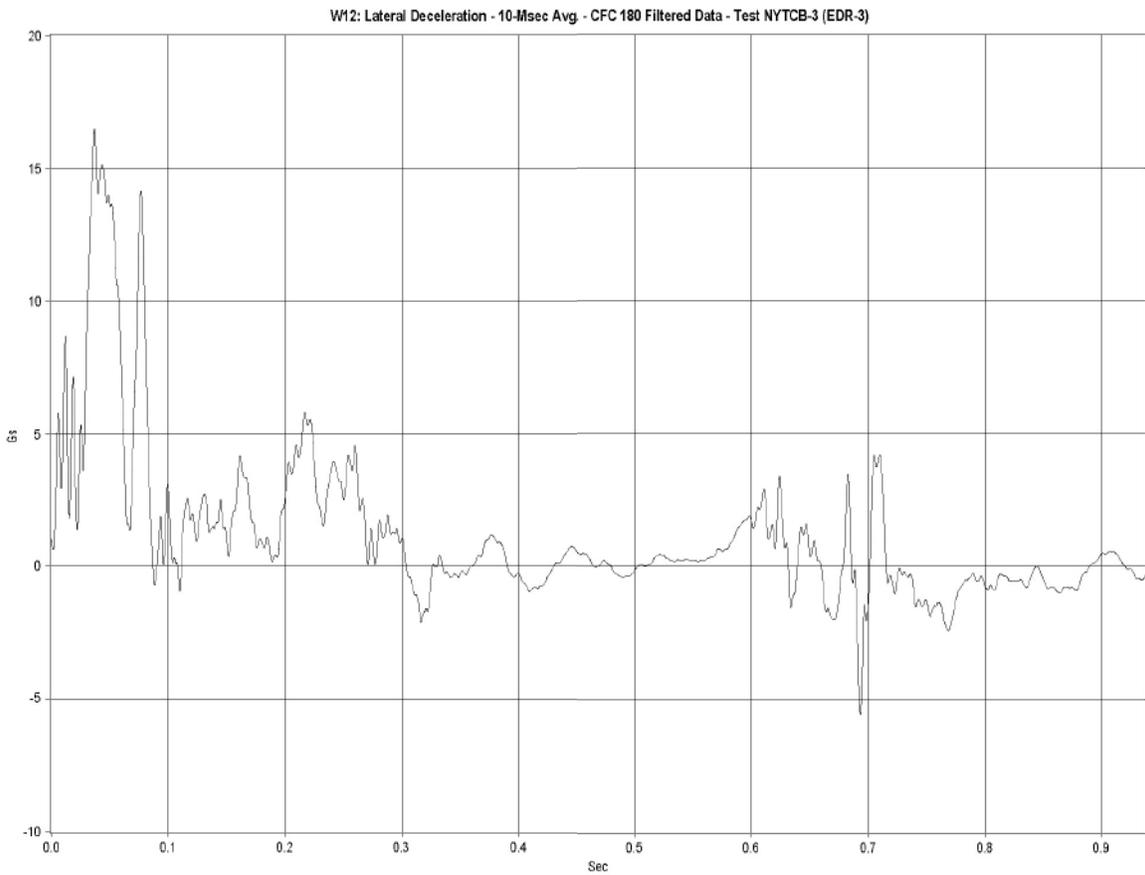


Figure H-4. Graph of Lateral Deceleration, Test NYTCB-3

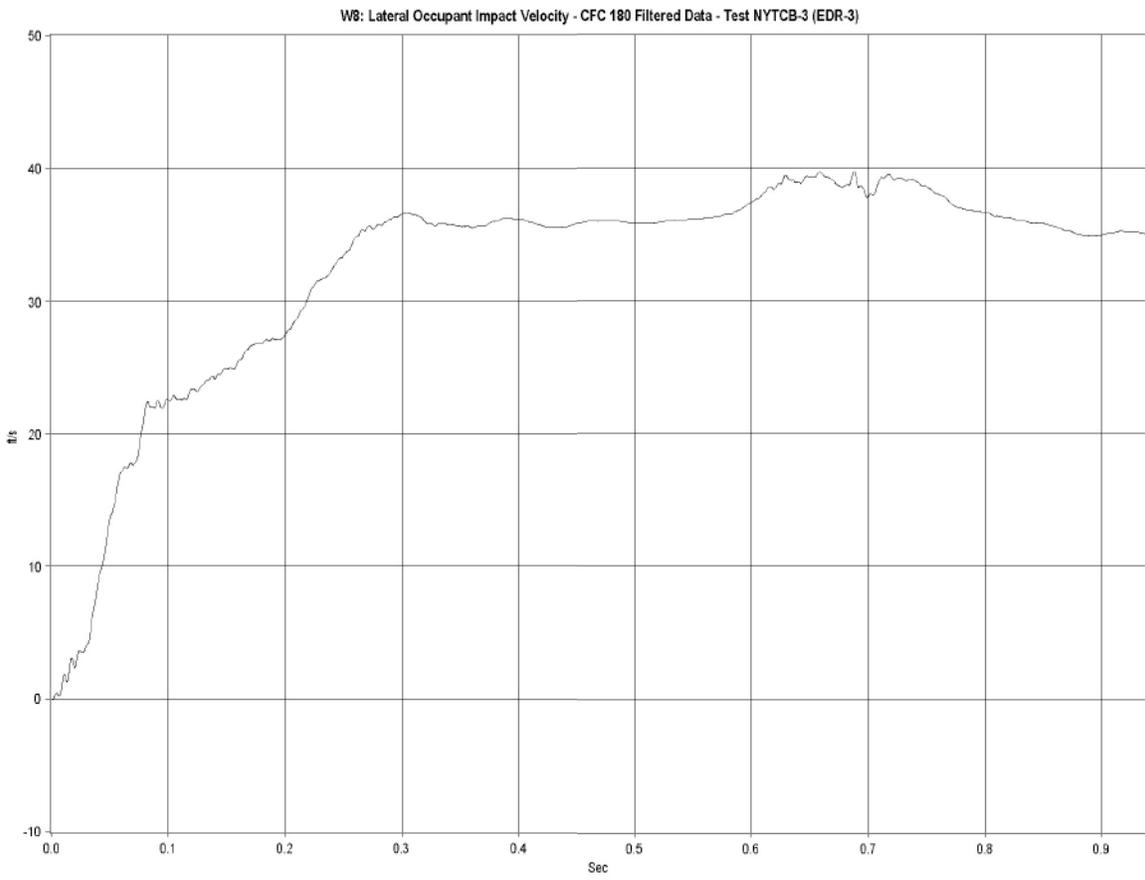


Figure H-5. Graph of Lateral Occupant Impact Velocity, Test NYTCB-3

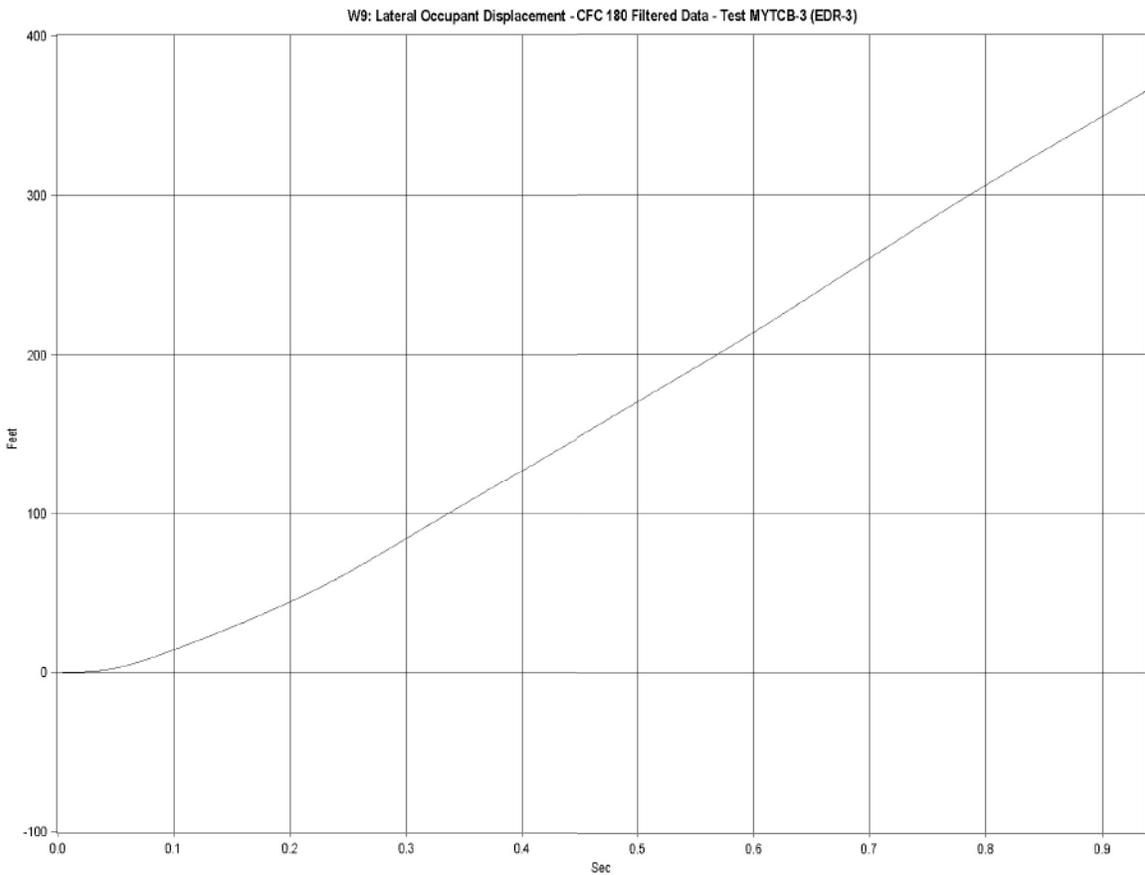


Figure H-6. Graph of Lateral Occupant Displacement, Test NYTCB-3

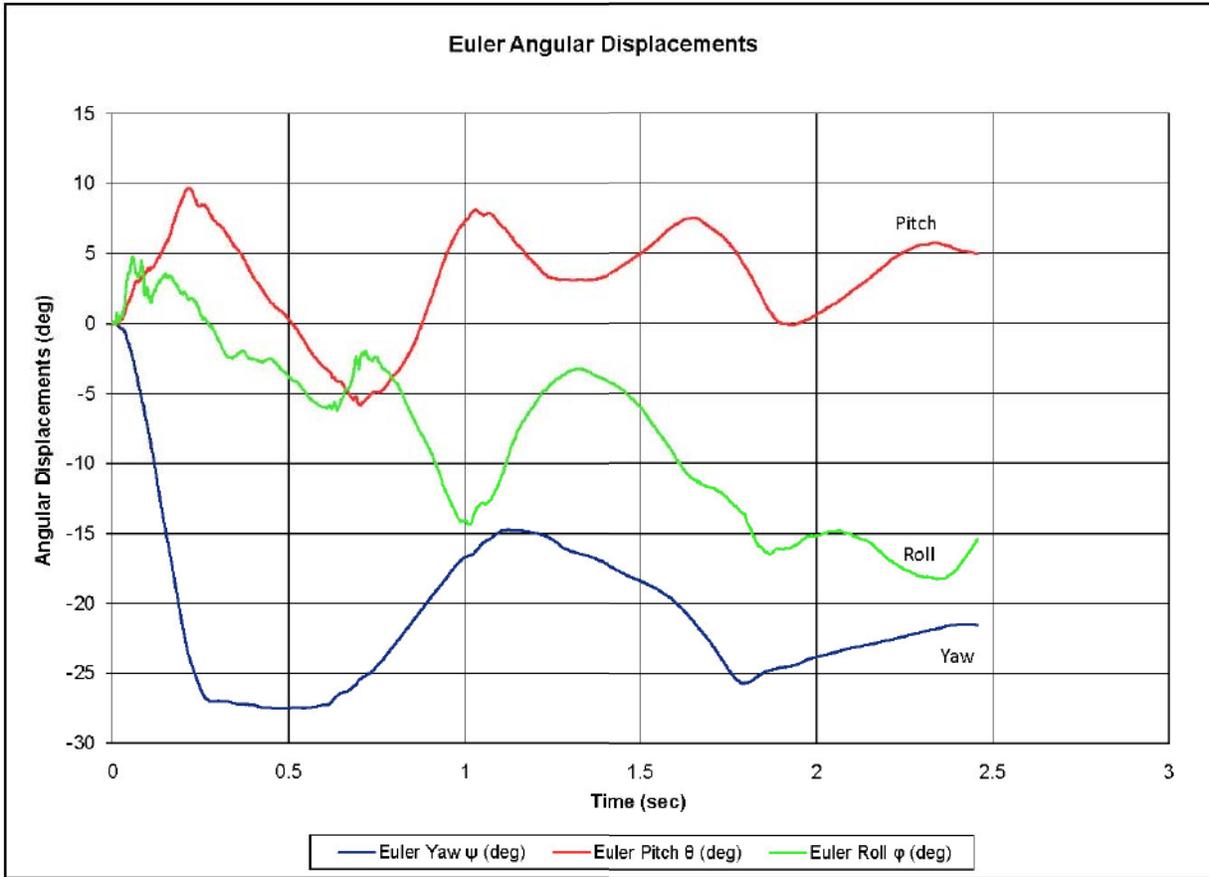
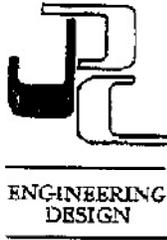


Figure H-7. Graph of Roll, Pitch, and Yaw Angular Displacements, Test NYTCB-3

APPENDIX I

Material Specifications



JERSEY PRECAST CORP.

