



U.S. Department
of Transportation
**Federal Highway
Administration**

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

December 23, 2009

In Reply Refer To:
HSSD/CC-106

Mr. Andy Keel, P.E.
Roadway Design Standards Engineer
605 Suwannee Street, MS 32
Tallahassee, FL 32399-0450

Dear Mr. Keel:

This letter is in response to your request for the Federal Highway Administration (FHWA) acceptance of a roadside safety device for use on the National Highway System (NHS).

Name of device: Florida Low-Profile Barrier Terminal
Type of device: End Terminal
Test Level: TL-2
Testing conducted by: E-Tech Testing Services, Inc., Rocklin, CA
Date of request: October 19, 2009
Date initially acknowledged: October 19, 2009
Date of completed package: November 27, 2009
Task Force 13 Designator: SER-04

You requested that we find this device acceptable for use on the NHS under the provisions of National Cooperative Highway Research Program (NCHRP) Report 350 "Recommended Procedures for the Safety Performance Evaluation of Highway Features."

Requirements

Roadside safety devices should meet the guidelines contained in the NCHRP Report 350 or the American Association of State Highway and Transportation Officials' Manual for Assessing Safety Hardware (MASH). The FHWA Memorandum "Identifying Acceptable Highway Safety Features" of July 25, 1997, provides further guidance on crash testing requirements of longitudinal barriers.



Description

The Florida Low-Profile work zone concrete (low-profile) barrier was earlier approved for use on the NHS as per FHWA Acceptance Letter HSA-10/B-115 dated August 12, 2003. The height of this low profile barrier is 18 inches. A study was conducted of existing end terminals successfully tested as per NCHRP 350 to specify with this low-profile barrier. This study revealed all end terminals were taller than 18 inches. Furthermore, none of the end terminals researched were compatible with the unique barrier-to-barrier connection system used by this low-profile barrier system. Upon impact this connection will simultaneously engage adjoining barrier segments. Barrier resistance in both inertial mass and contact surface friction serves to redirect the Test Level 2 (TL-2) impact force without requiring any positive mechanical anchorage to the roadway surface (e.g. vertical steel pins). This low-profile barrier also serves in providing an unobstructed driver view of cross-traffic.

The following design goals were established to develop a new end terminal for the Florida low-profile barrier.

- End terminal shall have a maximum height equal to or less than the height of the low-profile barrier segments (18 in.).
- End terminal shall not require mechanical anchorage to roadway surface, but instead shall rely on a combination of inertial mass resistance and flexural continuity with the low-profile barrier.
- End terminal shall be capable of being connected to the key and/or keyway ends of the low-profile barrier segments using a compatible connection system.
- For ease of transportation, handling, and installation, the end terminal shall be composed of segments that are relatively short in length (no longer than the 12 ft. length of the low-profile barrier segments).
- End terminal components shall be fabricated from materials that are durable with respect to impact loading, transportation, handling, and installation.

In addition, it was also determined that a barrier height of less than 18 in. would not provide the necessary level of safety with regard to vehicle redirection and resistance to vehicle rollover. Therefore there exists a diminished likelihood the tapered end terminal will successfully redirect a full-size pickup truck. For this reason, no part of the end terminal is considered to contribute to the required length of need (LON) of barrier to protect a particular work zone.

The end terminal is 20 ft. long. It is composed of two sections, (1) 12-ft. long reinforced concrete segment and (1) 8-ft. steel segment. The end terminal height varies from 18 inches at the point of connection to the low-profile barrier, tapering to 2 inches at the end of the end terminal. An innovative connection system and a nearly symmetric shape make the end terminal reversible. This reversibility permits the end-treatment to be attached to either the key or keyway ends of low-profile barrier segments. Neither the end terminal nor the low-profile barrier to which it attaches requires any mechanical anchorage to the roadway surface. This design was completed using a combination of numerical finite element impact simulation followed by full-scale crash tests per the requirements of NCHRP Report 350. The finite element impact analysis was used to establish the geometric shape of the end terminal and to quantify design forces.

Crash Testing

Full-scale crash tests conducted on the Florida low-profile barrier (Consolazio et al. 2003) were carried out in accordance with the longitudinal barrier requirements of NCHRP Report 350. Testing was conducted at TL-2 conditions (45 mph impact speed), hence the design and testing of the end terminal shall also correspond to 45 mph impact conditions. The newly developed end terminal shall be designed and tested as a gating terminal device. The following crash tests are required as per NCHRP Report 350 for a gating end terminal (descriptions have been adapted from Beason et al. 1998):

- NCHRP 350 test designation 2-30. This test involves an 820 kg passenger vehicle approaching parallel to the road way and impacting the end-treatment at a nominal speed and angle of 43.5 mph (70 km/h) and 0-degrees with the quarter point of vehicle aligned with the centerline of the end terminal. This test is intended to evaluate occupant risk and vehicle trajectory.
- NCHRP 350 test designation 2-31. This test involves a 2000-kg pickup truck impacting the end-treatment at a nominal speed and angle of 43.5 mph (70 km/h) and 0-degrees with the center line of vehicle aligned with the centerline of the end terminal. The purpose of this test is to evaluate the capacity of the end terminal to absorb the kinetic energy of the 2000-kg vehicle (in terms of structural adequacy criteria) in a safe manner (occupant risk).
- NCHRP 350 test designation 2-32. This test involves an 820-kg passenger vehicle impacting the end terminal at a nominal speed and angle of 43.5 mph (70 km/h) and 15-degrees with the center line of the vehicle aligned with the centerline of the nose of the end terminal. This test is intended to evaluate occupant risk and vehicle trajectory.
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Findings

Using simulation and physical crash testing, a new crashworthy end terminal was developed for specification with the Florida low-profile barrier system. Based on results obtained from separate simulations, the minimum required lateral deflection space that provides adequate barrier performance in drop-off zone applications is 6 in. for an impact speed of 45 mph. Subsequently, the end terminal was structurally-designed, fabricated, and subjected to a series of seven full-scale crash tests per the TL-2 requirements of NCHRP Report 350. Crash tests involving both a small car (820kg) and a full-size pickup truck (2000 kg) were successfully passed. The test data summary sheets are enclosed for reference.

Therefore, the device described in the request above and detailed in the enclosed drawings is acceptable for use on the NHS under the range of conditions tested, when acceptable to a highway agency.

Standard provisions

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

- This acceptance is limited to the crashworthiness characteristics of the devices and does not cover their structural features, nor conformity with the Manual on Uniform Traffic Control Devices.
- Any changes that may adversely influence the crashworthiness of the device will require a new acceptance letter.
- Should the FHWA discover that the qualification testing was flawed, that in-service performance reveals unacceptable safety problems, or that the device being marketed is significantly different from the version that was crash tested, we reserve the right to modify or revoke our acceptance.
- You will be expected to supply potential users with sufficient information on design and installation requirements to ensure proper performance.
- You will be expected to certify to potential users that the hardware furnished has essentially the same chemistry, mechanical properties, and geometry as that submitted for acceptance, and that it will meet the crashworthiness requirements of the FHWA and the NCHRP Report 350.
- To prevent misunderstanding by others, this letter of acceptance is designated as number CC-106 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 acceptance letter shall not be construed as authorization or consent by the FHWA to use, manufacture, or sell any patented device for which the applicant is not the patent holder. The acceptance letter is limited to the crashworthiness characteristics of the candidate device, and the FHWA is neither prepared nor required to become involved in issues concerning patent law. Patent issues, if any, are to be resolved by the applicant.

Sincerely yours,

David A. Nicol, P.E.
Director, Office of Safety Design
Office of Safety

Enclosures

FHWA:HSSD:WLongstreet:tb:x60087:12/17/09

File: s://directory folder/WLongstreet/CC106.doc

cc: HSSD (Reader, HSA; Chron File, HSSD; W.Longstreet, HSSD; NArtimovich, HSSD;
MMcDonough, HSSD)



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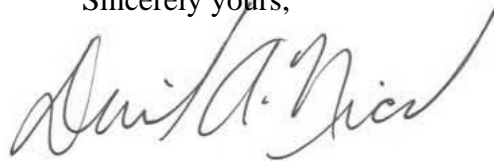
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A handwritten signature in cursive script, appearing to read "David A. Nicol".

David A. Nicol, P.E.
Director, Office of Safety Design
Office of Safety

Enclosures

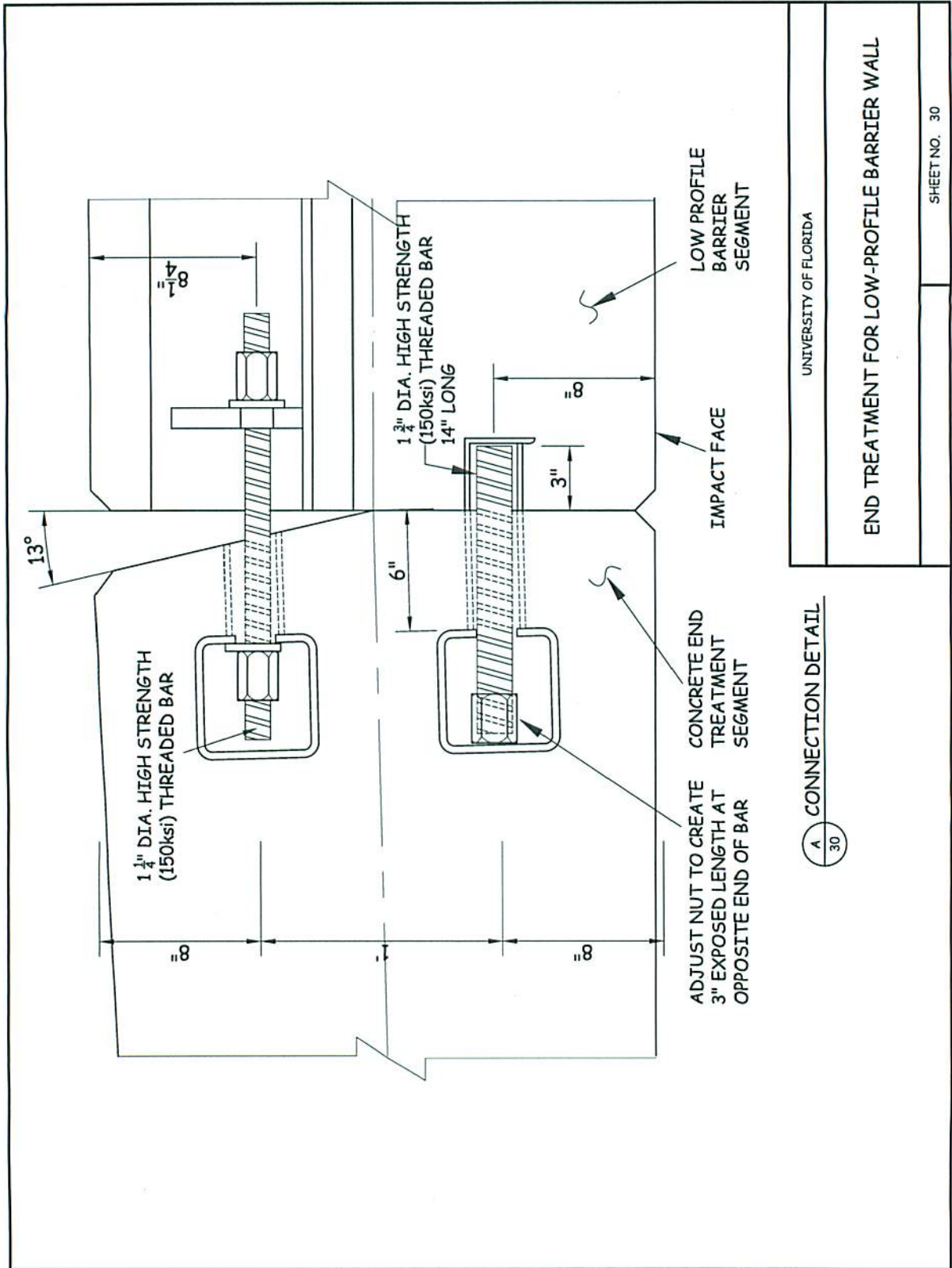


Illustration D-1. Drawings of Florida Concrete Curb End Treatment (14 of 14)