1000 Somerset St., New Brunswick, NJ 08901
P.O. Box 7413, North Brunswick, NJ 08902
Phone: 732-249-8973 • Fax: 732-249-9720
E-Mail: jrzprecast@aol.com
www.jerseyprecast.com



Date: June 13, 2007

Company: Midwest Roadside Safety Facility-
University of Nebraska

Proposal # 07-198

Attention: Gregg Averill

Location: Lincoln, Nebraska

Phone: 402-472-2022

Reference:

Fax: 402-709-2943

gaverill@bigred.unl.edu

JERSEY PRECAST CORPORATION PROPOSES TO MANUFACTURE AND DELIVER THE FOLLOWING:

Approximate Lft: 240

12 pcs Precast Temporary Construction Barrier 24" x 32"x 20" @ \$ 31.00 /Lft
M619-3R1 with pin holes
4000 psi Grey concrete, uncoated reinforcing, with uncoated steel interlocks

PICKED-UP - 400 LBS/LFT

Excludes: anchor bolts, washers, reflectors, delineators, stripes, fence post sleeves, and layout drawings

Terms:
Quote valid for 30 days
Payment at time of delivery or pick-up

Plus applicable taxes

Approved by: _____
Purchase Order #:
Please sign and return by fax

Yours truly
Paul Dentel

Rivers Metal Products, Inc.
 1000 North 38th Street
 Lincoln, NE 68504-1998

Telephone: (402) 466-2329
 Main Office Fax: (402) 466-9140
 Rotational Molds Division Fax: (402) 466-0937
 Internet E-mail: rmp@riversmetal.com

Sales Order: 75571

Order: 75571

Sales Order

Page 1 of 1

To: University of Nebraska - Lincoln Administration Building 600 NE 68588-0439	Ship To: University of Nebraska - Lincoln UNL-Midwest Roadside Safety 1901 Y STREET BUILDING C LINCOLN NE 68588-0401 <div style="text-align: center; font-weight: bold; font-size: 1.2em;"> SHIPPED JUL 12 2007 RIVERS METAL PROD </div>
---	--

Date: 7/5/2007 PO Number: VERBAL CURT FOB: RMP
 By: 7/11/2007 Sales Rep: Roger Harris Resale ID:
 Terms: Net 30 Days Ship Via: Customer

EN READY CURT 326-8122

Order Qty	Part Number/Description	Revision	Unit Price	Ext. Price
3.00 EA	DRILL 6" X 3/16" SQ. TUBE DRILL 6" X 6" X 3/16" SQUARE TUBES		191.50000 /E	\$574.50
Release	Date	Quantity		
1	7/11/2007	3.00		
24.00 EA	PLASMACUT 1/4 HR PLATE PLASMA CUT 1/4" HOT ROLL PLATE 8" X 8" WITH 7/8" HOLE IN CENTER		5.85000 /E	\$140.40
Release	Date	Quantity		
1	7/11/2007	24.00		
2.50 EA	HR 1 1" Hot Roll Round 20' 2 FULL LENGTHS CUT 1EA, 120.00"		45.49875 /E Discount:	\$113.75 -\$17.06
Release	Date	Quantity		
1	7/11/2007	2.50		

	Line Total:	\$811.59
	Miscellaneous Total:	\$0.00
	Total:	\$811.59

Signature

...duers, Inc.
... 38th Street
... NE 68504-1998



Telephone: (402) 466-1140
Main Office Fax: (402) 466-9140
Rotational Molds Division Fax: (402) 466-0957
Internet E-mail: rmp@diversmetal.com

Invoice: 624807

Invoice

Page: 1 of 1
Date: 9/5/2007

Bill To: Accounts Payable University of Nebraska - Lincoln 401 Administration Building Lincoln NE 68583-0439	Ship To: University of Nebraska - Lincoln 401 Administration Building Lincoln NE 68583-0439
---	---

PO Number: ~~624807~~
 Sales Rep: Paul Mara
 Picking Slip:

Terms: Not 30 Days
 Ordered: 9/5/2007
 Sales Tax ID: 0305-256-556

F.O.B: RMP
 Ship Via: Pick-up
 Ship Date: 9/5/2007

Line	Quantity	Part Number/Description	Revision	Unit Price	Ext Price
1	3.00EA	RT6614 8 X 6 X 1/4 HR RECT TUBE X 24'		483.33330 EA	\$1,450.00

This material was not charged on invoice number 624623 line 2 was a labor only charge

	- Taxes -	Taxable Amount	Percent	Amount
Payment Schedule	Government	\$1,450.00		
	Due Date	Amount		
	10/5/2007	\$1,450.00		

Please remit this amount: \$1,450.00



U.S. Department
of Transportation

Federal Highway
Administration

Memorandum

Subject: **ACTION:** NYS Concrete Barrier with
Box Beam Stiffener FHWA Eligibility
Letter B-239

Date: November 1, 2012

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

In Reply Refer To:
HSST

To: Jonathan D. McDade
Division Administrator
Albany, New York

This memorandum is in response to your request for the Federal Highway Administration (FHWA) to review a roadside safety system for eligibility for reimbursement under the Federal-aid highway program.

Name of system: New York State Temporary Concrete Barrier with Box
Beam Stiffener
Type of system: Portable Concrete Barrier with reduced deflection
Test Level: MASH Test Level 3
Testing conducted by: Mid West Roadside Safety Facility (MWRSF)

Decision

The following device is eligible, with details provided below and in the attachments:

- New York State Temporary Concrete Barrier (TCB) with Box Beam Stiffener. Stiffener detail may also be used with other TCB as noted.

Based on a review of crash test results certifying the device described herein meets the crash test and evaluation criteria of the National Cooperative Highway Research Program (NCHRP) Report 350, the device is eligible for reimbursement under the Federal-aid highway program. Eligibility for reimbursement under the Federal-aid highway program does not establish approval or endorsement by the FHWA for any particular purpose or use.

The FHWA, the Department of Transportation, and the United States Government do not endorse products or services and the issuance of a reimbursement eligibility letter is not an endorsement of any product or service.

FHWA: HSST: NArtimovicht: sf: x61331:10/26/12: **sf.Updated 11/1/12**
File: s://directory folder/HSST/Artimovich/B239_NYS Box Beam
TCB.docx
cc: HSST (NArtimovich)

Requirements

To be found eligible for Federal-aid funding, roadside safety devices should meet the crash test and evaluation criteria contained in the National Cooperative Highway Research Program (NCHRP) Report 350 or the American Association of State Highway and Transportation Officials' Manual for Assessing Safety Hardware (MASH).

Description

Previous crash testing of the New York State Department of Transportation (NYSDOT) temporary concrete barrier (TCB) system had been conducted according to the National Cooperative Highway Research Program (NCHRP) Report 350 criteria, and documented in FHWA Letter B-94, dated January 24, 2002. In the 2001 test at the Texas Transportation Institute, the unpinned NYSDOT TCB system, a 2,076-kg (4,577-lb) pickup truck impacted the ten barrier system at a speed of 100.8 km/h (62.6 mph) and at an angle of 25.6 degrees. During the impact, the vehicle was redirected smoothly and the barrier system experienced 1,270 mm (50 in.) of deflection. The upstream end was pulled 148 mm (5.8 in.) longitudinally downstream, while the downstream end was displaced 5 mm (0.2 in.) longitudinally upstream, or toward the impact point.

Crash Testing of Stiffened Barrier

In the 2008 testing at the Midwest Roadside Safety Facility (MRSF) the 60.96-m (200-ft) long test installation consisted of box beam stiffened temporary concrete barrier sections in a free-standing configuration with both end sections anchored. The ten 6,096-mm (20-ft) long, temporary concrete barrier sections were installed with the first and last sections attached to the concrete using nine 25-mm (1-in.) diameter by 394-mm (15.5-in.) long, A36 steel rods, five anchors and four anchors on the traffic and back sides, respectively. Each anchor rod was driven into a hole drilled in the concrete to an embedment depth of 127 mm (5 in.).

The three joints between barrier nos. 4 and 7 were stiffened with a box beam section consisting of a 152-mm x 152-mm x 4.8-mm (6-in. x 6-in. x 0.1875-in.) ASTM A500 Grade C box beam, which was 3,658 mm (12 ft) long. The box beams were connected to the barriers with 19-mm (0.75-in.) diameter by 432-mm (17-in.) long, Grade 5 continuously threaded rods and nuts. An 83-mm (3.25-in.) outside diameter x 22-mm (0.875-in.) inside diameter x 9.5-mm (0.375-in.) thick Grade 5 fender washer was placed on the traffic side of the barrier between the barrier and the nut. A 203-mm x 203-mm x 6.4-mm (8-in. x 8-in. x 0.25-in.) A36 steel plate was placed on the back side of the barrier between the nut and the box beam section.

Details of the crash are in the attached Figure 29 Summary of Test Results. The maximum dynamic deflection was 700 mm (approximately 28 inches). This is 44 percent less deflection than the 1,270 mm (50 in.) recorded in the test of the un-stiffened barrier.

The analysis of the test results for test no. NYTCB-1 showed that the stiffened temporary concrete barrier system with anchored ends adequately contained and redirected the 2270P vehicle with controlled lateral displacements of the barrier system. This test was determined to meet the TL-3 safety performance criteria of test designation no. 3-11 found in MASH.

Summary and Standard Provisions

Therefore, the system described and detailed in this memorandum is eligible for reimbursement and may be installed under the range of conditions tested. We also concur that the same stiffening method may be used to reduce the deflection of other portable concrete barrier systems with the following provisions:

- 1) The length of the individual barrier segments are at least 20 feet long.
- 2) The deflection of the system to be retrofit was no greater than 50 inches under NCHRP Report 350 Test Level 3 conditions.
- 3) The barriers are anchored at both ends to achieve the limited deflection properties demonstrated in the crash testing. If the end sections are not anchored then the barrier line, with stiffeners, should be extended until the barrier's desired deflection can be achieved.

Please note the following standard provisions that apply to FHWA eligibility letters:

- This finding of eligibility does not cover other structural features of the systems, nor conformity with the Manual on Uniform Traffic Control Devices.
- Any changes that may influence system conformance with NCHRP Report 350 criteria will require a new reimbursement eligibility letter.
- Should the FHWA discover that the qualification testing was flawed, that in-service performance reveals safety problems, or that the system is significantly different from the version that was crash tested, we reserve the right to modify or revoke this letter.
- You are expected to supply potential users with sufficient information on design and installation 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 crash test and evaluation criteria of the NCHRP Report 350.
- To prevent misunderstanding by others, this letter of eligibility is designated as number B-239 and 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 at our office 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. The FHWA does not become involved in issues concerning patent law. Patent issues, if any, are to be resolved by the applicant.

Attachments



Memorandum

Subject: **ACTION:** NYS Concrete Barrier with
Box Beam Stiffener FHWA Eligibility
Letter B-239

Date: NOV - 1 2012

From: Michael S. Griffith *Michael S. Griffith*
Director, Office of Safety Technologies
Office of Safety

In Reply Refer To:
HSST

To: Jonathan D. McDade
Division Administrator
Albany, New York

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Details of the crash are in the attached Figure 29 Summary of Test Results. The maximum dynamic deflection was 700 mm (approximately 28 inches). This is 44 percent less deflection than the 1,270 mm (50 in.) recorded in the test of the un-stiffened barrier.