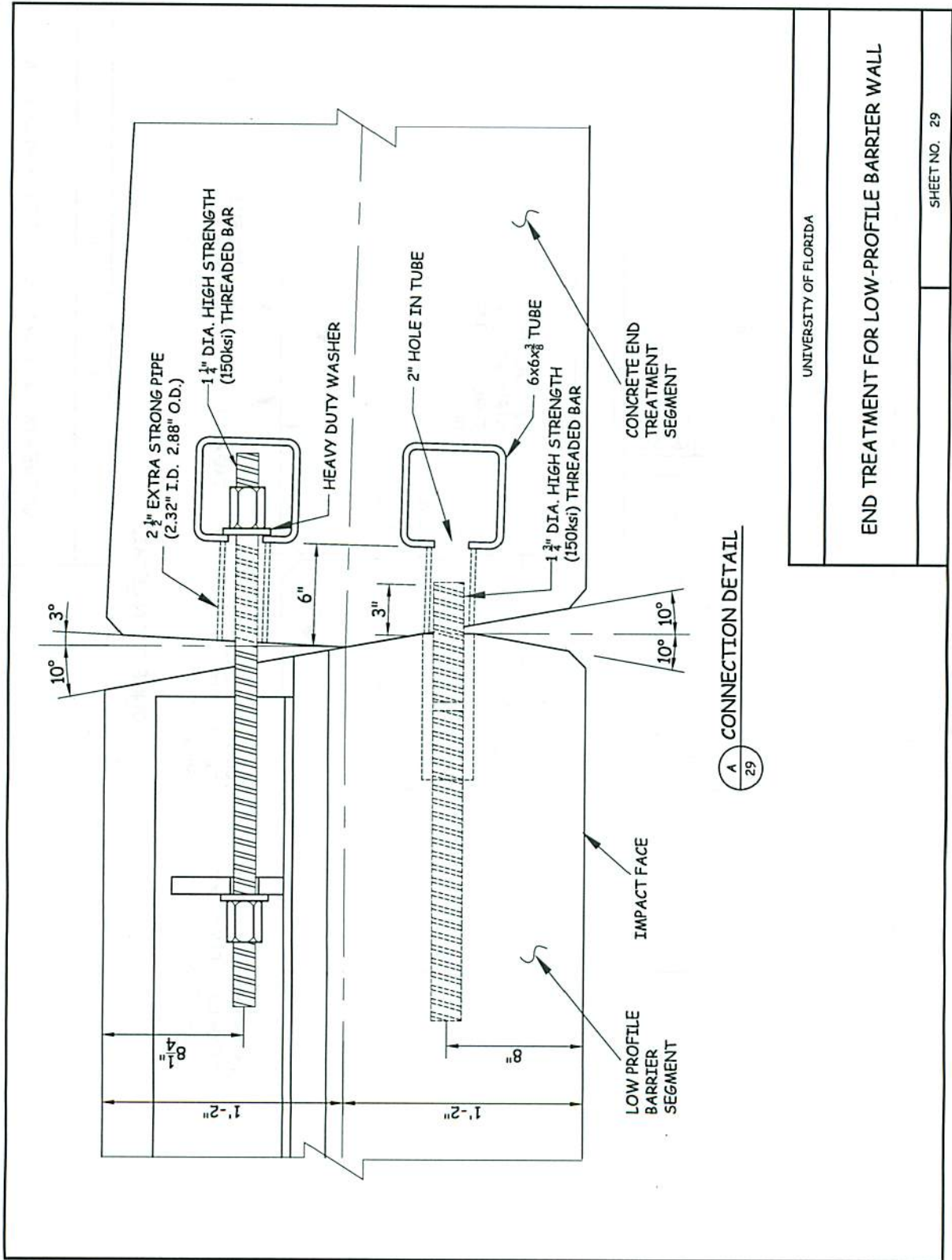


Illustration D-1. Drawings of Florida Concrete Curb End Treatment (13 of 14)

UNIVERSITY OF FLORIDA

END TREATMENT FOR LOW-PROFILE BARRIER WALL

SHEET NO. 29

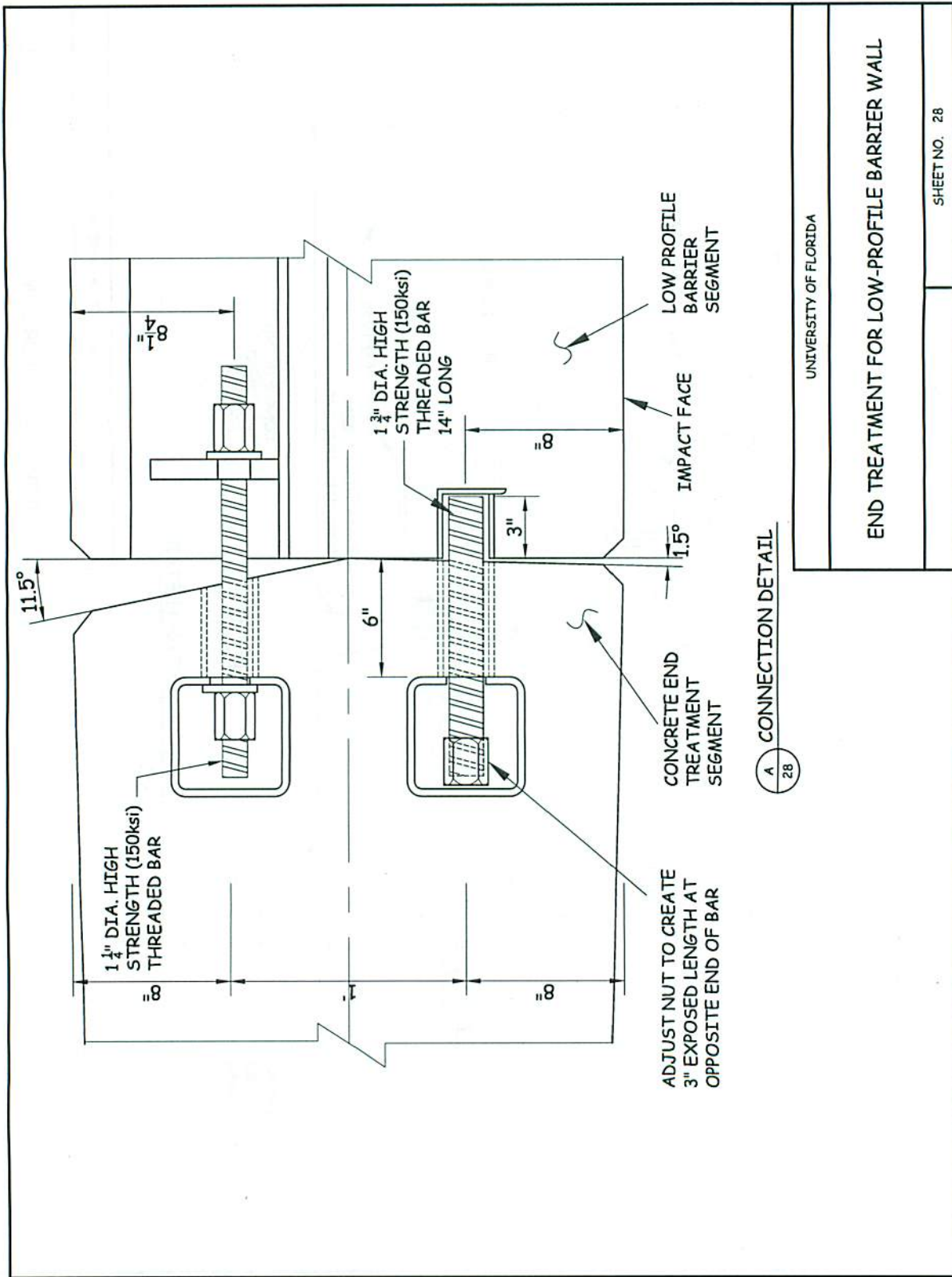


Illustration D-1. Drawings of Florida Concrete Curb End Treatment (12 of 14)

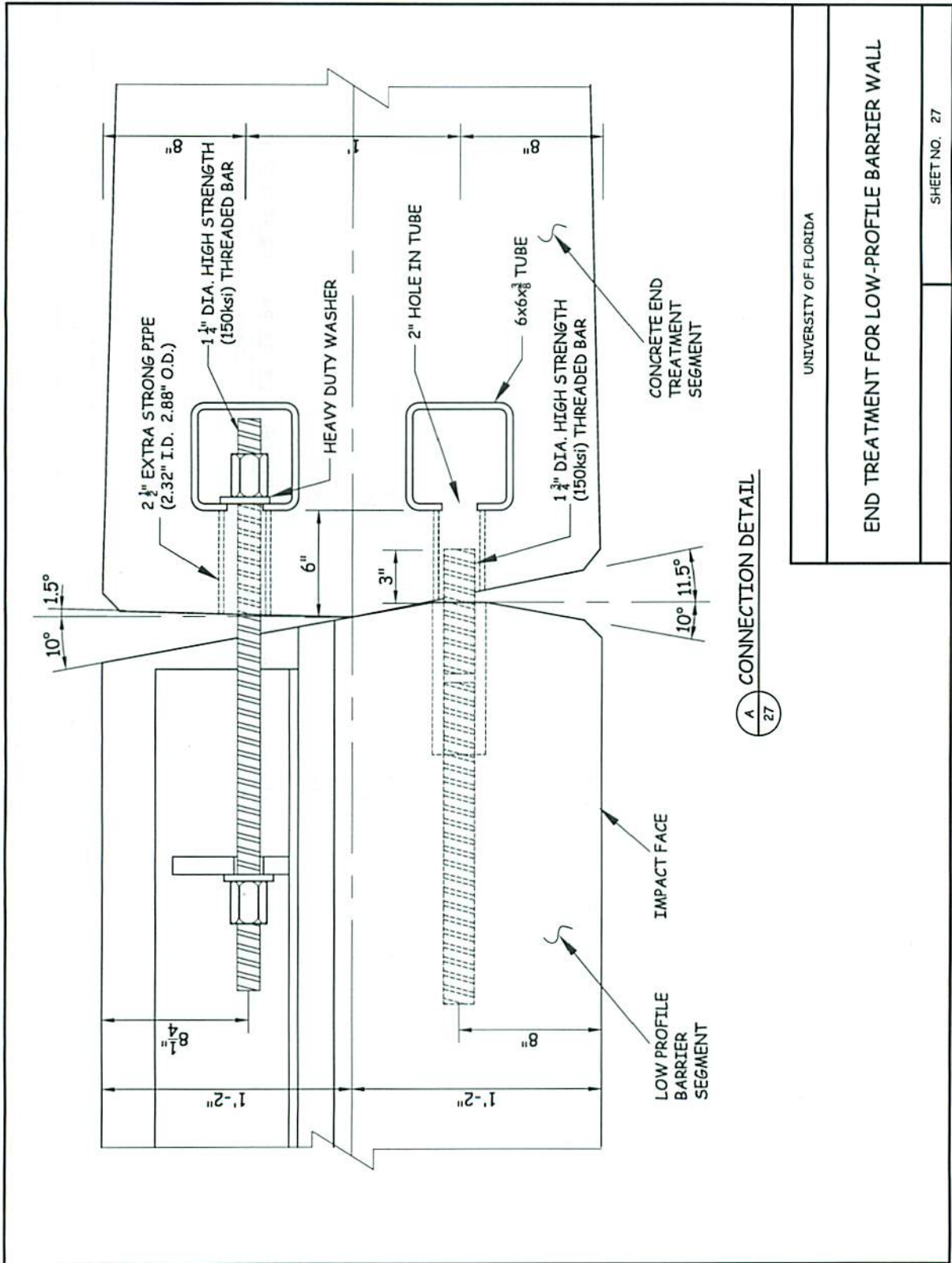


Illustration D-1. Drawings of Florida Concrete Curb End Treatment (11 of 14)