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Summary and Standard Provisions

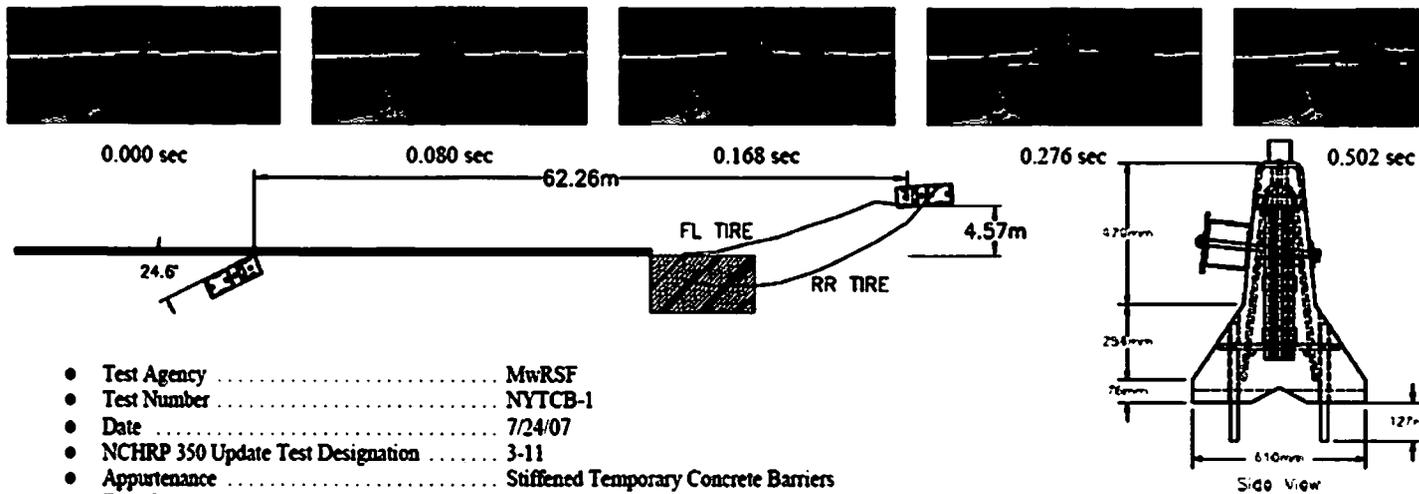
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- 1) The length of the individual barrier segments are at least 20 feet long.
- 2) The deflection of the system to be retrofit was no greater than 50 inches under NCHRP Report 350 Test Level 3 conditions.
- 3) The barriers are anchored at both ends to achieve the limited deflection properties demonstrated in the crash testing. If the end sections are not anchored then the barrier line, with stiffeners, should be extended until the barrier's desired deflection can be achieved.

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- You are expected to supply potential users with sufficient information on design and installation 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 crash test and evaluation criteria of the NCHRP Report 350.
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- 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. The FHWA does not become involved in issues concerning patent law. Patent issues, if any, are to be resolved by the applicant.

Attachments



64

- Test Agency MwRSF
- Test Number NYTCB-1
- Date 7/24/07
- NCHRP 350 Update Test Designation 3-11
- Appurtenance Stiffened Temporary Concrete Barriers
- Total Length 60.96 m
- Key Elements - Barrier
 - Description New York TCB with Connection Keys
 - Length 6,096 mm
 - Base Width 610 mm
 - Height 810 mm
- Key Elements - Anchor Ends
 - Size 25 mm diameter ASTM A36 rod
 - Length 394 mm
 - Number per Barrier 5 traffic-side, 4 back-side
- Key Elements - Box Beam Stiffener
 - Size 152 mm x 152 mm x 4.8 mm
 - Length 3,658 mm
 - Connector Rod 19 mm diameter x 432 mm long Grade 5
 - Plate Washer 203 mm x 203 mm x 6.4 mm
- Type of Soil N/A
- Test Vehicle
 - Type/Designation 2270P
 - Make and Model 2002 Dodge Ram 1500 Quad Cab 4x2
 - Curb 2,302 kg
 - Test Inertial 2,275 kg
 - Gross Static 2,275 kg
- Impact Conditions
 - Speed 99.5 km/h
 - Angle 24.6 degrees
 - Impact Location 1,300 mm upstream from downstream end of barrier 4

- Exit Conditions
 - Speed 62.9 km/h
 - Angle 7 deg
 - Exit Box Criterion Pass
- Post-Impact Trajectory
 - Vehicle Stability Satisfactory
 - Stopping Distance 62.3 m downs
4.6 m laterally
- Occupant Impact Velocity
 - Longitudinal -4.67 m/s < 12
 - Lateral 6.33 m/s < 12.
- Occupant Ridedown Deceleration
 - Longitudinal 4.72 g's < 20.
 - Lateral 8.36 g's < 20.
- THIV (not required) 7.45 m/s
- PHD (not required) 8.71 g's
- Test Article Damage Moderate
- Test Article Deflections
 - Permanent Set 660 mm
 - Dynamic 700 mm
 - Working Width 1,311 mm
- Vehicle Damage Moderate
 - VDS¹¹ 11-LFQ-3
 - CDC¹⁴ 11-LYEN2
 - Maximum Deformation 38 mm
- Angular Displacements
 - Roll -10.5 deg
 - Pitch -11.4 deg
 - Yaw 28.0 deg

Figure 29. Summary of Test Results and Sequential Photographs. Test NYTCB-1

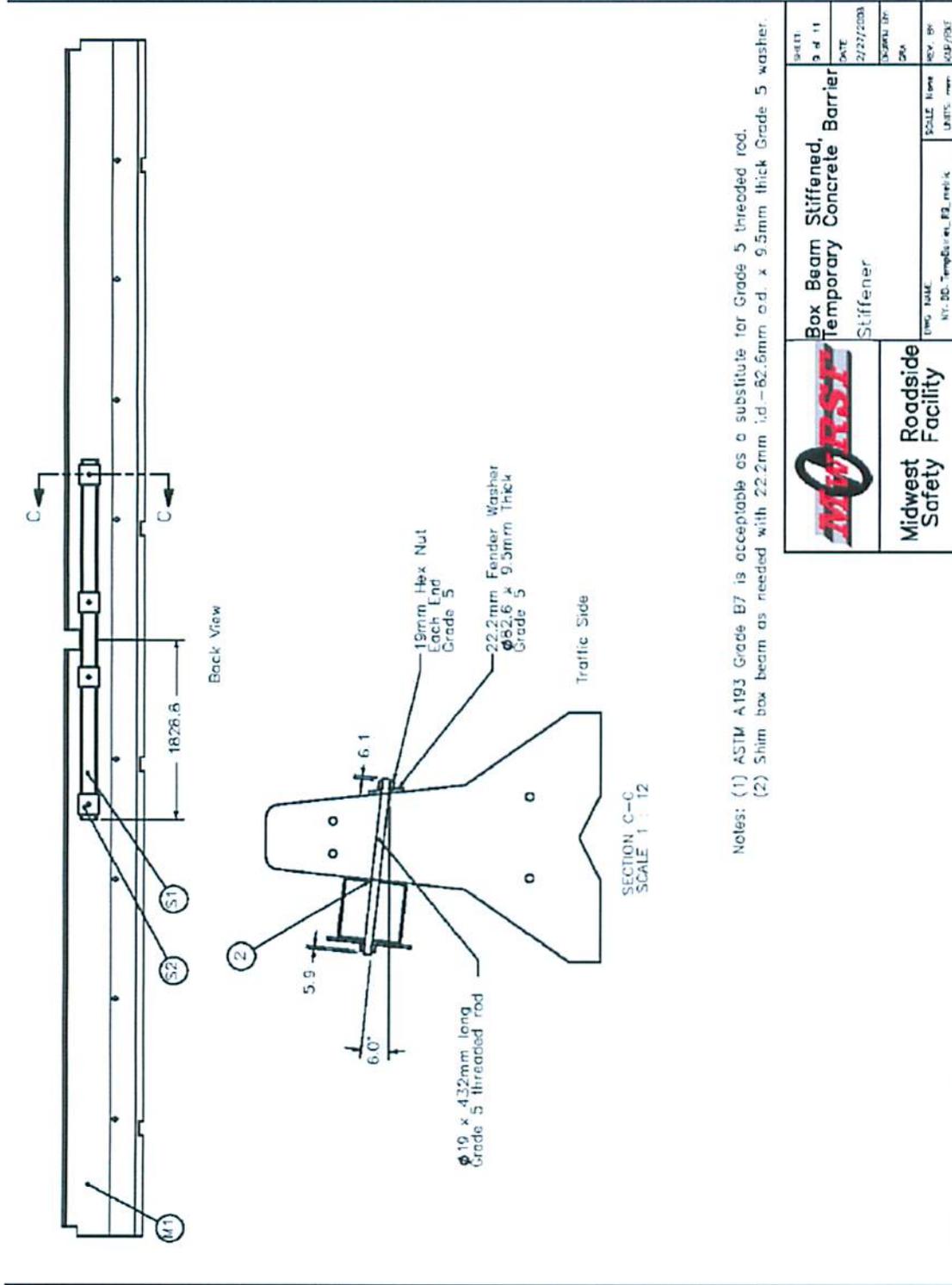


Figure 21. Box Beam Stiffener Details, Test NYTCB-1

STATE OF NEW YORK
DEPARTMENT OF TRANSPORTATION

U.S. CUSTOMARY STANDARD SHEET

TEMPORARY CONCRETE BARRIER
 (SHEET 2 OF 3)

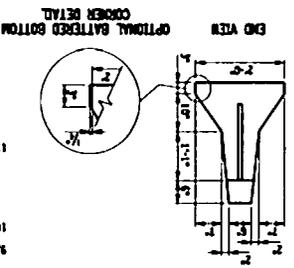
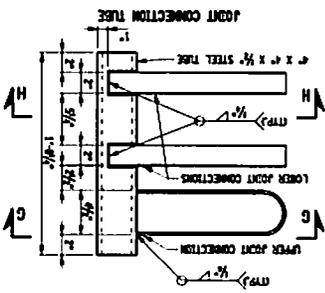
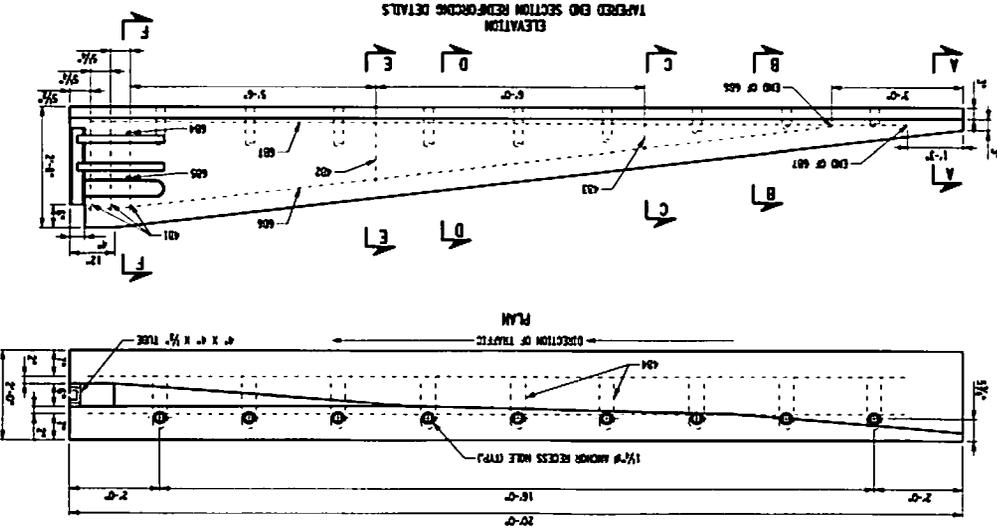
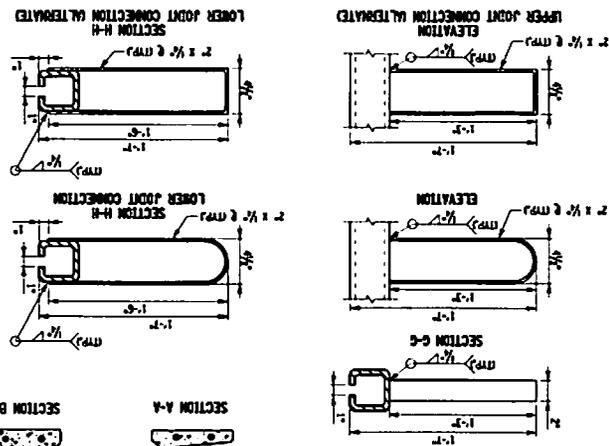
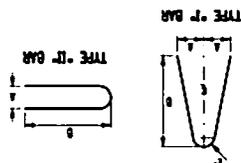
APPROVED SEPTEMBER 30, 2009 ISSUED UNDER E.D. 09-073

619-01

EFFECTIVE DATE: 01/07/10

TAPERED END SECTION BAR LIST

MARK	SIZE	NUMBER PER SECTION	LENGTH	TYPE	A	B	C	LOCATION
BAR 13	#4	3	4'-11"	1	5"	28"	1"	STIRRUPS
BAR 12	#4	1	5'-2"	1	5"	18"	1"	STIRRUPS
BAR 11	#4	1	5'-2"	1	5"	18"	1"	STIRRUPS
BAR 10	#4	1	5'-2"	1	5"	18"	1"	STIRRUPS
BAR 9	#4	9	5'-1"	2	5"	18"	1"	STIRRUPS
BAR 8	#4	1	5'-2"	1	5"	18"	1"	STIRRUPS
BAR 7	#4	1	5'-2"	1	5"	18"	1"	STIRRUPS
BAR 6	#4	1	5'-2"	1	5"	18"	1"	STIRRUPS
BAR 5	#4	1	5'-2"	1	5"	18"	1"	STIRRUPS
BAR 4	#4	1	5'-2"	1	5"	18"	1"	STIRRUPS
BAR 3	#4	1	5'-2"	1	5"	18"	1"	STIRRUPS
BAR 2	#4	1	5'-2"	1	5"	18"	1"	STIRRUPS
BAR 1	#4	1	5'-2"	1	5"	18"	1"	STIRRUPS
BAR 19	#4	2	18'-2"	1	5"	18"	1"	TRANSVERSE TOP
BAR 18	#4	2	18'-2"	1	5"	18"	1"	TRANSVERSE TOP
BAR 17	#4	2	18'-2"	1	5"	18"	1"	TRANSVERSE TOP
BAR 16	#4	2	18'-2"	1	5"	18"	1"	TRANSVERSE TOP
BAR 15	#4	2	18'-2"	1	5"	18"	1"	TRANSVERSE TOP
BAR 14	#4	2	18'-2"	1	5"	18"	1"	TRANSVERSE TOP
BAR 13	#4	2	18'-2"	1	5"	18"	1"	TRANSVERSE TOP
BAR 12	#4	2	18'-2"	1	5"	18"	1"	TRANSVERSE TOP
BAR 11	#4	2	18'-2"	1	5"	18"	1"	TRANSVERSE TOP
BAR 10	#4	2	18'-2"	1	5"	18"	1"	TRANSVERSE TOP
BAR 9	#4	2	18'-2"	1	5"	18"	1"	TRANSVERSE TOP
BAR 8	#4	2	18'-2"	1	5"	18"	1"	TRANSVERSE TOP
BAR 7	#4	2	18'-2"	1	5"	18"	1"	TRANSVERSE TOP
BAR 6	#4	2	18'-2"	1	5"	18"	1"	TRANSVERSE TOP
BAR 5	#4	2	18'-2"	1	5"	18"	1"	TRANSVERSE TOP
BAR 4	#4	2	18'-2"	1	5"	18"	1"	TRANSVERSE TOP
BAR 3	#4	2	18'-2"	1	5"	18"	1"	TRANSVERSE TOP
BAR 2	#4	2	18'-2"	1	5"	18"	1"	TRANSVERSE TOP
BAR 1	#4	2	18'-2"	1	5"	18"	1"	TRANSVERSE TOP

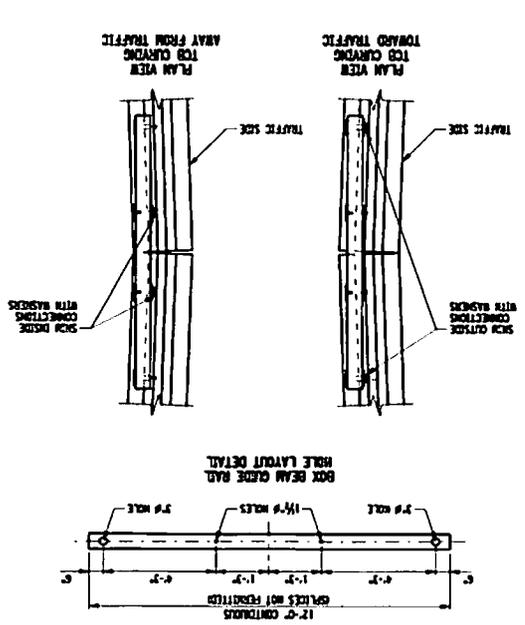
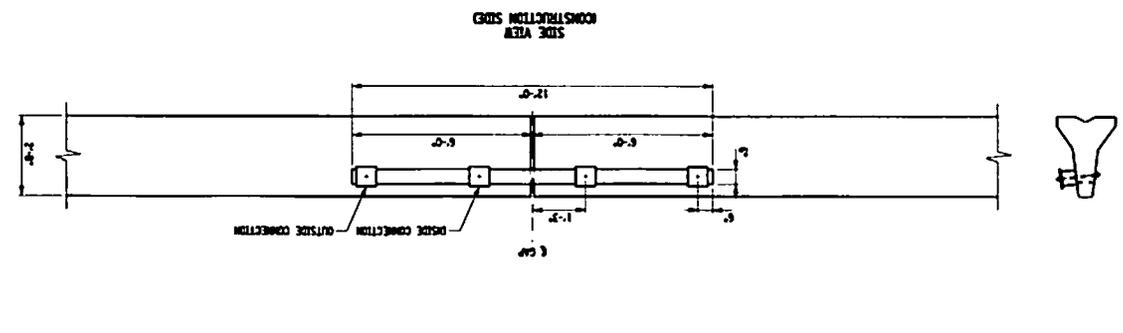
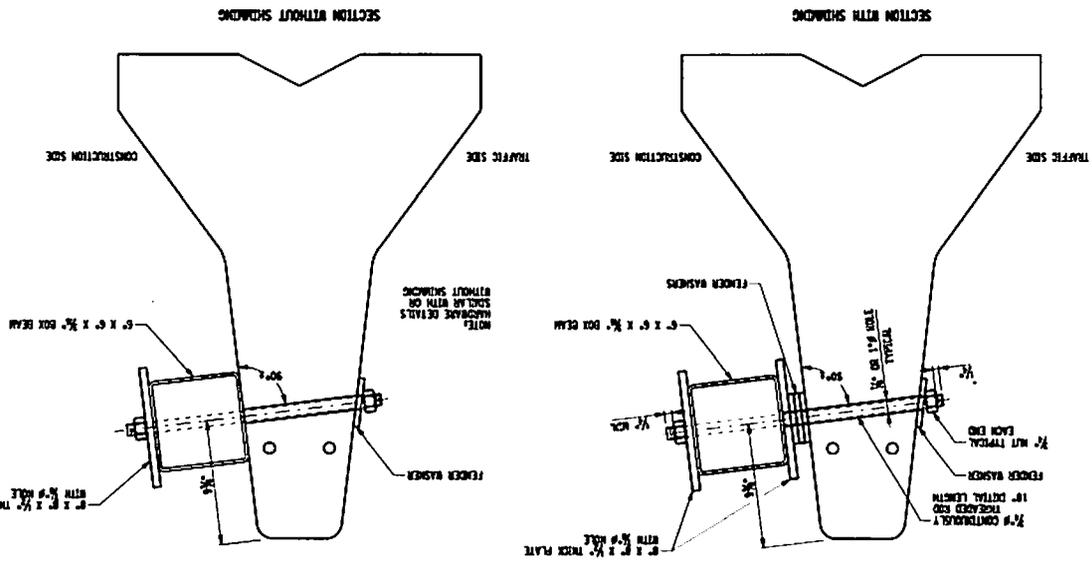


- NOTES:**
- TEMPORARY CONCRETE BARRIER SHALL BE PRECAST IN ACCORDANCE WITH THE REQUIREMENTS OF SP-08, PRECAST CONCRETE BARRIER.
 - STEEL PLATE SHALL BE ASTM A36. STEEL GRADE SHALL BE A572 GRADE 50. STEEL JOINT SHALL BE C, AND REINFORCING BARS SHALL BE A615 GRADE 60.
 - ALL REINFORCING SHALL BE PERFORMED BY A QUALIFIED WELDER IN ACCORDANCE WITH SECTION 8 OF THE NYS STEEL CONSTRUCTION MANUAL.
 - SPACES TO BE REINFORCED SHALL BE FEE OF SLAB, CURB, JOINTS, CORNERS OR ANY OTHER MATERIAL THAT WILL PREVENT PROPER WELDING OR PRODUCE COLLECTIBLE FLAKES.
 - REINFORCING SHALL BE SCHEDULED REINFORCING COMPARED TO THE REQUIREMENTS OF SECTION 7 OF THE NYS STEEL CONSTRUCTION MANUAL.
 - CONCRETE CLEAN CORNER FOR REINFORCING BARS SHALL BE 1/2" RADIUS EXCEPT WHERE OTHERWISE SPECIFIED.
 - A RADIUS OF (C) THE RECESSES (L)TING DEVICES, WITH THE CAPACITY TO LIFT A MASS OF 6 TONS INCLUDING SHALL BE INSTALLED ON EACH SECTION.
 - 1/2" ASTM A308 ANCHOR PINS SHALL BE PLACED IN FOUR RECESSES OF EACH SECTION TO BE POWERED.
 - CONNECTION KEY COVER PLATE SHALL BE INSTALLED FLUSH WITH THE GASKET TOP.
 - THE DETAILS SHOWN FROM THIS SECTION ARE FOR APPROXIMATE ENDS WHICH ARE TO BE LOCATED TO THE LEFT OF THE TRAFFIC FLOW ON THE RIGHT.
 - APPROXIMATE ENDS IS TO BE LOCATED TO THE RIGHT OF THE TRAFFIC FLOW ON THE END. APPROXIMATE ENDS IS TO BE LOCATED TO THE LEFT OF THE TRAFFIC FLOW ON THE END. APPROXIMATE ENDS IS TO BE LOCATED TO THE RIGHT OF THE TRAFFIC FLOW ON THE END. APPROXIMATE ENDS IS TO BE LOCATED TO THE LEFT OF THE TRAFFIC FLOW ON THE END.
 - ALL CORNERS OF THE SECTION SHALL BE RADIUS TO A 1" RADIUS. THE SECTION SHALL HAVE A SMOOTH FINISH TO A 1/2" RADIUS. THE SECTION SHALL BE FINISHED UNLESS OTHERWISE NOTED.
 - COMPARATIVE WORK SHALL BE LOCATED AND RECORDED.
 - SECTION SHALL BE CONSTRUCTED AS SHOWN IN ALL RECESSES IN ALL.

619-01	
DEPT. OF TRANSPORTATION	DEPT. OF EMPLOYERS
STATE OF NEW YORK	ISSUED UNDER CS-10-024
DEPARTMENT OF TRANSPORTATION	APPROVED SEPTEMBER 1, 2010
U.S. CUSTOMARY STANDARD SHEET	BY J.J. TUNNEY, P.E.
TEMPORARY CONCRETE BARRIER (SHEET 3 OF 3)	

EFFECTIVE DATE 01/05/11

BOX BEAM STIFFENING OF TEMPORARY CONCRETE BARRIER



- NOTES:
1. TEMPORARY CONCRETE BARRIER GORE SHALL BE FIELD IN ACCORDANCE WITH THE REQUIREMENTS OF 810-40 PERMANENT CONCRETE BARRIER AND STANDARD SHEET TITLED "TEMPORARY CONCRETE BARRIER - SHEET 1 OF 3" AND "TEMPORARY CONCRETE BARRIER - SHEET 2 OF 3".
 2. BOX BEAM SHALL BE IN ACCORDANCE WITH THE REQUIREMENTS OF 8110-21, BOX BEAM BARRIERS AND MEDIAN BARRIERS, BARS.
 - a. HOWEVER, THE BOX BEAM NEED NOT BE NEW.
 - b. THE CURVING REMAINING ON THE OLD PIECES SHALL BE SUFFICIENT TO ENSURE THE STEEL IS STRUCTURALLY INTACT.
 3. TOP WITH BOX BEAM STIFFENING SHALL BE AT LEAST 50'-0" BEYOND THE AREA INCLUDING LIMITED DEFLECTIONS, UNDER SPACE LIMITS SUCH AS EXTENSIONS. THE FIRST LAST TOP SEGMENT SHOULD BE PAVED WITH 4 PINS ON THE CONSTRUCTION SIDE.
 4. TEMPORARY CONCRETE BARRIERS WITH BOX BEAM STIFFENING MAY ONLY BE USED WITH TOP SEGMENTS 14'-0" OR LONGER.
 5. TEMPORARY CONCRETE BARRIER MAY ONLY BE INSTALLED TO THE FOLLOWING MAXIMUM RADII: 14'-0" SEGMENT - 257'-0" RADII; 16'-0" SEGMENT - 184'-0" RADII; 18'-0" SEGMENT - 207'-0" RADII; AND 20'-0" SEGMENT - 237'-0" RADII.
 6. WHEN TEMPORARY CONCRETE BARRIERS ARE PLACED ON A RADIUS, THE RESULTING GAPS BETWEEN THE BOX BEAM AND CONCRETE BARRIER SHALL BE SHIMMED.
 7. THE SHIMMING SHALL CONSIST OF 2" X 6" X 1/2" SQUARE PLATE, AND FINGER WASHERS AS NEEDED TO SHIM THE BOX BEAM STIFFENING TO THE TOP.
 8. FINGER WASHERS SHALL BE 3" MINIMUM DIA.
 9. HARDWARE OTHER THAN THE BOX BEAM NEED NOT BE GALVANNEZED.
 10. THE PRESENCE OF NORMAL HOLES DRILLED FOR THIS SHEET WILL NOT AFFECT THE RESPONSIBILITY OF THE CONCRETE SEGMENTS.