UNIVERSITY OF FLORIDA

END TREATMENT FOR LOW-PROFILE BARRIER WALL

SHEET NO. 27

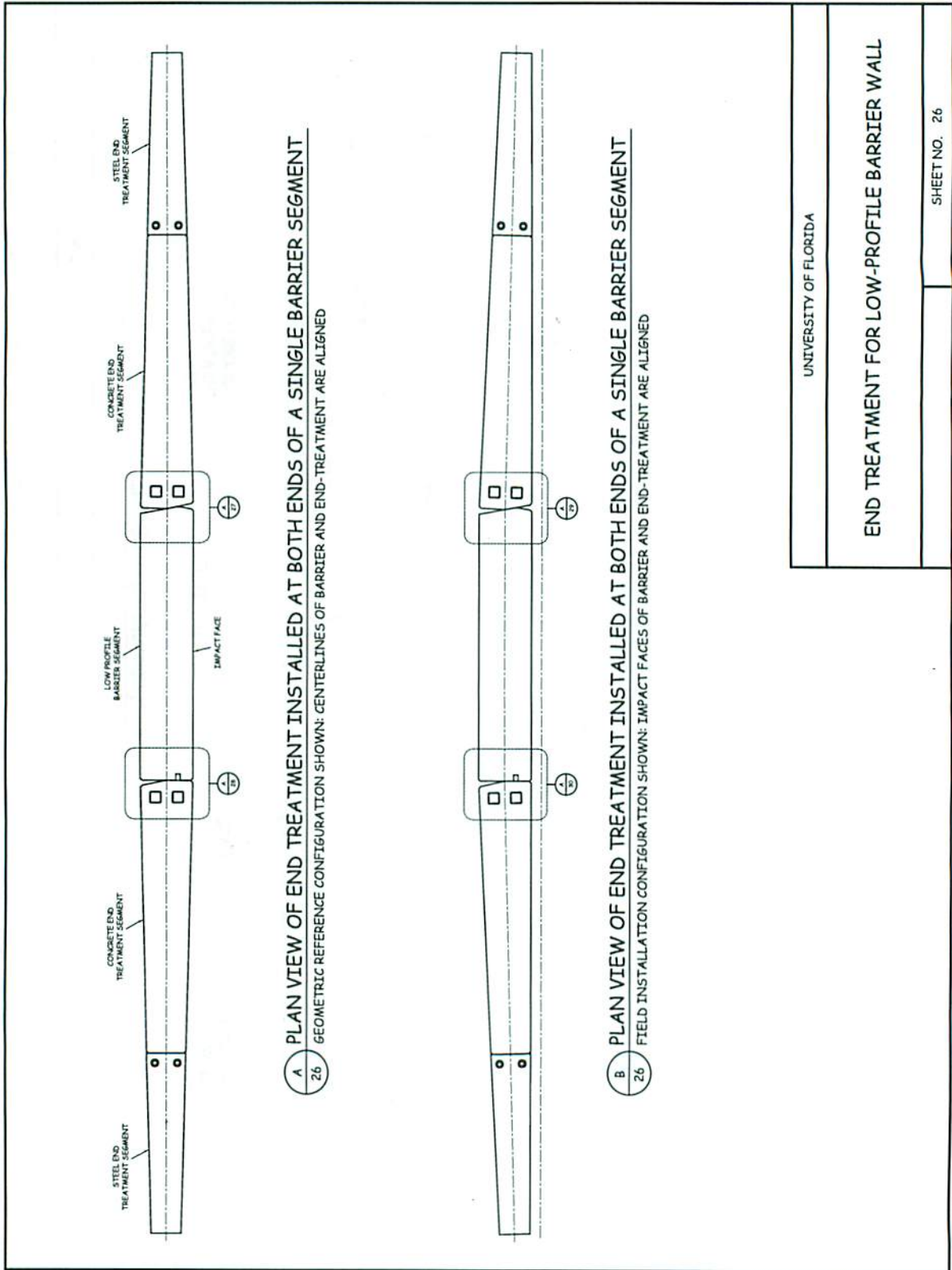
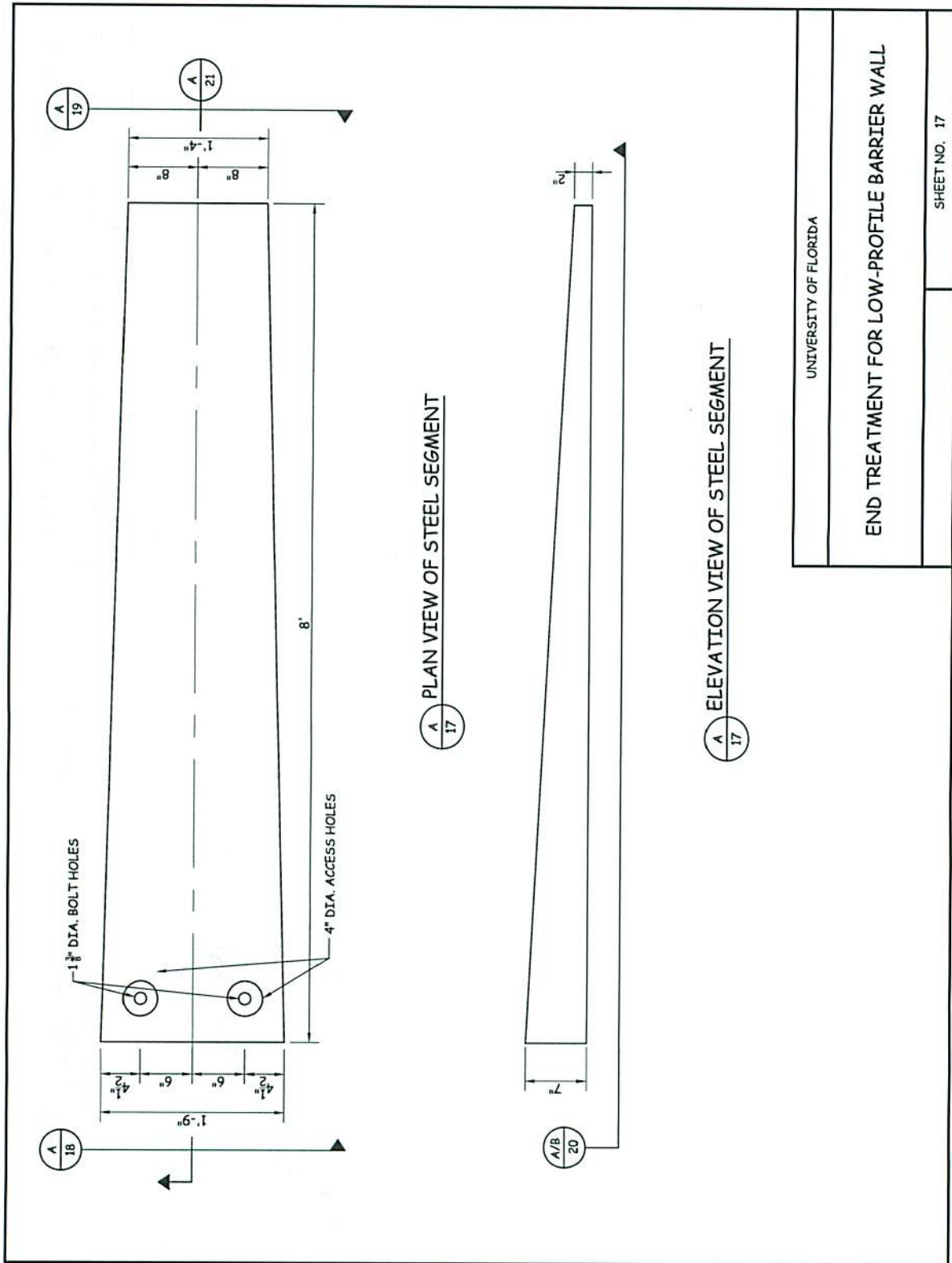


Illustration D-1. Drawings of Florida Concrete Curb End Treatment (9 of 14)

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END TREATMENT FOR LOW-PROFILE BARRIER WALL	
	SHEET NO. 26



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END TREATMENT FOR LOW-PROFILE BARRIER WALL

SHEET NO. 17

Illustration D-1. Drawings of Florida Concrete Curb End Treatment (8 of 14)

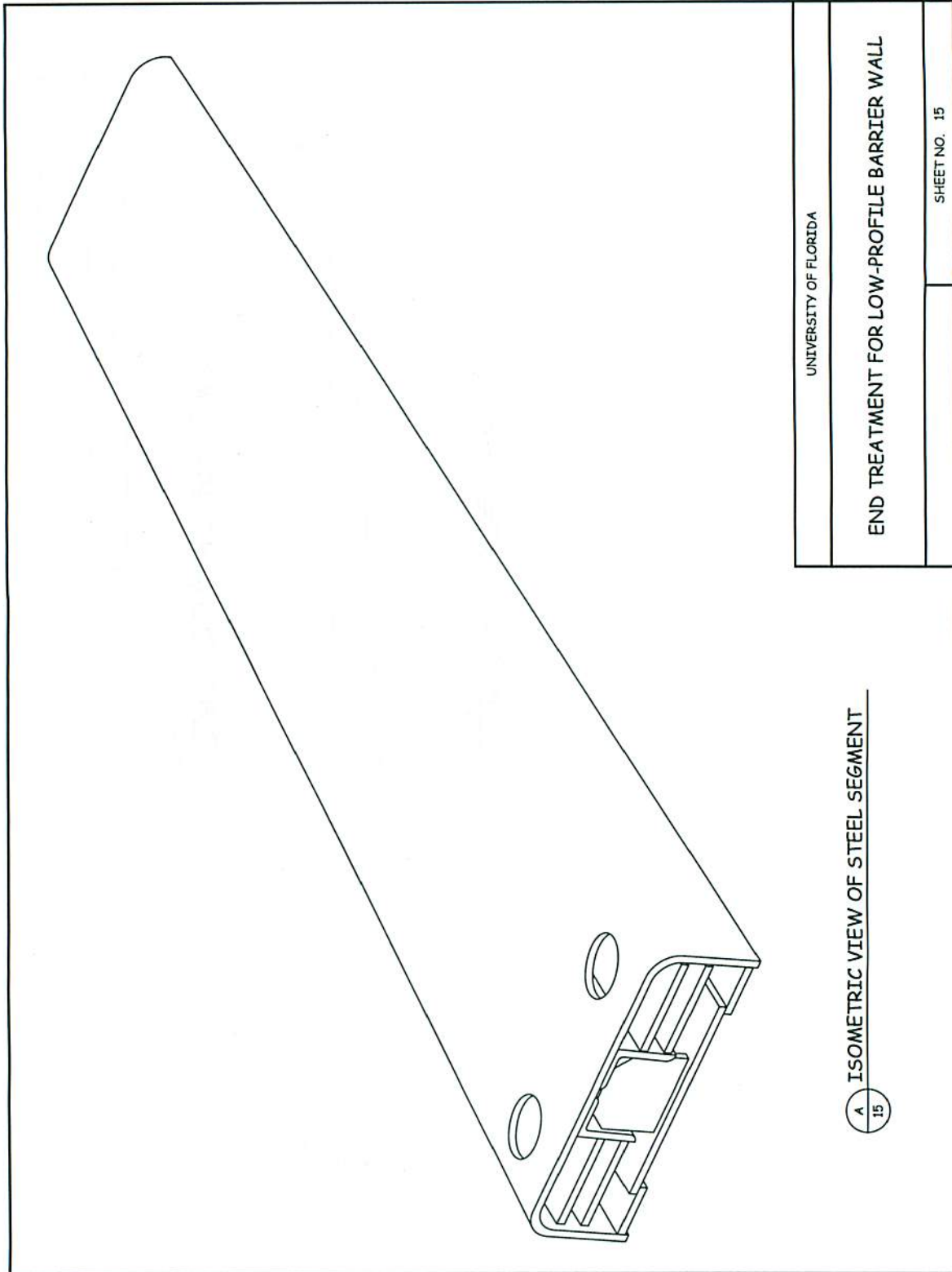
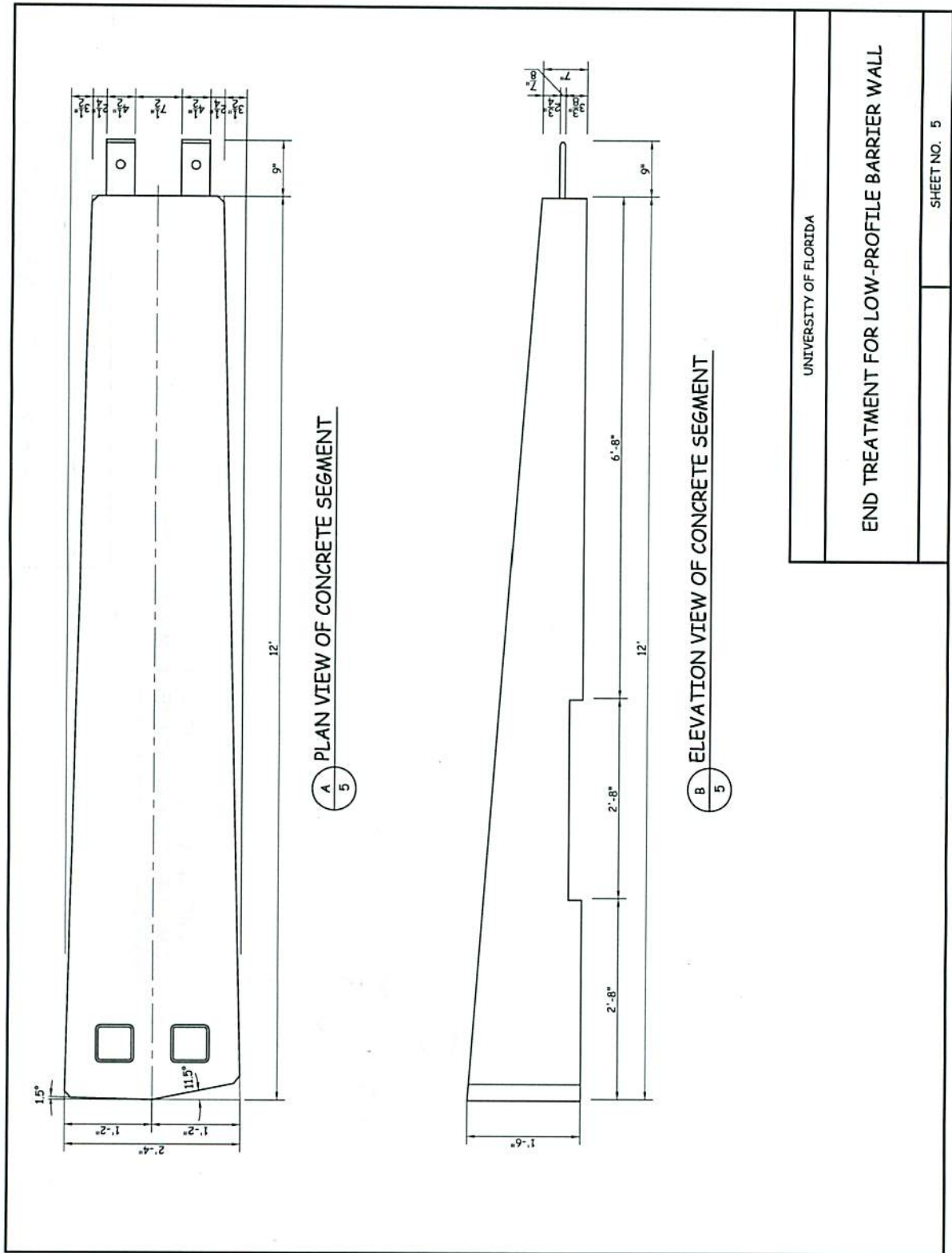
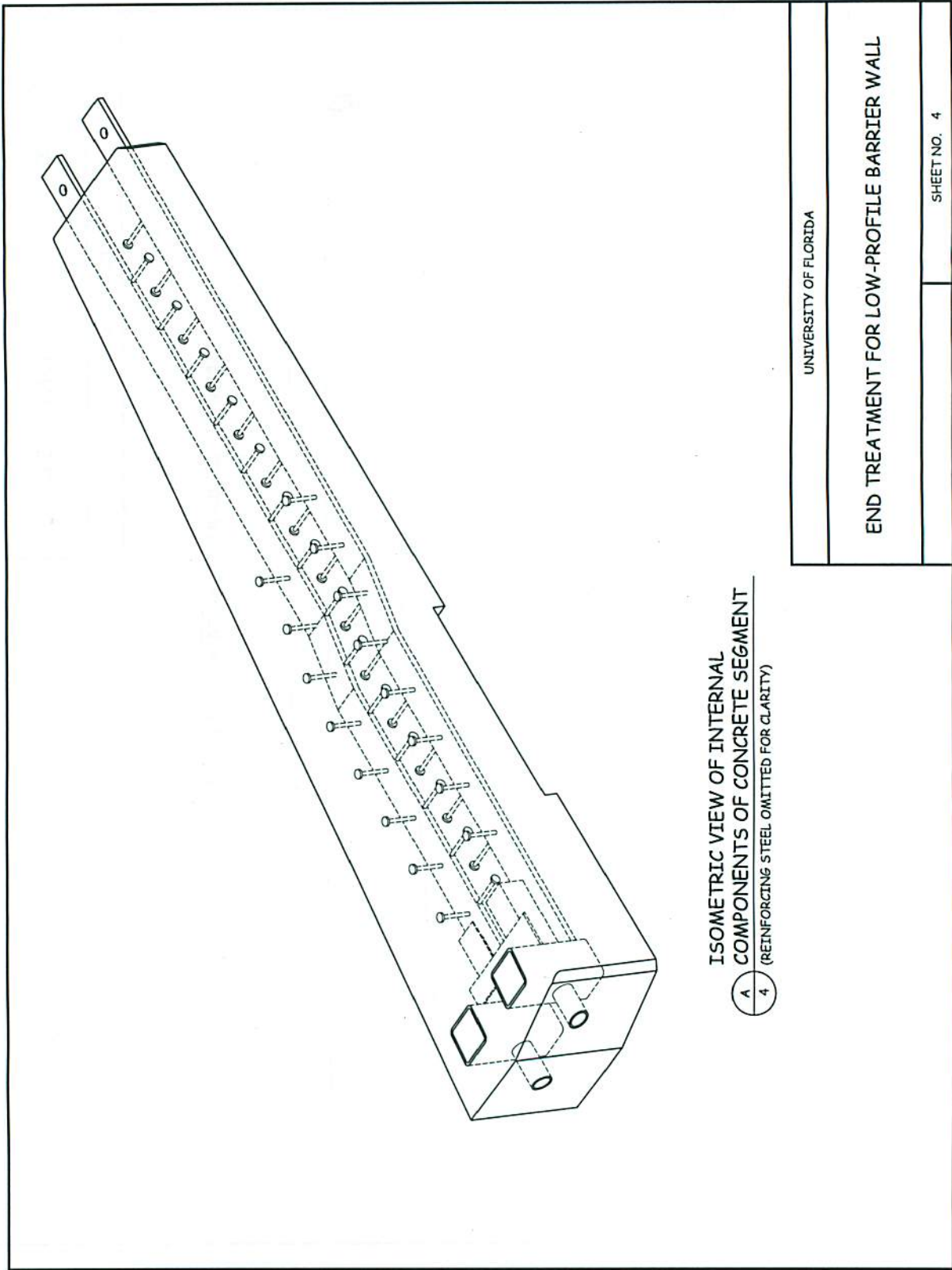


Illustration D-1. Drawings of Florida Concrete Curb End Treatment (7 of 14)



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END TREATMENT FOR LOW-PROFILE BARRIER WALL
SHEET NO. 5

Illustration D-1. Drawings of Florida Concrete Curb End Treatment (6 of 14)



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END TREATMENT FOR LOW-PROFILE BARRIER WALL
SHEET NO. 4

Illustration D-1. Drawings of Florida Concrete Curb End Treatment (5 of 14)