To:		<p style="text-align: center;"><i>New York State Department of Transportation</i> ENGINEERING BULLETIN</p>	<p style="font-size: 2em; font-weight: bold; text-align: center;">EB</p> <p style="font-weight: bold; text-align: center;">10-034</p>
Title: BOX BEAM STIFFENING OF TEMPORARY CONCRETE BARRIER			
Distribution: <input checked="" type="checkbox"/> Manufacturers (18) <input type="checkbox"/> Surveyors (33) <input checked="" type="checkbox"/> Local Govt. (31) <input checked="" type="checkbox"/> Consultants (34) <input checked="" type="checkbox"/> Agencies (32) <input checked="" type="checkbox"/> Contractors (39) <input type="checkbox"/> _____ ()		Approved: <u>/s/J.F. Tynan</u> <u>8-31-10</u> James F. Tynan, P.E. Date Deputy Chief Engineer (Construction)	

ADMINISTRATIVE INFORMATION:

- This Engineering Bulletin (EB) is effective beginning with projects submitted for the letting of 01/06/11.
- This EB does not supersede any previous issuances.
- This standard sheet will be incorporated into the next complete printing of the Standard Sheets.

PURPOSE:

The purpose of this EB is to issue Standard Sheets *619-01 Temporary Concrete Barrier (Sheet 3 of 3)* and *M619-72 Box Beam Stiffening of Temporary Concrete Barrier*.

TECHNICAL INFORMATION:

- Box Beam Stiffening of Temporary Concrete Barrier is an option to limit the deflection of temporary concrete barrier to 2.2 feet for standard impact conditions (5000# pickup impacting at 62 mph and a 25° angle). Without box beam stiffening, the deflection was 3.3 feet. With all segments pinned and no box beam stiffening, the deflection was 0.7 feet.
- Standard Specification Section 619 will subsequently be modified to include construction details and separate payment items for Box Beam Stiffened Temporary Concrete Barrier. In the interim, if a designer plans to use this detail, he/she must submit a special specification to the Design Quality Assurance Bureau, Specification and Standards Section for approval. Contact Terry Hale at terry.hale@dot.state.ny.us or (518) 485-7009 for assistance.
- Standard Sheets 619-01, 1 of 2 and 2 of 2 will be renumbered to 1 of 3 and 2 of 3 on the website, but will not be reissued.

TRANSMITTED MATERIALS:

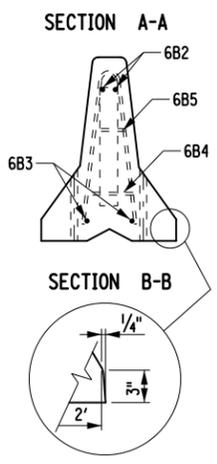
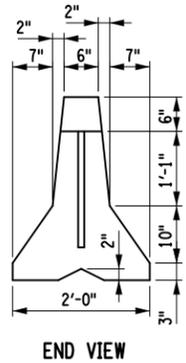
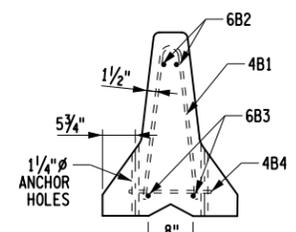
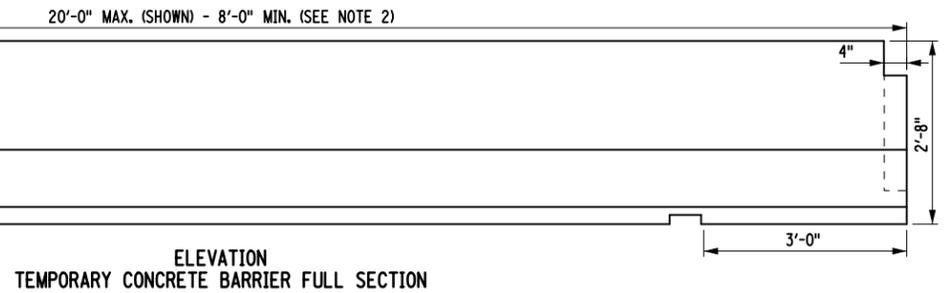
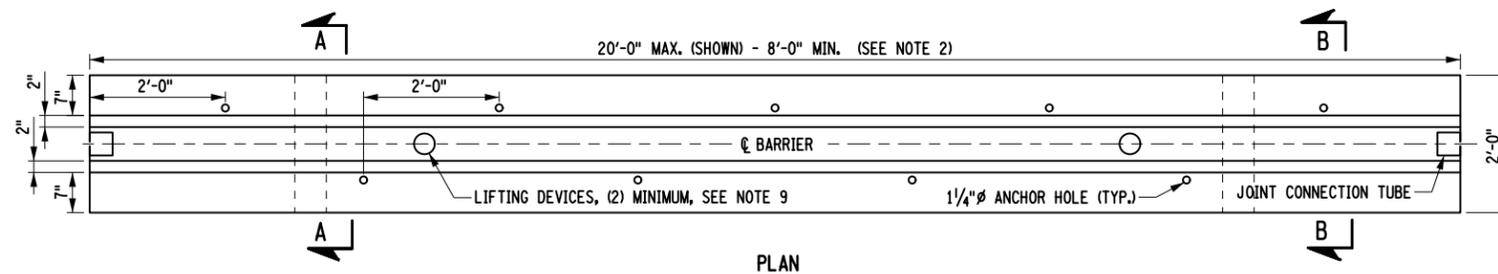
Standard Sheets *619-01 Temporary Concrete Barrier (Sheet 3 of 3)* and *M619-72 Box Beam Stiffening of Temporary Concrete Barrier* are available on the IntraDOT and the Department's website at: <https://www.nysdot.gov/main/business-center/engineering/cadd-info/drawings>

BACKGROUND:

In 2007, research was conducted on a concept to reduce the deflection of TCB without the need to pin units into the pavement or a bridge deck. The concept involved bolting 12 foot lengths of 6" x 6" box beam on the back side of the TCB, spanning across the joints.

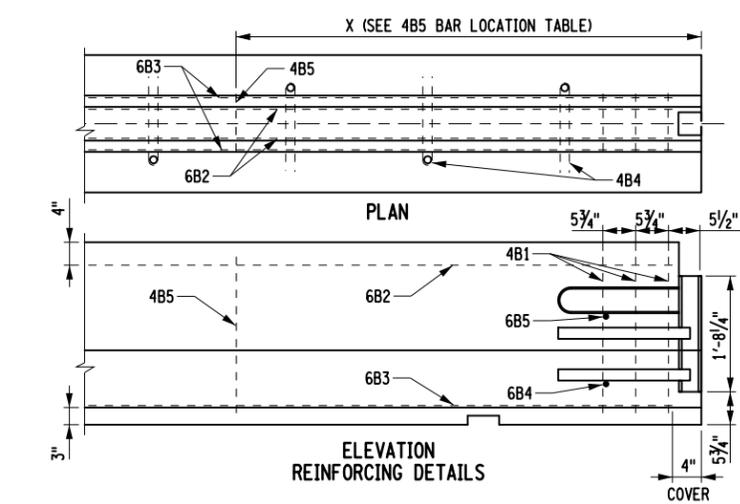
CONTACT:

For additional information contact Terry Hale of the Design Quality Assurance Bureau at (518) 485-7009, thale@dot.state.ny.us or Tom Melander of the Office of Construction at (518) 457-6472, tmelander@dot.state.ny.us.



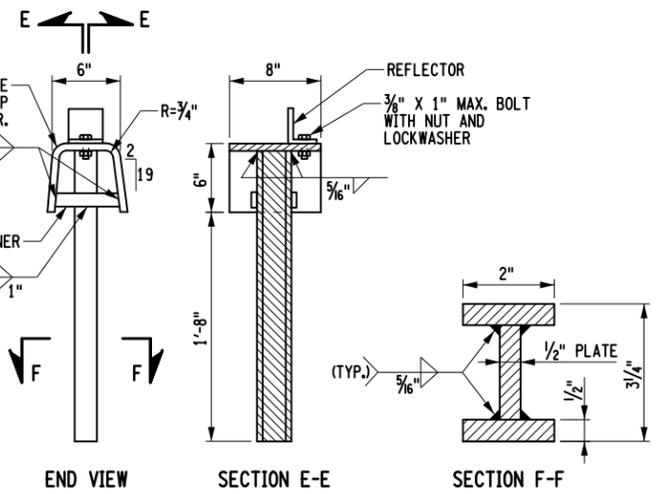
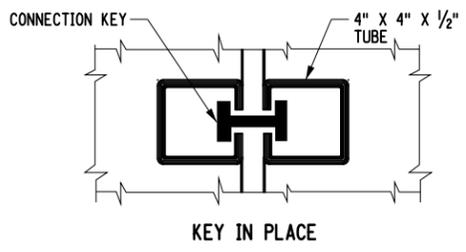
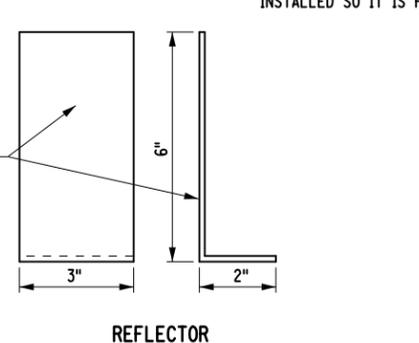
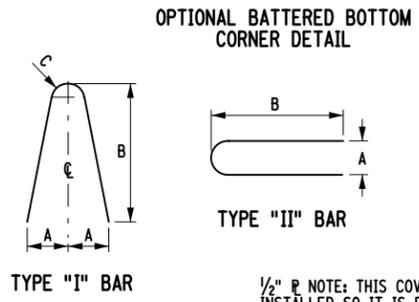
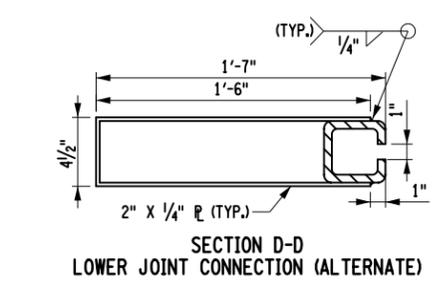
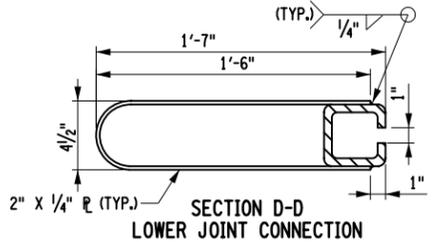
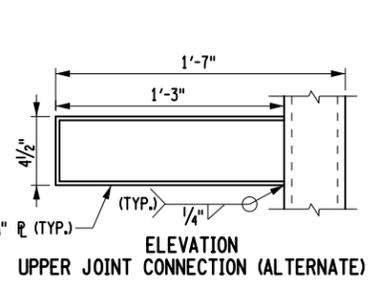
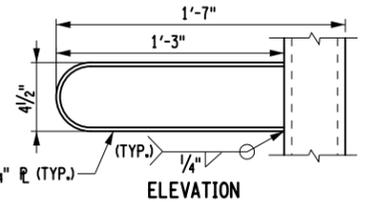
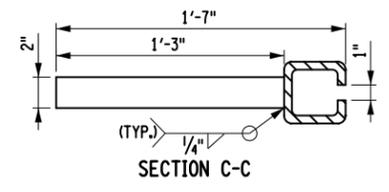
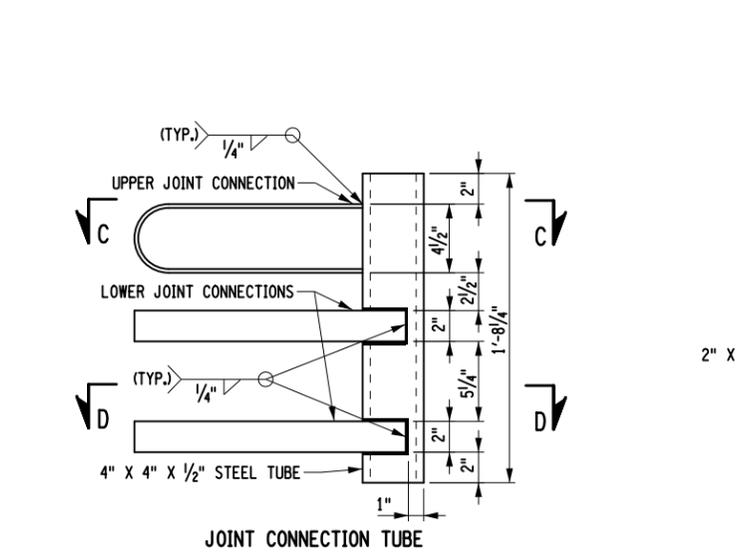
- NOTES:
- TEMPORARY CONCRETE BARRIER SHALL BE PRECAST IN ACCORDANCE WITH THE REQUIREMENTS OF §704-05 PRECAST CONCRETE BARRIER.
 - TEMPORARY CONCRETE BARRIER SHALL BE PRECAST UNITS OF ONE OF THE FOLLOWING NOMINAL LENGTHS 8', 10', 12', 14', 16', 18', 20'.
 - STEEL PLATE REINFORCEMENT SHALL BE ASTM A36M, A572M, GRADE 345 STEEL, TUBE REINFORCEMENT SHALL BE ASTM A500, GRADE B OR C, AND REINFORCING BARS SHALL BE A615, GRADE 420. EPOXY BARS ARE NOT REQUIRED.
 - ALL WELDING SHALL BE PERFORMED BY A WELDER QUALIFIED IN ACCORDANCE WITH SECTION 8 OF THE NYS STEEL CONSTRUCTION MANUAL.
 - SURFACES TO BE WELDED SHALL BE FREE OF SLAG, RUST, MOISTURE, GREASE OR ANY OTHER MATERIAL THAT WILL PREVENT PROPER WELDING OR PRODUCE OBJECTIONABLE FUMES.
 - WELDING SHALL BE SHIELDED METAL ARC WELDING USING PROPERLY DRIED 5/32" E7018 ELECTRODES CONFORMING TO THE REQUIREMENTS OF SECTION 7 OF THE NYS STEEL CONSTRUCTION MANUAL.
 - THE NUMBER AND PLACEMENT OF THE 4B4 AND 4B5 BARS WILL VARY WITH THE LENGTH OF THE BARRIER SEGMENT.
 - CONCRETE CLEAR COVER FOR REINFORCING BARS SHALL BE 1/2" (MIN.) UNLESS OTHERWISE SPECIFIED.
 - A MINIMUM OF (2) TWO RECESSED LIFTING DEVICES, EACH WITH THE CAPACITY TO LIFT A MASS OF 6 TONS (MINIMUM), SHALL BE INSTALLED ON EACH SEGMENT. SEGMENT MASS IS APPROXIMATELY 400 LBS/FT.
 - ONE DRAINAGE POCKET SHALL BE INCLUDED IN THE CENTER OF 8'-0" AND 10'-0" SEGMENTS, TWO DRAINAGE POCKETS IN ALL OTHER SEGMENTS.
 - CONNECTION KEY COVER PLATE SHALL BE INSTALLED FLUSH WITH THE BARRIER TOP.
 - 1" Ø ASTM A36M ANCHOR PINS SHALL BE PLACED IN FOUR ANCHOR HOLES OF EACH SEGMENT TO BE PINNED. PINS SHALL BE PLACED ON THE WORKZONE SIDE OF THE BARRIER.
 - BASED ON SEGMENT LENGTH AND MAXIMUM JOINT ROTATION, TEMPORARY CONCRETE BARRIER CAN ONLY BE INSTALLED TO THE FOLLOWING MINIMUM RADII: 8' - 92', 10' - 115', 12' - 138', 14' - 161', 16' - 184', 18' - 207', 20' - 230'.