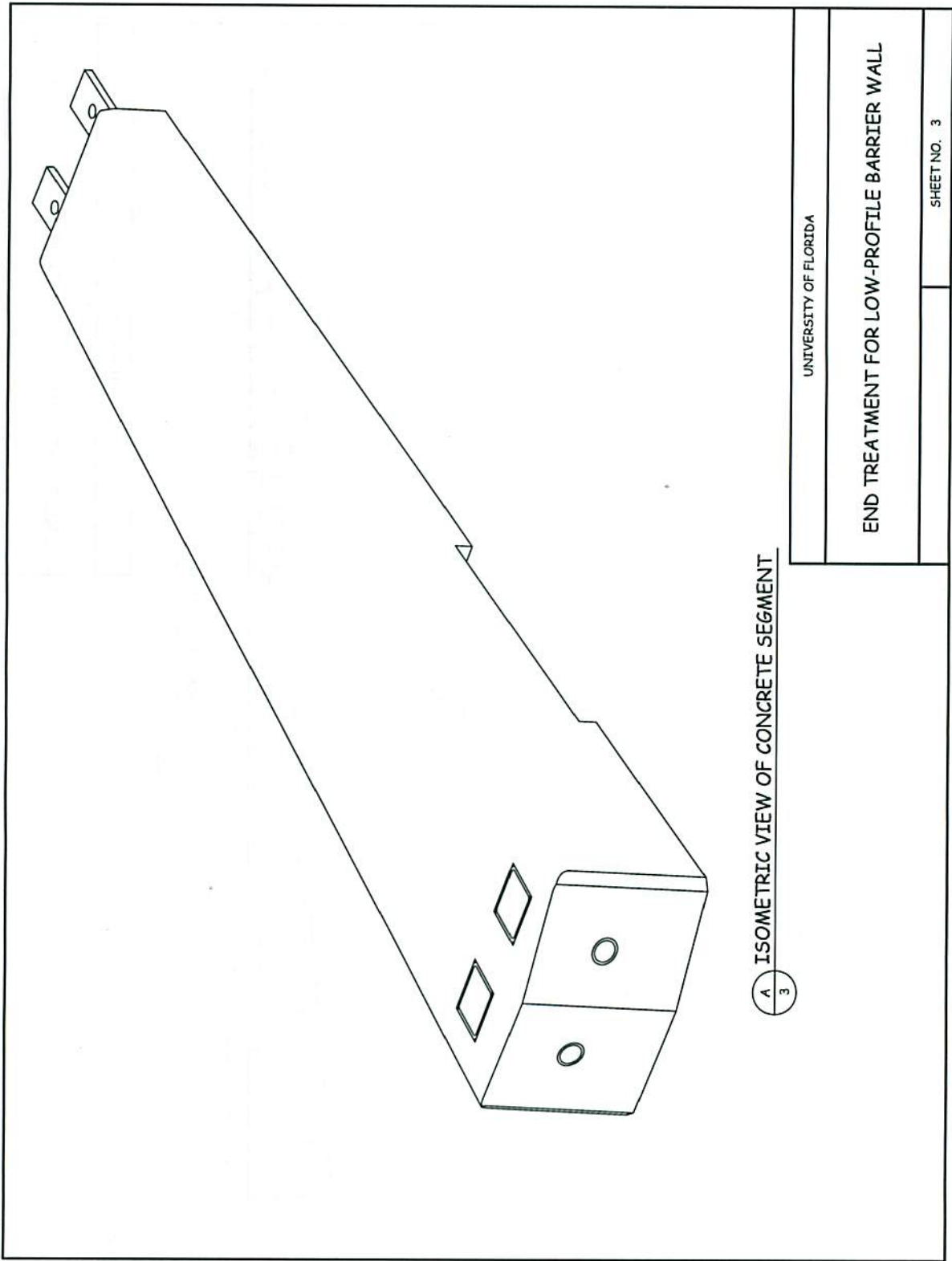
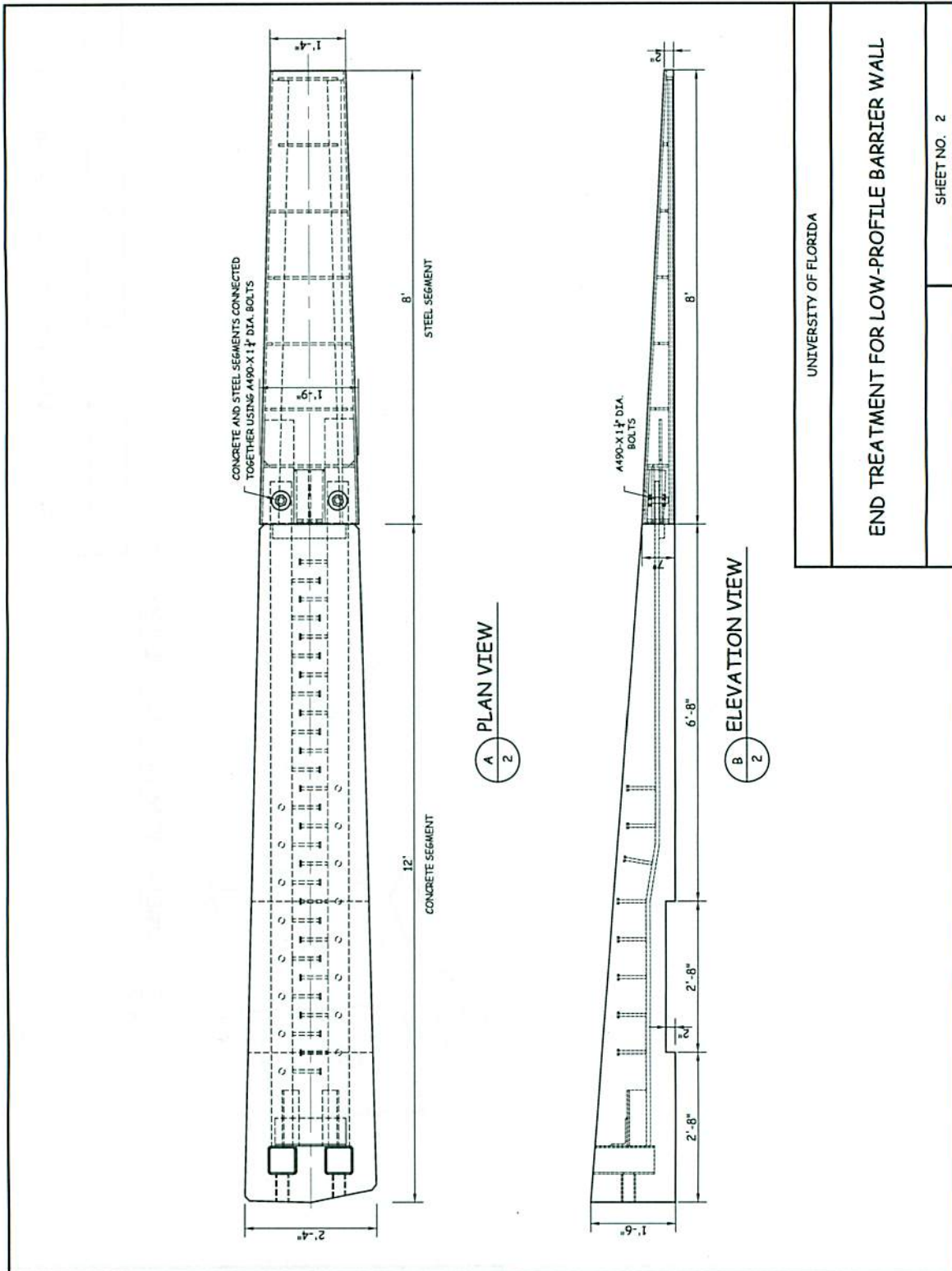
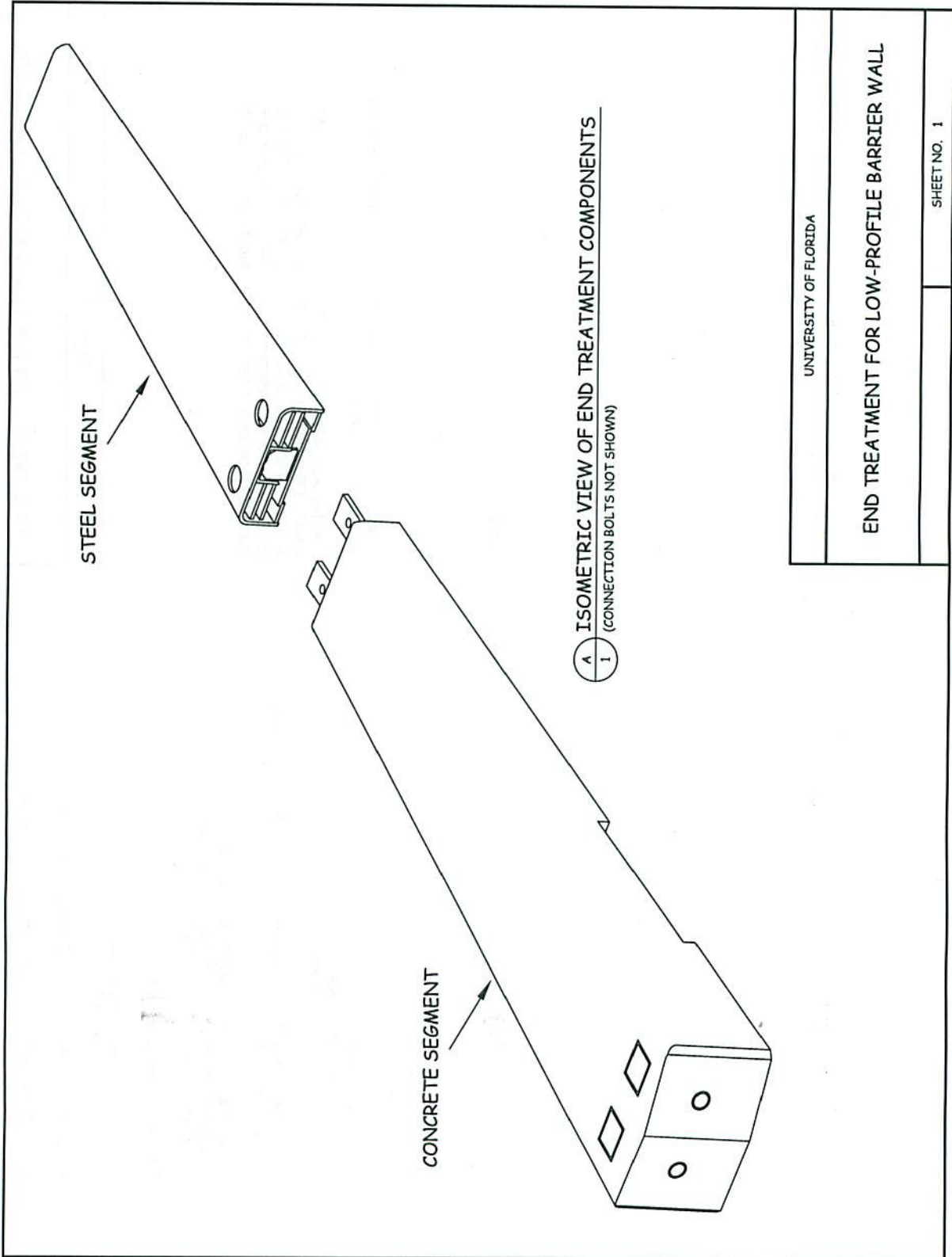


Illustration D-1. Drawings of Florida Concrete Curb End Treatment (4 of 14)



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END TREATMENT FOR LOW-PROFILE BARRIER WALL	
	SHEET NO. 2

Illustration D-1. Drawings of Florida Concrete Curb End Treatment (3 of 14)



UNIVERSITY OF FLORIDA
END TREATMENT FOR LOW-PROFILE BARRIER WALL
SHEET NO. 1

Illustration D-1. Drawings of Florida Concrete Curb End Treatment (2 of 14)



UNIVERSITY OF FLORIDA TAPERED END TREATMENT FOR LOW-PROFILE BARRIER WALL

TABLE OF CONTENTS	SHEET
OVERVIEW OF THE PRODUCT	1-2
CONCRETE SEGMENT	3-14
STEEL SEGMENT	15-25
CONNECTION OF END TREATMENT TO BARRIER SEGMENTS	26-30