FULL SECTION BAR LIST								
MARK	SIZE	NUMBER PER SECTION	LENGTH	TYPE	A	B	C	LOCATION
4B1	4	6	4'-11"	I	5"	28"	1"	STIRRUPS
4B4	4	1 PER RECESS	3'-1"	II	4"	15 1/2"		ANCHOR RECESS HOOPS
4B5	4	SEE TABLE	4'-11"	I	5"	28"	1"	STIRRUPS
6B2	6	2	SEE NOTE 7	STR.				LONGITUDINAL (TOP)
6B3	6	2	SEE NOTE 7	STR.				LONGITUDINAL (BOTTOM)
6B4	6	2	1'-2"	STR.				TRANSVERSE (BOTTOM)
6B5	6	2	6"	STR.				TRANSVERSE (TOP)



4B5 BAR LOCATION TABLE		
NOMINAL LENGTH OF BARRIER UNIT	X	NO. EACH SECTION
20'	6'-11"	2
18'	6'-5"	2
16'	5'-11"	2
14'	7'	1
12'	6'	1
10'	5'	1
8'	N/A	0

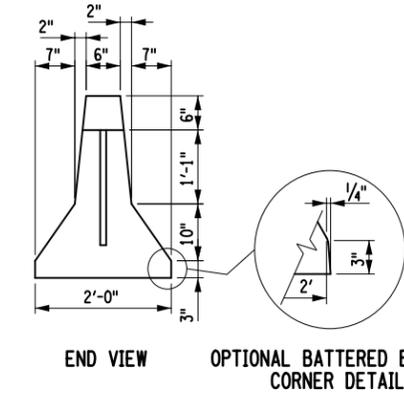
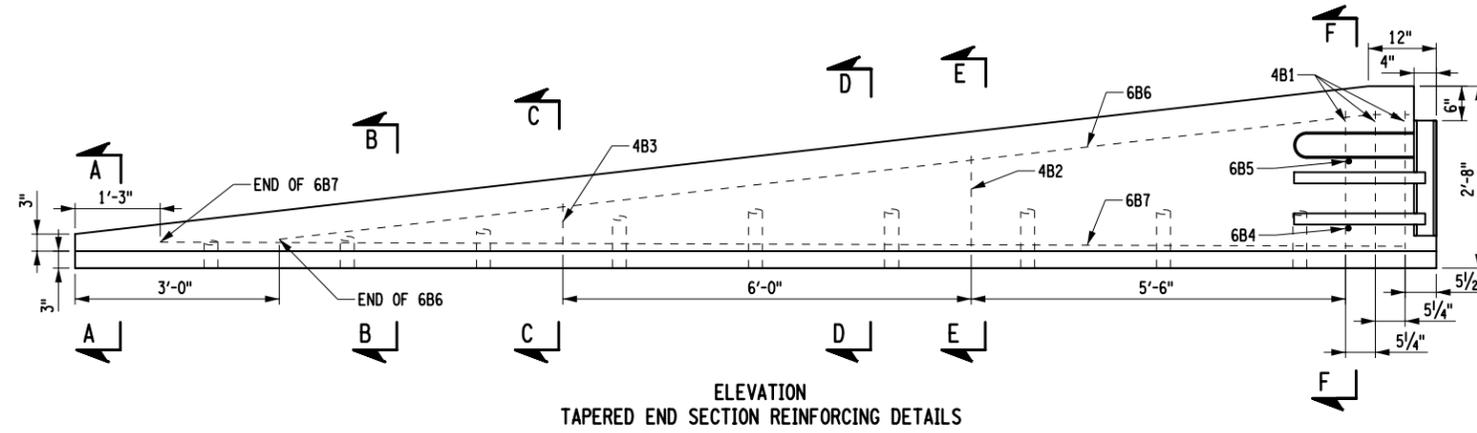
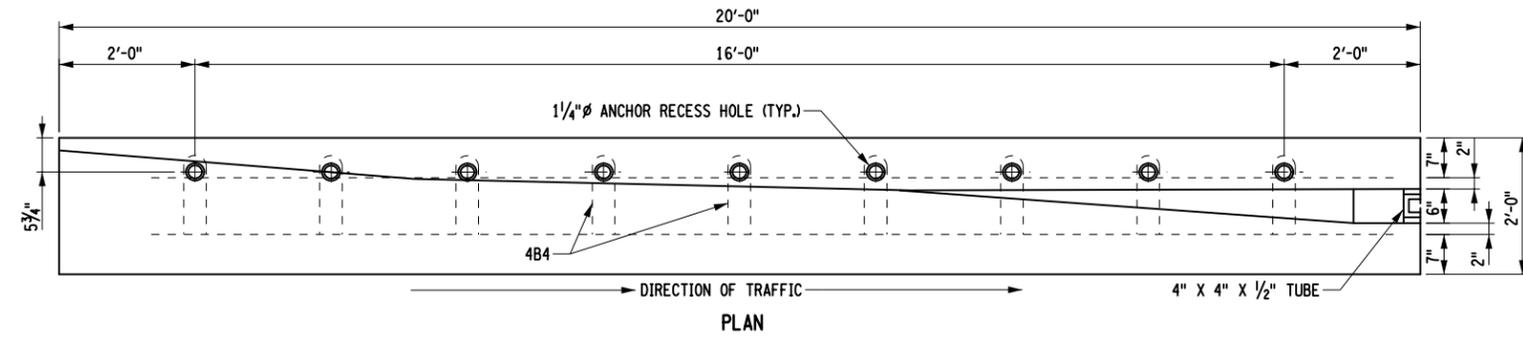
"X" DISTANCE FROM END OF BARRIER TO 4B5 BAR



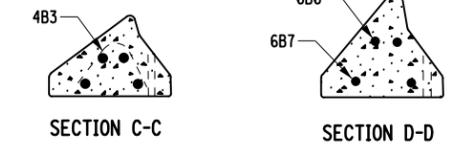
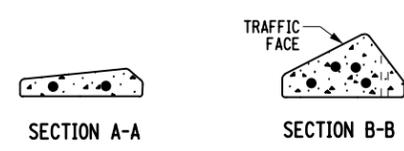
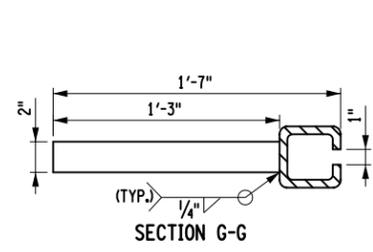
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 ISSUED WITH EB 13-042
 EFFECTIVE DATE: 01/07/10

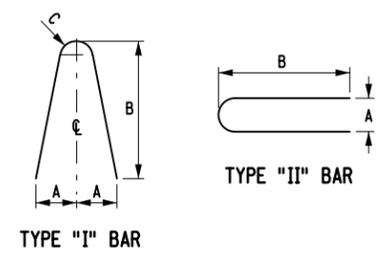
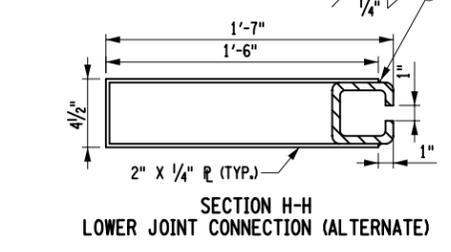
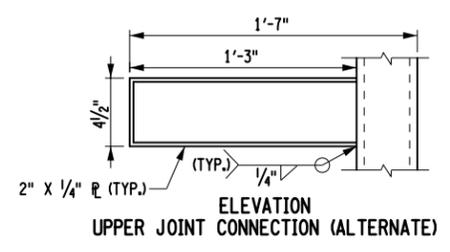
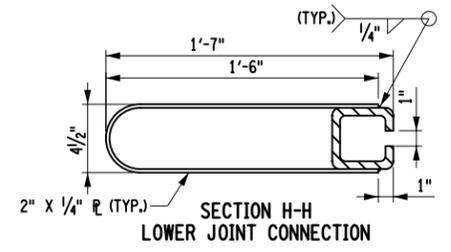
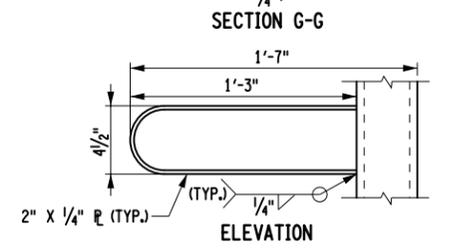
STATE OF NEW YORK DEPARTMENT OF TRANSPORTATION	
U.S. CUSTOMARY STANDARD SHEET	
TEMPORARY CONCRETE BARRIER (SHEET 1 OF 3)	
APPROVED JULY 10, 2014	ISSUED UNDER EB 09-025
/S/ J. F. TYNAN, P.E. DEPUTY CHIEF ENGINEER (CONSTRUCTION)	619-01



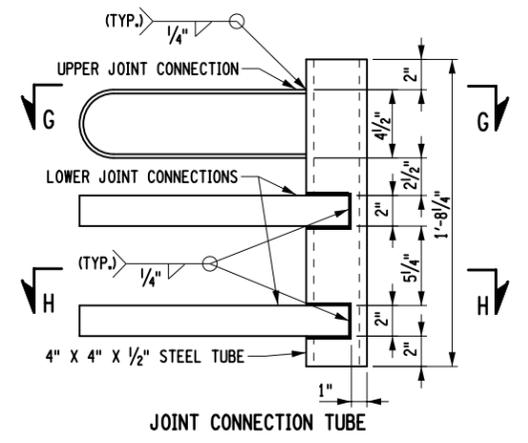
- NOTES:
- TEMPORARY CONCRETE BARRIER SHALL BE PRECAST IN ACCORDANCE WITH THE REQUIREMENTS OF §704-05, PRECAST CONCRETE BARRIER.
 - STEEL PLATE SHALL BE ASTM A36M, A572M, GRADE 345, TUBE STEEL SHALL BE ASTM A500 GRADE B OR C, AND REINFORCING BARS SHALL BE A615 GRADE 420.
 - ALL WELDING SHALL BE PERFORMED BY A QUALIFIED WELDER IN ACCORDANCE WITH SECTION 8 OF THE NYS STEEL CONSTRUCTION MANUAL.
 - SURFACES TO BE WELDED SHALL BE FREE OF SLAG, RUST, MOISTURE, GREASE OR ANY OTHER MATERIAL THAT WILL PREVENT PROPER WELDING OR PRODUCE OBJECTIONABLE FUMES.
 - WELDING SHALL BE SHIELDED METAL ARC WELDING USING PROPERLY DRIED 5/32" E7018 ELECTRODES CONFORMING TO THE REQUIREMENTS OF SECTION 7 OF THE NYS STEEL CONSTRUCTION MANUAL.
 - CONCRETE CLEAR COVER FOR REINFORCING BARS SHALL BE 1/2" (MIN.) EXCEPT WHERE OTHERWISE SPECIFIED.
 - A MINIMUM OF (2) TWO RECESSED LIFTING DEVICES, WITH THE CAPACITY TO LIFT A MASS OF 6 TONS (MINIMUM) SHALL BE INSTALLED ON EACH SEGMENT.
 - 1" ASTM A36M ANCHOR PINS SHALL BE PLACED IN FOUR RECESSES OF EACH SEGMENT TO BE PINNED.
 - CONNECTION KEY COVER PLATE SHALL BE INSTALLED FLUSH WITH THE BARRIER TOP.
 - THE DETAILS SHOWN FOR THE END SECTIONS ON THIS SHEET ARE FOR APPROACH ENDS WHICH ARE TO BE LOCATED TO THE LEFT OF THE TRAFFIC FLOW ON ONE-WAY OPERATIONS OR BETWEEN OPPOSING FLOWS OF TRAFFIC ON TWO-WAY OPERATIONS. WHEN AN APPROACH END IS TO BE LOCATED TO THE RIGHT OF THE TRAFFIC FLOW, THE END SEGMENT SHALL BE CONSTRUCTED SO THAT IT IS OPPOSITE-HAND (REVERSED IN ALL CONFIGURATIONS, ANCHOR HOLE LOCATIONS AND REINFORCEMENT).
 - ALL CORNERS ON THE TOP OF THE SEGMENT SHALL BE ROUNDED TO A 1" RADIUS. THE SEGMENT SHALL HAVE A SMOOTH TRANSITION TO A 6" END-OF-SECTION HEIGHT. ALL END SECTIONS SHALL BE PINNED UNLESS OTHERWISE NOTED.