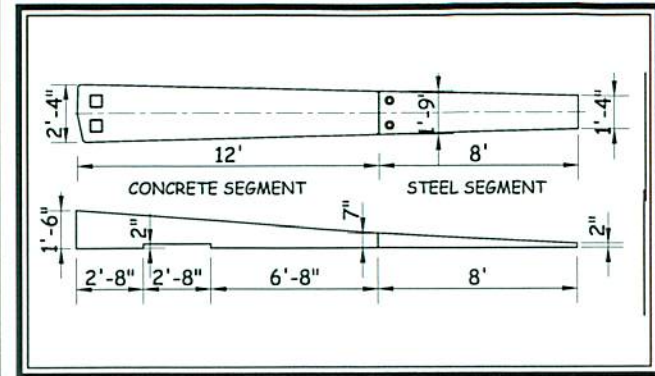
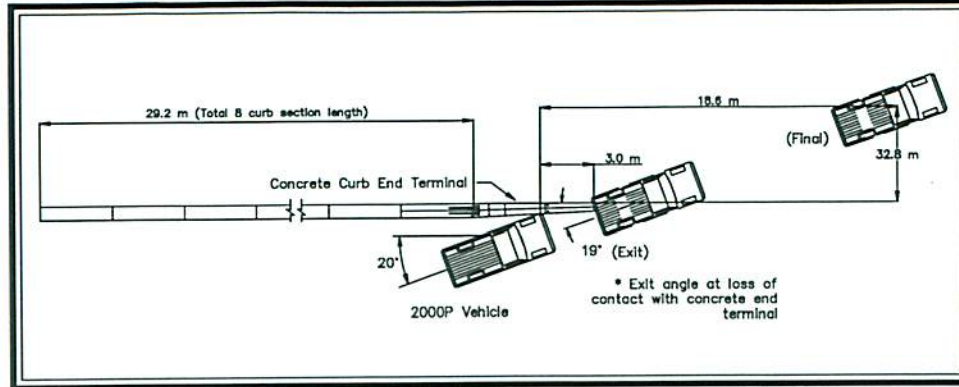
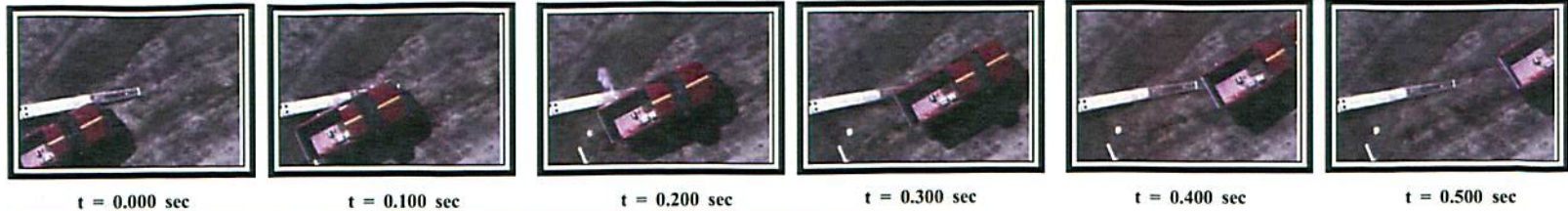
GENERAL NOTES:

1. CONCRETE
 - A. CONCRETE MIX:
 - f_c'i = 3,000 psi AT FORM REMOVAL
 - f'c = 5,000 psi AT 28 DAYS.
 - B. CURING SHALL BE IN ACCORDANCE WITH CURRENT FLORIDA DOT STANDARDS.
 - C. NEITHER TRANSPORT NOR INSTALLATION OF BARRIER SEGMENTS SHALL TAKE PLACE BEFORE THE 28 DAY CONCRETE STRENGTH HAS BEEN ACHIEVED.
2. ALL REBAR SHALL BE A615, GR60.
3. ALL STRUCTURAL STEEL (EXCEPT AS NOTED BELOW) SHALL BE A572 GRADE 50
4. ALL STRUCTURAL STEEL TUBE SHALL BE A500 GRADE B OR C
5. ALL STRUCTURAL STEEL PIPE SHALL BE A53 GRADE B
6. FABRICATION OF THE CONCRETE UNITS SHALL CONFORM TO THE REQUIREMENTS OF ACT 318-02.
7. MANUFACTURERS OF CONCRETE UNITS SHALL CONFORM TO THE CURRENT FLORIDA DEPARTMENT OF TRANSPORTATION REQUIREMENTS FOR QUALITY CONTROL. CONTACT THE FLORIDA DEPARTMENT OF TRANSPORTATION, STATE MATERIALS OFFICE FOR INFORMATION ON CURRENT REQUIREMENTS (352-955-6683).

UNIVERSITY OF FLORIDA

END TREATMENT FOR LOW-PROFILE BARRIER WALL

Illustration D-1. Drawings of Florida Concrete Curb End Treatment (1 of 14)



E-TECH Testing Services, Inc.

General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 2-39
Test No.	71-1776-007
Date	6/12/08
Test Article	
Type	University of Florida
.....	Concrete Curb End Treatment
.....	6.1 m length
Installation Length	35.3 m overall with (8) curbs
Material and key elements	Terminal: (1) 2.4 m long Steel
.....	Segment and (1) 3.7 m Concrete
.....	Segment, Barrier: (8) 3.7 m Curb
.....	Segments
Foundation Type and Condition	Aged chip seal asphalt, dry
Test Vehicle	
Type	Production Model
Designation	2000P
Model	1988 Chevrolet C2500
.....	3/4 Ton Pickup
Mass (kg)	
Curb	1893
Test inertial	2000
Dummy	N/A
Gross Static	2000
Impact Conditions	
Speed (km/h)	71.3
Angle (deg)	20
Impact Severity (kJ)	45.9

Exit conditions

Speed (km/h)	68.1
Angle (deg - veh. c.g.)	19
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	0.9
y-direction	-1.0
Ridedown Acceleration (g's)	
x-direction	-1.0
y-direction	-1.6
European Committee for Normalization (CEN) Values	
THIV (km/h)	5.4
PHD (g's)	1.8
ASI	0.3
Post-Impact Vehicular Behavior (deg - rate gyro)	
Maximum Roll Angle	4.1
Maximum Pitch Angle	-4.3
Maximum Yaw Angle	-29.1

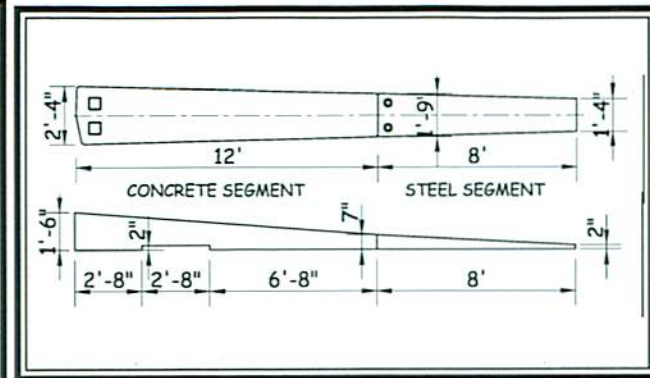
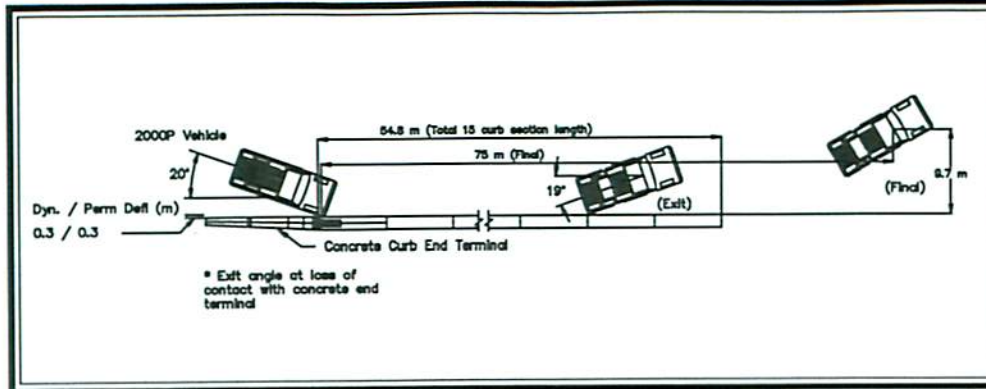
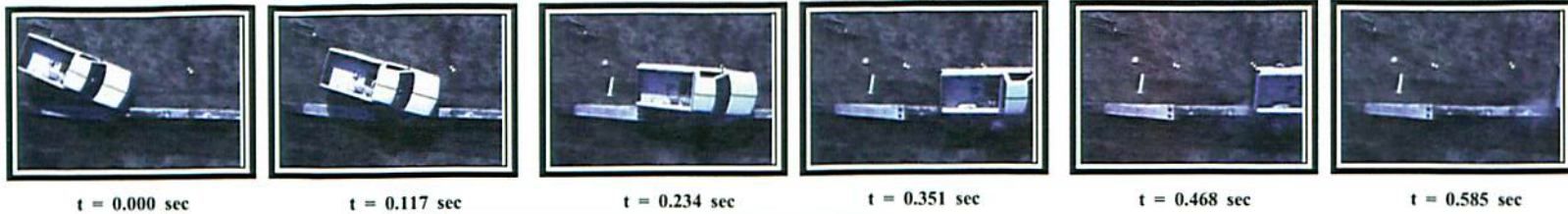
Test Article Deflections (m)

Dynamic	N/A
Permanent	N/A

Vehicle Damage (Primary Impact)

Exterior	
VDS	N/A
CDC	N/A
Interior	
VCDI	AS0000000
Maximum Deformation (mm)	Negligible

Figure 31. Summary of Results - Florida Curb End Treatment Test 71-1776-007



E-TECH Testing Services, Inc.

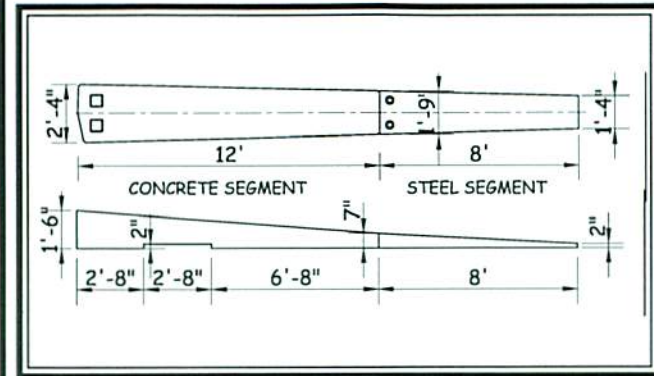
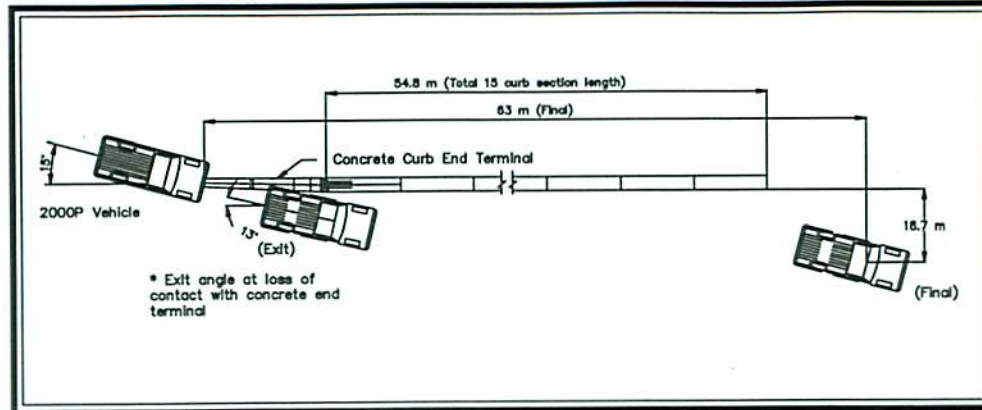
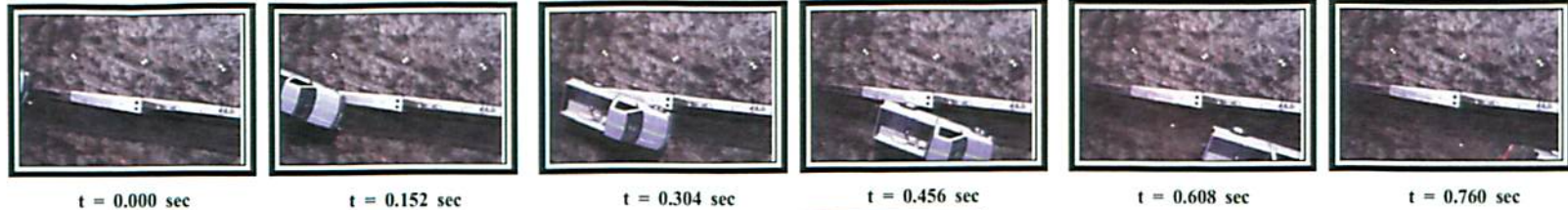
General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 2-35
Test No.	71-1776-006
Date	5/29/08
Test Article	
Type	University of Florida
.....	Concrete Curb End Treatment
.....	6.1 m length
Installation Length	60.9 overall with (15) curbs
Material and key elements	Terminal: (1) 2.4 m long Steel
.....	Segment and (1) 3.7 m Concrete
.....	Segment, Barrier: (15) 3.7 m Curb
.....	Segments
Foundation Type and Condition	Aged chip seal asphalt, dry
Test Vehicle	
Type	Production Model
Designation	2000P
Model	1993 Chevrolet C2500
.....	3/4 Ton Pickup
Mass (kg)	
Curb	1877
Test inertial	2013
Dummy	N/A
Gross Static	2013
Impact Conditions	
Speed (km/h)	72.4
Angle (deg)	20
Impact Severity (kJ)	47.6