TRANSITION SECTIONS



TAPERED END SECTION BAR LIST								
MARK	SIZE	NUMBER PER SECTION	LENGTH	TYPE	A	B	C	LOCATION
4B1	13	3	4'-11"	I	5"	28"	1"	STIRRUPS
4B2	13	1	3'-3"	I	5"	18"	1"	STIRRUPS
4B3	13	1	1'-8"	I	5"	8"	1"	STIRRUPS
4B4	13	9	3'-1"	II	4"	15 1/2"		HOOPS
6B4	19	1	1'-2"	STR.				
6B5	19	1	6"	STR.				
6B6	19	2	16'-7"	STR.				TRANSVERSE (TOP)
6B7	19	2	18'-2"	STR.				TRANSVERSE (BOTTOM)



STATE OF NEW YORK
DEPARTMENT OF TRANSPORTATION

U.S. CUSTOMARY STANDARD SHEET

TEMPORARY CONCRETE BARRIER
(SHEET 2 OF 3)

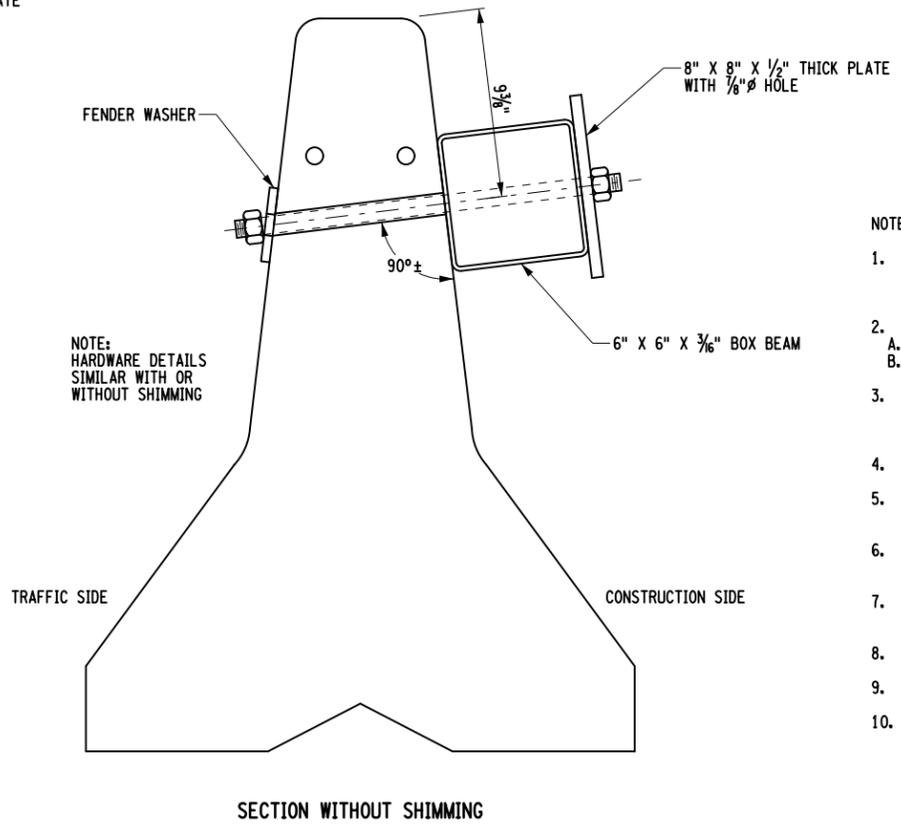
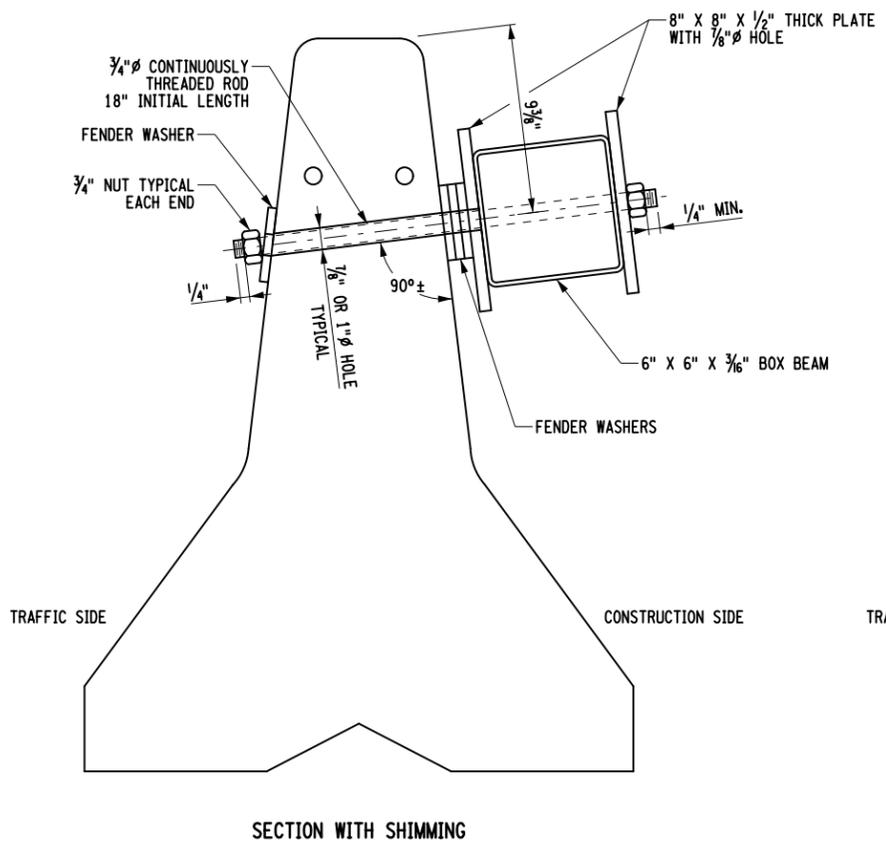
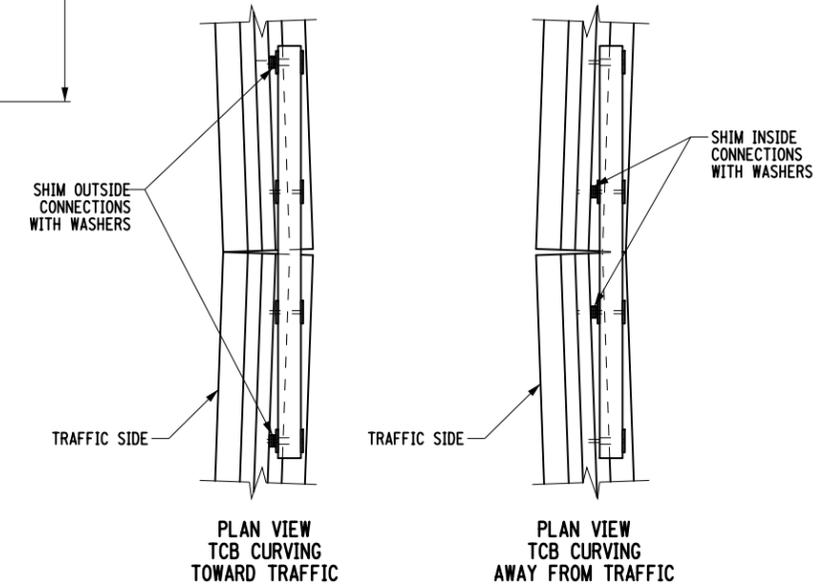
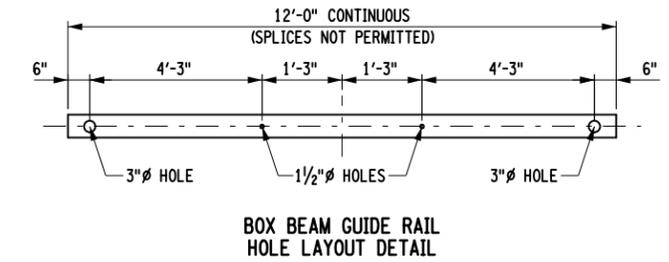
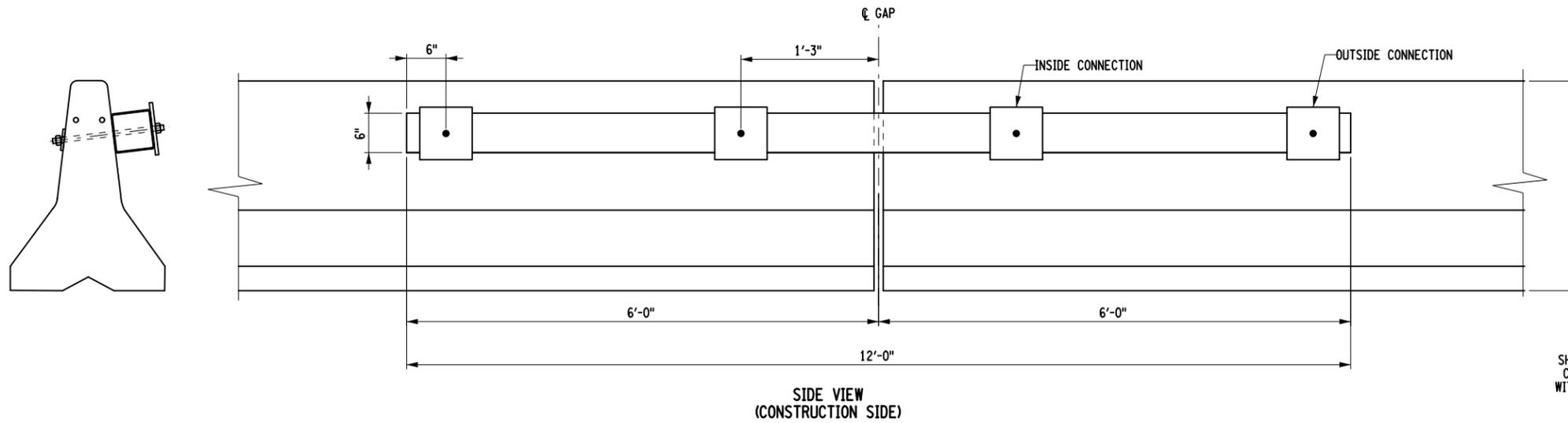
APPROVED SEPTEMBER 30, 2009 ISSUED UNDER EB 09-025

/S/ J. F. TYNAN, P.E.
DEPUTY CHIEF ENGINEER
(CONSTRUCTION)