Exit conditions

Speed (km/h)	52.3
Angle (deg - veh. c.g.)	19
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	3.0
y-direction	-3.9
Ridedown Acceleration (g's)	
x-direction	-3.3
y-direction	-7.5
European Committee for Normalization (CEN) Values	
THIV (km/h)	17.4
PHD (g's)	7.5
ASI	0.6
Post-Impact Vehicular Behavior (deg - rate gyro)	
Maximum Roll Angle	21.5
Maximum Pitch Angle	-5.8
Maximum Yaw Angle	-47.2
Test Article Deflections (m)	
Dynamic	0.3
Permanent	0.3
Vehicle Damage (Primary Impact)	
Exterior	
VDS	N/A
CDC	N/A
Interior	
VCDI	AS0000000
Maximum Deformation (mm)	Negligible

Figure 26. Summary of Results - Florida Curb End Treatment Test 71-1776-006

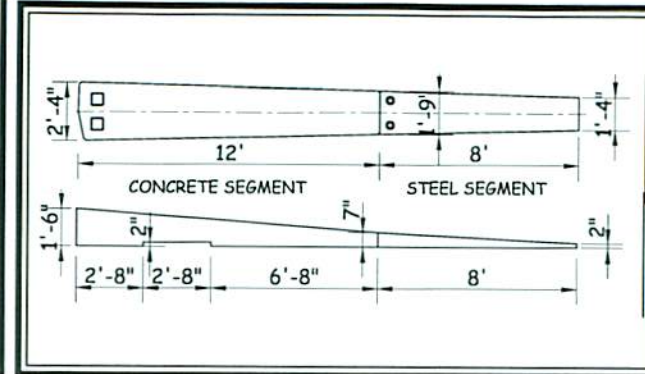
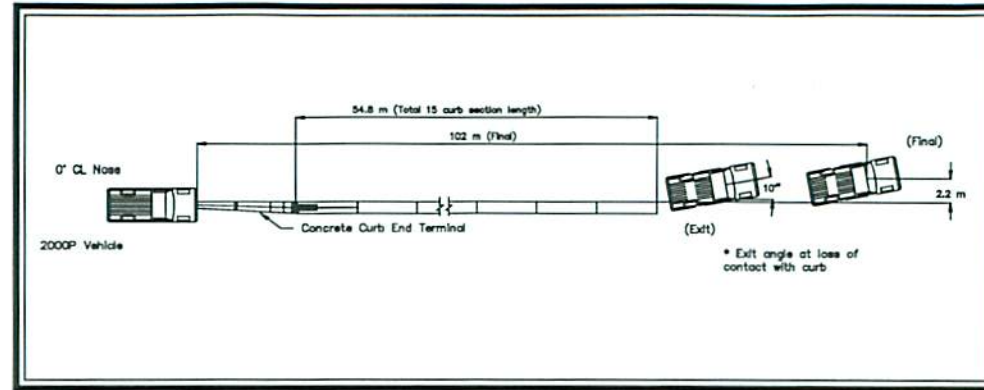
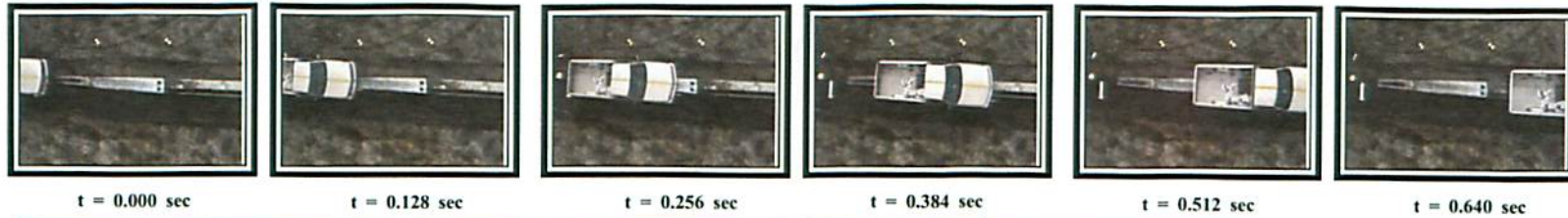


E-TECH Testing Services, Inc.

Florida Concrete Curb End Treatment Crash Test Results - 29 of 117

General Information		Exit conditions	
Test Agency	E-TECH Testing Services, Inc.	Speed (km/h)	69.5
Test Designation	NCHRP 350 Test 2-33	Angle (deg - veh. c.g.)	13
Test No.	71-1776-001	Occupant Risk Values	
Date	4/29/08	Impact Velocity (m/s)	
Test Article		x-direction	1.0
Type	University of Florida	y-direction	-0.5
.....	Concrete Curb End Treatment	Ridedown Acceleration (g's)	
.....	6.1 m length	x-direction	-1.6
.....	60.9 overall with (15) curbs	y-direction	-1.4
.....	Terminal: (1) 2.4 m long Steel	European Committee for Normalization (CEN) Values	
.....	Segment and (1) 3.7 m Concrete	THIV (km/h)	5.4
.....	Segment, Barrier: (15) 3.7 m Curb	PHD (g's)	1.6
.....	Segments	ASI	0.3
.....	Aged chip seal asphalt, dry	Post-Impact Vehicular Behavior (deg - rate gyro)	
Foundation Type and Condition		Maximum Roll Angle	8.7
Test Vehicle		Maximum Pitch Angle	8.8
Type	Production Model	Maximum Yaw Angle	15.2
Designation	2000P	Test Article Deflections (m)	
Model	1989 Chevrolet C2500	Dynamic	N/A
.....	3/4 Ton Pickup	Permanent	N/A
.....		Vehicle Damage (Primary Impact)	
Mass (kg)		Exterior	
Curb	1883	VDS	N/A
Test inertial	2000	CDC	N/A
Dummy	N/A	Interior	
Gross Static	2000	VCDI	AS0000000
Impact Conditions		Maximum Deformation (mm)	Negligible
Speed (km/h)	73.1		
Angle (deg)	15		
Impact Severity (kJ)	412.6		

Figure 16. Summary of Results - Florida Curb End Treatment Test 71-1776-001



E-TECH Testing Services, Inc.

General Information

Test Agency E-TECH Testing Services, Inc.
 Test Designation NCHRP 350 Test 2-31
 Test No. 71-1776-005
 Date 5/20/08

Test Article

Type University of Florida
 Concrete Curb End Treatment
 Installation Length 6.1 m length
 60.9 overall with (15) curbs
 Material and key elements Terminal: (1) 2.4 m long Steel
 Segment and (1) 3.7 m Concrete
 Segment, Barrier: (15) 3.7 m Curb
 Segments
 Foundation Type and Condition Aged chip seal asphalt, dry

Test Vehicle

Type Production Model
 Designation 2000P
 Model 1988 Chevrolet Pickup
 Mass (kg)
 Curb 1837
 Test inertial 1999
 Dummy N/A
 Gross Static 1999

Impact Conditions

Speed (km/h) 72.0
 Angle (deg) 0
 Impact Severity (kJ) 400.2

Exit conditions

Speed (km/h) 43.2
 Angle (deg - veh. c.g.) 10

Occupant Risk Values

Impact Velocity (m/s)
 x-direction 1.3
 y-direction -0.3
 Ridedown Acceleration (g's)
 x-direction -2.2
 y-direction -1.3

European Committee for Normalization (CEN) Values

THIV (km/h) 5.7
 PHD (g's) 2.2
 ASI 0.3

Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle 15.3
 Maximum Pitch Angle 29.1
 Maximum Yaw Angle -10.6

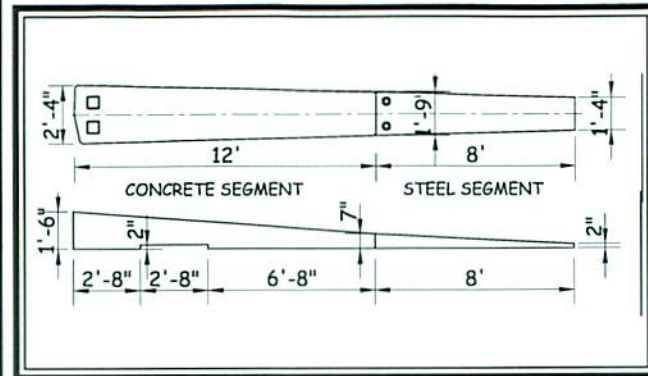
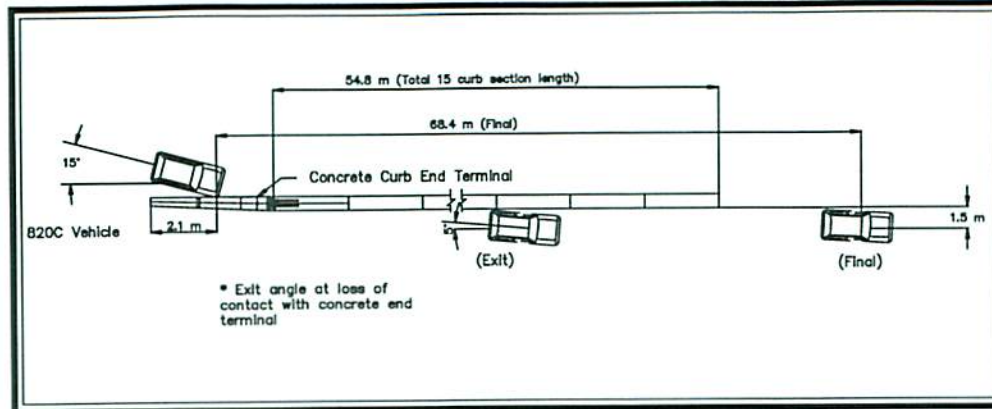
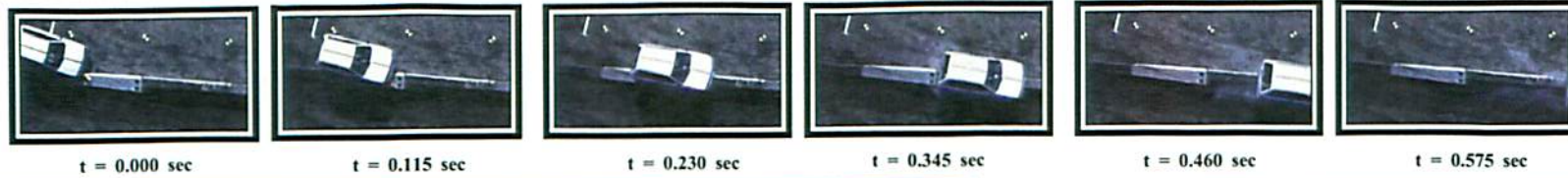
Test Article Deflections (m)

Dynamic N/A
 Permanent N/A

Vehicle Damage (Primary Impact)

Exterior
 VDS N/A
 CDC N/A
 Interior
 VCDI AS0000000
 Maximum Deformation (mm) Negligible

Figure 6. Summary of Results - Florida Curb End Treatment Test 71-1776-005



E-TECH Testing Services, Inc.