EFFECTIVE DATE: 01/07/10

619-01

FILE NAME = 619-0102_010710.dgn
DATE/TIME = 10-SEP-2010 14:55
USER = rlohse



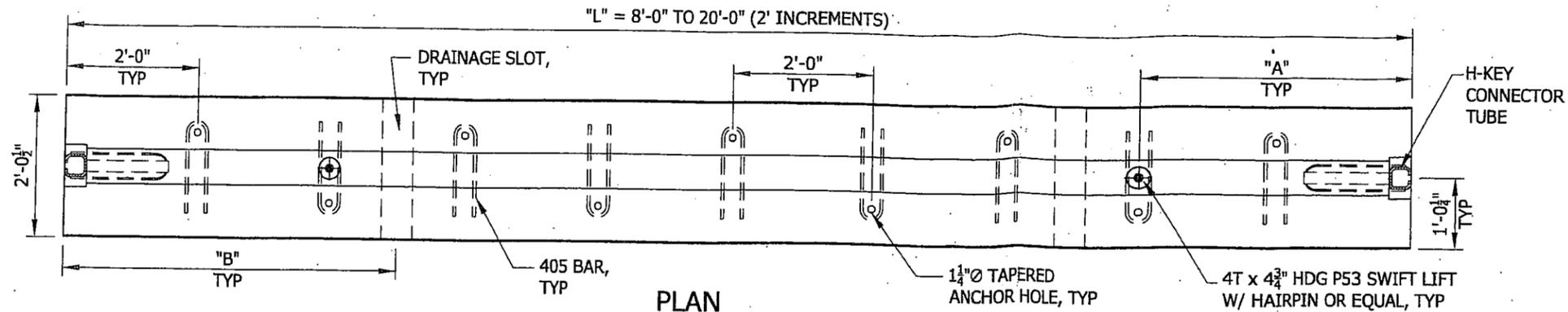
- NOTES:
- TEMPORARY CONCRETE BARRIER (TCB) SHALL BE PRECAST IN ACCORDANCE WITH THE REQUIREMENTS OF §704-05 PRECAST CONCRETE BARRIER AND STANDARD SHEET TITLED "TEMPORARY CONCRETE BARRIER - SHEET 1 OF 3" AND "TEMPORARY CONCRETE BARRIER - SHEET 2 OF 3".
 - BOX BEAM SHALL BE IN ACCORDANCE WITH THE REQUIREMENTS OF §710-21, BOX BEAM RAILING AND MEDIAN BARRIER, RAILS.
 - HOWEVER, THE BOX BEAM NEED NOT BE NEW.
 - THE GALVANIZING REMAINING ON THE OLD PIECES SHALL BE SUFFICIENT TO ENSURE THE STEEL IS STRUCTURALLY INTACT.
 - TCB WITH BOX BEAM STIFFENER SHALL BEGIN AT LEAST 50'-0" PRIOR TO, BE CONTINUOUS THROUGH AND EXTEND AT LEAST 50'-0" BEYOND THE AREA REQUIRING LIMITED DEFLECTIONS. WHERE SPACE LIMITS SUCH EXTENSIONS, THE FIRST/LAST TCB SEGMENT SHOULD BE PINNED WITH 4 PINS ON THE CONSTRUCTION SIDE.
 - TEMPORARY CONCRETE BARRIER WITH BOX BEAM STIFFENER MAY ONLY BE USED WITH TCB SEGMENTS 14'-0" OR LONGER.
 - TEMPORARY CONCRETE BARRIER MAY ONLY BE INSTALLED TO THE FOLLOWING MINIMUM RADII: 14'-0" SEGMENT - 161'-0" RADIUS, 16'-0" SEGMENT - 184'-0" RADIUS, 18'-0" SEGMENT - 207'-0" RADIUS, AND 20'-0" SEGMENT - 230'-0" RADIUS.
 - WHERE TEMPORARY CONCRETE BARRIERS ARE PLACED ON A RADIUS, THE RESULTING GAPS BETWEEN THE BOX BEAM AND CONCRETE BARRIER SHALL BE SHIMMED.
 - THE SHIMMING SHALL CONSIST OF 8" X 8" X 1/2" SQUARE PLATE, AND FENDER WASHERS AS NEEDED TO SNUG THE BOX BEAM STIFFENER TO THE TCB.
 - FENDER WASHERS SHALL BE 3" NOMINAL O.D.
 - HARDWARE OTHER THAN THE BOX BEAM NEED NOT BE GALVANIZED.
 - THE PRESENCE OF NORMAL HOLES DRILLED PER THIS SHEET WILL NOT AFFECT THE REUSABILITY OF THE CONCRETE SEGMENTS.

FILE NAME = 619-0103_010611e1.dgn
 DATE/TIME = 14-NOV-2013 09:01
 USER = rlohse

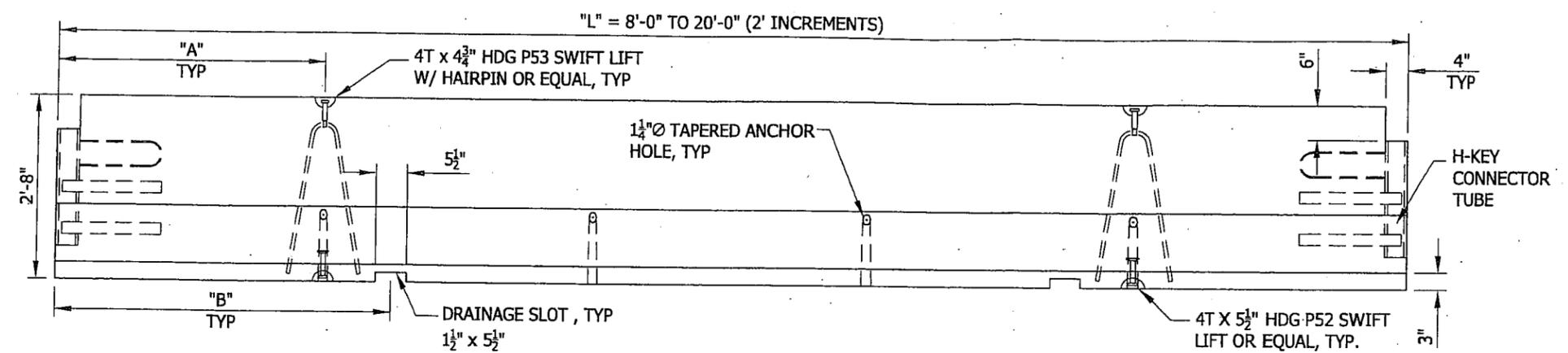
BOX BEAM STIFFENING OF TEMPORARY CONCRETE BARRIER

	STATE OF NEW YORK DEPARTMENT OF TRANSPORTATION	
	U.S. CUSTOMARY STANDARD SHEET	
TEMPORARY CONCRETE BARRIER (SHEET 3 OF 3)		
ERRATA 1 EFF. 01/09/2014 ISSUED WITH EB 13-042	APPROVED: NOVEMBER 4, 2013 /S/ J.F. TYNAN, P.E. DEPUTY CHIEF ENGINEER (CONSTRUCTION)	ISSUED UNDER EB 10-034 619-01
EFFECTIVE DATE: 01/06/11		

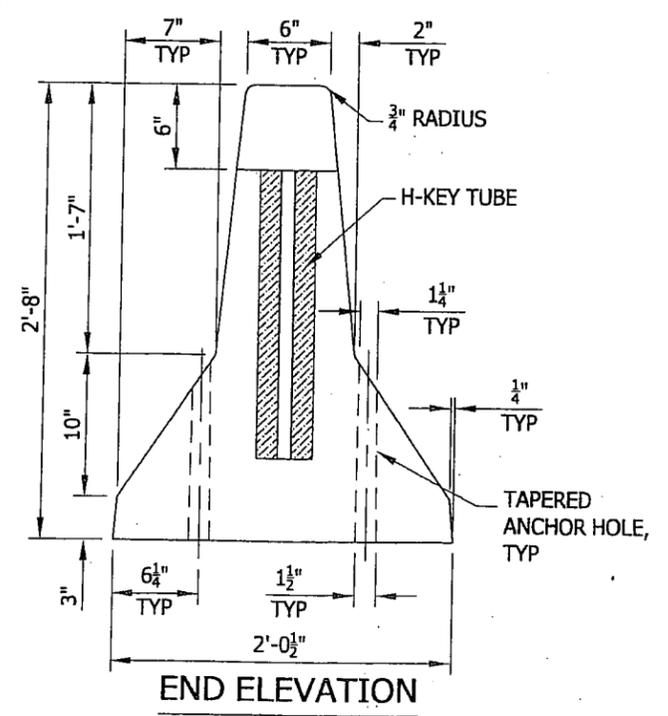
300.36
ISSUED 1/10/12



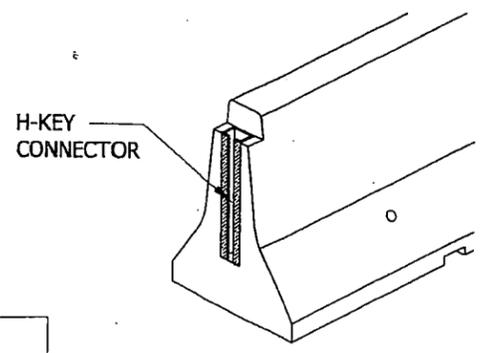
PLAN



ELEVATION



END ELEVATION



END ISOMETRIC

TABLE						
MK#	LENGTH (FT)	VOLUME (C.Y.)	WEIGHT (TONS)	LIFTING "A"	SLOT "B"	HOLES (QTY)
H8	8'-0"	0.80	1.61	2'-0"	5'-0" *	3
H10	10'-0"	0.99	2.01	2'-0"	5'-0" *	4
H12	12'-0"	1.19	2.42	2'-0"	3'-0"	5
H14	14'-0"	1.39	2.82	4'-0"	5'-0"	6
H16	16'-0"	1.59	3.22	4'-0"	5'-0"	7
H18	18'-0"	1.79	3.62	4'-0"	5'-0"	8
H20	20'-0"	1.99	4.03	4'-0"	5'-0"	9

* 8'-0" & 10'-0" UNITS HAVE ONLY (1) DRAINAGE SLOT. SLOT IN 8'-0" UNIT IS 5'-0" IN FROM ONE END & 3'-0" IN FROM THE OTHER.

NOTES:

1. ALL MATERIAL SHALL CONFORM TO SECTION 704-05, PRECAST CONCRETE BARRIER, OF THE NYSDOT STANDARD SPECIFICATIONS AND THE FORT MILLER CO., INC. QUALITY CONTROL PLAN FOR MANUFACTURING PRECAST CONCRETE.
2. REINFORCING BARS SHALL BE ASTM A615, GRADE 60.
3. CONCRETE TO BE 3,000 PSI @ 28 DAYS.
4. AIR CONTENT SHALL BE 5.0 - 9.0%.
5. MINIMUM STRIPPING STRENGTH: 2,000 PSI.
6. POSITION OF REINFORCEMENT TO BE MAINTAINED WITH THERMOPLASTIC CHAIRS OR PLASTIC TIPPED SLAB BOLSTERS.
7. CURING WITH MEMBRANE CURING COMPOUND SHALL CONFORM TO NYSDOT SPECIFICATION 704-03.
8. ALL H-KEY & TUBE DETAILS, MATERIALS AND WELDING REQUIREMENTS SHALL CONFORM TO NYSDOT STANDARD SHEET 619-01.
9. CONCRETE CLEAR COVER FOR REINFORCING BARS SHALL BE 1 1/2", UNLESS OTHERWISE SPECIFIED.

DIMENSIONAL TOLERANCES:

1. H-KEY CONNECTOR LOCATION: ± 1/4"
2. CROSS-SECTIONAL DIMENSIONS: ± 1/4"
3. PLUMBNESS: ± 1/4"
4. LONGITUDINAL DIMENSIONS (LAY LENGTH): ± 1/4" PER 10'-0"
5. WHEN CHECKED WITH A 10'-0" STRAIGHT EDGE, IRREGULARITIES SHALL NOT EXCEED ± 1/4"
6. REINFORCING COVER: 1 1/2" (-1/4", +3/8")
7. REINFORCING SPACING: ± 2" NON-CUMULATIVE

TESTING/INSPECTION:

FMC QCP/NYSDOT

UNIT MARKING:

EACH UNIT SHALL BE PERMANENTLY MARKED WITH THE FOLLOWING:

FMC MM/YY

EACH UNIT SHALL ALSO BE LABELED OR PAINTED WITH THE FOLLOWING INFORMATION FOR FIELD INSPECTION PURPOSES:

FMC
D.O.M.
MK#/PIECE I.D.
NYSDOT

NYSDOT

Approved

Approved As Noted

ORIGINAL SIGNED BY:
J. P. REIDY

JAN 0 5 2012

By _____, Date _____
For: Director Materials Bureau
Drawing Verified In English Units Only

NO.	DATE	BY	REVISIONS

THE FORT MILLER Co., Inc.
 P.O. BOX 98
 SCHUYLERVILLE, NY 12871
 (518) 695-5000/(518) 695-4970 FAX
 www.fortmiller.com

F.M. JOB NO. NA
 SHEET NO. 1 OF 2
 DATE: 12-19-11
 DRN. BY: TDS
 CHK. BY: SDH
 SCALE: NONE

CONTRACT NO.: _____
 PROJECT: _____
 LOCATION: _____
 SUBJECT: H-KEY TEMPORARY BARRIER 8' TO 20'

CONTRACTOR: _____
 ENGINEER/ARCHITECT NYSDOT

DWG. NO. **TB5-1**