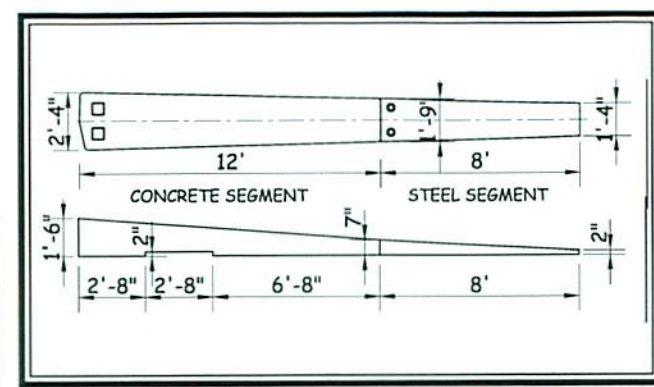
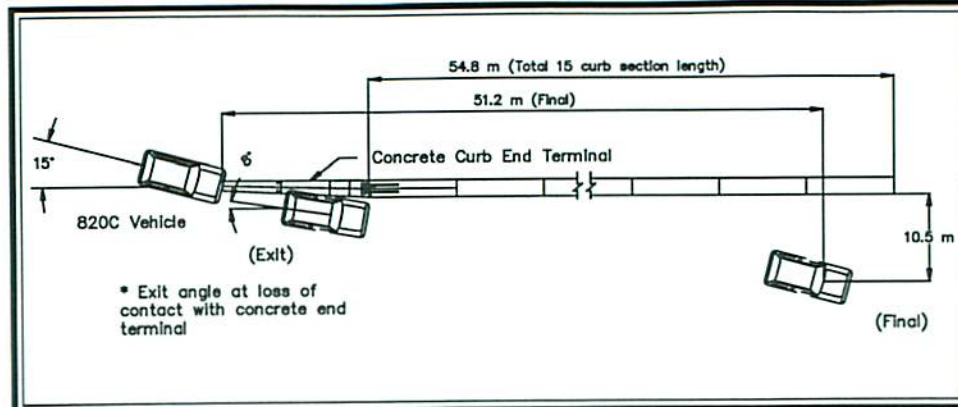
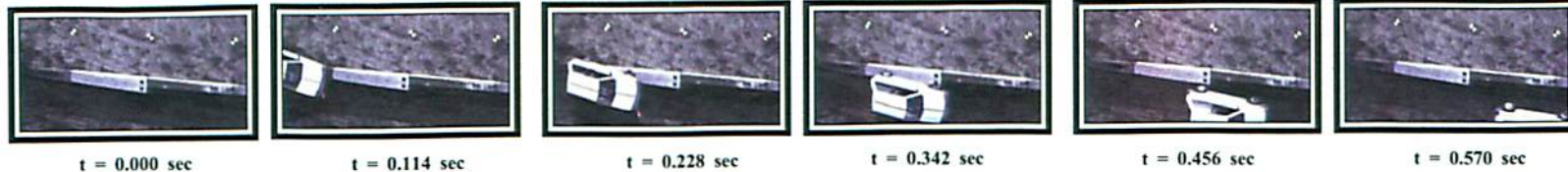
General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 2-34
Test No.	71-1776-003
Date	5/13/08
Test Article	
Type	University of Florida
.....	Concrete Curb End Treatment
.....	6.1 m length
Installation Length	60.9 overall with (15) curbs
Material and key elements	Terminal: (1) 2.4 m long Steel
.....	Segment and (1) 3.7 m Concrete
.....	Segment, Barrier: (15) 3.7 m Curb
.....	Segments
Foundation Type and Condition	Aged chip seal asphalt, dry
Test Vehicle	
Type	Production Model
Designation	820C
Model	1988 Ford Festiva
.....	
Mass (kg)	
Curb	818
Test inertial	832
Dummy	75
Gross Static	907
Impact Conditions	
Speed (km/h)	71.7
Angle (deg)	15
Impact Severity (kJ)	11.0

Exit conditions

Speed (km/h)	64.8
Angle (deg - veh. c.g.)	5
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	1.7
y-direction	-2.1
Ridedown Acceleration (g's)	
x-direction	-1.7
y-direction	-6.0
European Committee for Normalization (CEN) Values	
THIV (km/h)	9.8
PHD (g's)	6.0
ASI	0.5
Post-Impact Vehicular Behavior (deg - rate gyro)	
Maximum Roll Angle	33.2
Maximum Pitch Angle	9.2
Maximum Yaw Angle	-24.4
Test Article Deflections (m)	
Dynamic	N/A
Permanent	N/A
Vehicle Damage (Primary Impact)	
Exterior	
VDS	N/A
CDC	N/A
Interior	
VCDI	AS0000000
Maximum Deformation (mm)	Negligible

Figure 21. Summary of Results - Florida Curb End Treatment Test 71-1776-003



E-TECH Testing Services, Inc.

General Information

Test Agency E-TECH Testing Services, Inc.
 Test Designation NCHRP 350 Test 2-32
 Test No. 71-1776-002

Date 5/08/08

Test Article

Type University of Florida
 Concrete Curb End Treatment
 6.1 m length
 Installation Length 60.9 overall with (15) curbs
 Material and key elements Terminal: (1) 2.4 m long Steel Segment and (1) 3.7 m Concrete Segment, Barrier: (15) 3.7 m Curb Segments
 Foundation Type and Condition Aged chip seal asphalt, dry

Test Vehicle

Type Production Model
 Designation 820C
 Model 1988 Ford Festiva

Mass (kg)

Curb 818
 Test inertial 832
 Dummy 75
 Gross Static 907

Impact Conditions

Speed (km/h) 72.0
 Angle (deg) 15
 Impact Severity (kJ) 166.6

Exit conditions

Speed (km/h) 68.9
 Angle (deg - veh. c.g.) 8

Occupant Risk Values

Impact Velocity (m/s)
 x-direction 0.9
 y-direction -1.2
 Ridedown Acceleration (g's)
 x-direction -1.0
 y-direction -1.7

European Committee for Normalization (CEN) Values

THIV (km/h) 5.4
 PHD (g's) 1.8
 ASI 0.3

Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle 27.5
 Maximum Pitch Angle 6.6
 Maximum Yaw Angle 10.5

Test Article Deflections (m)

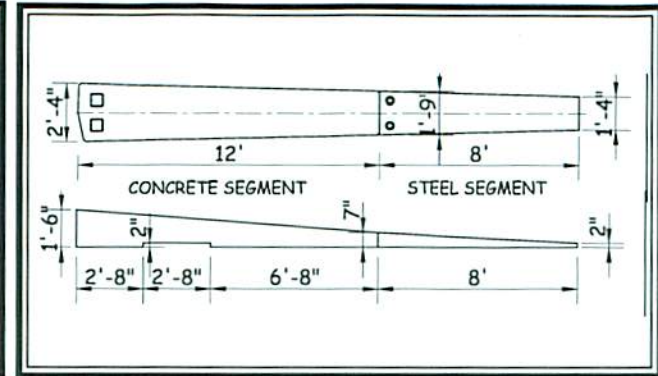
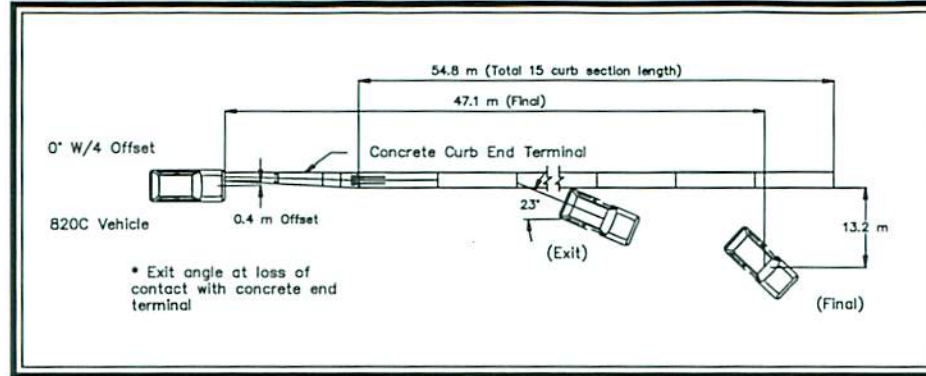
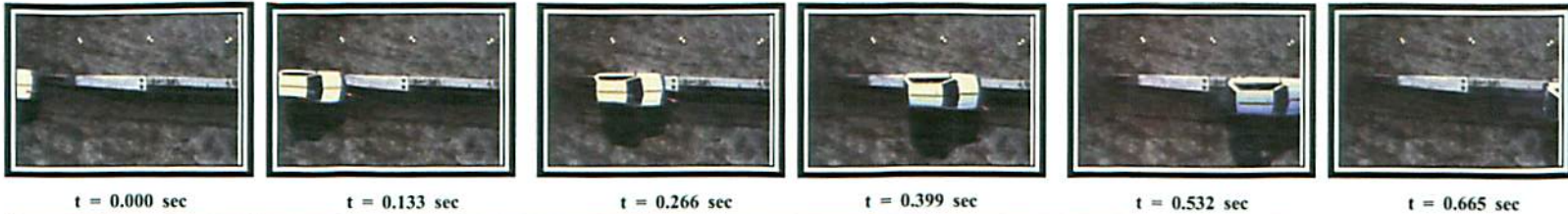
Dynamic N/A
 Permanent N/A

Vehicle Damage (Primary Impact)

Exterior
 VDS N/A
 CDC N/A
 Interior
 VCDI AS0000000
 Maximum Deformation (mm) Negligible

Florida Concrete Curb End Treatment Crash Test Results - 23 of 117

Figure 11. Summary of Results - Florida Curb End Treatment Test 71-1776-002



E-TECH Testing Services, Inc.

General Information

Test Agency E-TECH Testing Services, Inc.
 Test Designation NCHRP 350 Test 2-30
 Test No. 71-1776-004
 Date 5/16/08

Test Article

Type University of Florida
 Concrete Curb End Treatment
 6.1 m length
 Installation Length 60.9 overall with (15) curbs
 Material and key elements Terminal: (1) 2.4 m long Steel Segment and (1) 3.7 m Concrete Segment, Barrier: (15) 3.7 m Curb Segments

Foundation Type and Condition Aged chip seal asphalt, dry

Test Vehicle

Type Production Model
 Designation 820C
 Model 1988 Ford Festiva

Mass (kg)
 Curb 818
 Test inertial 832
 Dummy 75
 Gross Static 907

Impact Conditions

Speed (km/h) 71.0
 Angle (deg) 0
 Impact Severity (kJ) 161.7

Exit conditions

Speed (km/h) 60.1
 Angle (deg - veh. c.g.) 23

Occupant Risk Values

Impact Velocity (m/s)
 x-direction 1.0
 y-direction -0.3
 Ridedown Acceleration (g's)
 x-direction -3.9
 y-direction 3.0

European Committee for Normalization (CEN) Values

THIV (km/h) 5.5
 PHD (g's) 4.6
 ASI 0.3

Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle 24.8
 Maximum Pitch Angle 15.3
 Maximum Yaw Angle 42.7

Test Article Deflections (m)

Dynamic N/A
 Permanent N/A

Vehicle Damage (Primary Impact)

Exterior
 VDS N/A
 CDC N/A
 Interior
 VCDI AS0000000
 Maximum Deformation (mm) Negligible

Figure 1. Summary of Results - Florida Curb End Treatment Test 71-1776-004