



Report No. 400001-ETP2
Report Date: November 2010

**NCHRP REPORT 350 TEST 2-30 OF THE TL-2 ET-PLUS
WITH HBA AND SYTP**

by

Roger P. Bligh, P.E.
Research Engineer

C. Eugene Buth, P.E.
Senior Research Fellow

and

Wanda L. Menges
Research Specialist

Contract No.: P2010456
Test No.: 400001-ETP2
Test Date: September 1, 2010

Sponsored by
Trinity Highway Products, LLC

TEXAS TRANSPORTATION INSTITUTE PROVING GROUND

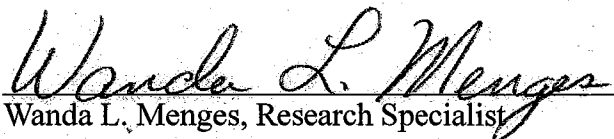
Mailing Address:
Roadside Safety & Physical Security
Texas A&M University System
3135 TAMU
College Station, TX 77843-3135

Located at:
Texas A&M Riverside Campus
Building 7091
3100 State Highway 47
Bryan, TX 77807

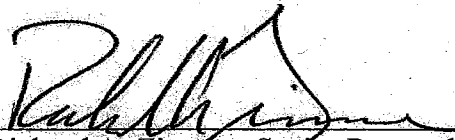


DISCLAIMER

The contents of this report reflect the views of the authors who are solely responsible for the facts and accuracy of the data, and the opinions, findings and conclusions presented herein. The contents do not necessarily reflect the official views or policies of Trinity Highway Products, LLC, The Texas A&M University System, or Texas Transportation Institute. This report does not constitute a standard, specification, or regulation. In addition, the above listed agencies assume no liability for its contents or use thereof. The names of specific products or manufacturers listed herein do not imply endorsement of those products or manufacturers. The results reported herein apply only to the article being tested. The full-scale crash test was performed according to TTI Proving Ground quality procedures and according to the *MASH* guidelines and standards.



Wanda L. Menges, Research Specialist
Deputy Quality Manager



Richard A. Zimmer, Senior Research Specialist
Test Facility Manager
Quality Manager
Technical Manager

1. Report No.		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle NCHRP REPORT 350 TEST 2-30 OF THE TL-2 ET-PLUS WITH HBA AND SYTP				5. Report Date November 2010	
7. Author(s) Roger P. Bligh, C. Eugene Buth, and Wanda L. Menges				8. Performing Organization Report No. 400001-ETP2	
9. Performing Organization Name and Address Texas Transportation Institute Proving Ground The Texas A&M University System College Station, Texas 77843-3135				10. Work Unit No. (TRAVIS)	
				11. Contract or Grant No. P2010456	
12. Sponsoring Agency Name and Address Trinity Highway Products, LLC 2525 Stemmons Freeway Dallas, TX 75207				13. Type of Report and Period Covered Test Report August – September 2010	
				14. Sponsoring Agency Code	
15. Supplementary Notes Research Study Title: NCHRP Report 350 TL 2-30 ETPLUS with HBA Post Name of Contacting Representative: Brian Smith					
16. Abstract <p>At the request of Trinity Highway Products, LLC, <i>NCHRP Report 350</i> test designation 2-30 was performed on a Test Level 2 (TL-2) ET-PLUS guardrail end treatment. This test involves an 820-kg small passenger car impacting the TL-2 ET-PLUS at a nominal impact speed and angle of 70 km/h and 0 degrees, respectively, with the vehicle quarter-point centered on the terminal.</p> <p>This report presents details of test installation, a description of the test, test results, and an evaluation of the TL-2 ET-PLUS. The TL-2 ET-PLUS with HBA and SYTP performed acceptably according to criteria set forth in <i>NCHRP Report 350</i> for test 2-30.</p>					
17. Key Words End treatment, guardrail, crash test, roadside safety			18. Distribution Statement Copyrighted. Not to be copied or reprinted without consent from Trinity Highway Products, LLC.		
19. Security Classif.(of this report) Unclassified		20. Security Classif.(of this page) Unclassified		21. No. of Pages 56	22. Price

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSION FACTORS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in ²	square inches	645.2	square millimeters	mm ²
ft ²	square feet	0.093	square meters	m ²
yd ²	square yard	0.836	square meters	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	square kilometers	km ²
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
NOTE: volumes greater than 1000 L shall be shown in m ³				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
°F	Fahrenheit	$\frac{5}{9}(F-32)$ or $(F-32)/1.8$	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa
APPROXIMATE CONVERSION FACTORS FROM UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm ²	square millimeters	0.0016	square inches	in ²
m ²	square meters	10.764	square feet	ft ²
m ²	square meters	1.196	square yards	yd ²
ha	hectares	2.47	acres	ac
km ²	square kilometers	0.386	square miles	mi ²
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m ³	cubic meters	35.314	cubic feet	ft ³
m ³	cubic meters	1.357	cubic yards	yd ³
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
°C	Celsius	$1.8C+32$	Fahrenheit	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m ²	candela/m ²	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in ²

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
INTRODUCTION	1
TECHNICAL DISCUSSION	3
TEST PARAMETERS.....	3
Test Facility	3
Test Article – Design and Construction.....	3
Test Conditions	6
Evaluation Criteria.....	10
CRASH TEST 400001-ETP2 (<i>NCHRP REPORT 350 TEST NO. 2-30</i>).....	11
Test Vehicle	11
Soil and Weather Conditions	11
Impact Description.....	11
Damage to Test Article.....	14
Vehicle Damage.....	14
Occupant Risk Factors	14
ASSESSMENT OF TEST RESULTS	21
SUMMARY OF TEST RESULTS.....	21
CONCLUSIONS.....	23
REFERENCES	25
APPENDIX A. DETAILS OF THE TL-2 ET-PLUS WITH HBA AND SYTP.....	27
APPENDIX B. CRASH TEST PROCEDURES AND DATA ANALYSIS.....	35
ELECTRONIC INSTRUMENTATION AND DATA PROCESSING	35
ANTHROPOMORPHIC DUMMY INSTRUMENTATION.....	36
PHOTOGRAPHIC INSTRUMENTATION AND DATA PROCESSING	36
TEST VEHICLE PROPULSION AND GUIDANCE.....	36
APPENDIX C. TEST VEHICLE PROPERTIES AND INFORMATION	37
APPENDIX D. SEQUENTIAL PHOTOGRAPHS.....	41
APPENDIX E. VEHICLE ANGULAR DISPLACEMENTS AND ACCELERATIONS	43

LIST OF FIGURES

	<u>Page</u>
Figure 1. Details of the HBA Post.....	4
Figure 2. Details of the SYTP.....	5
Figure 3. Details of the King Block.....	7
Figure 4. Layout of test installation.....	8
Figure 5. TL-2 ET-PLUS with HBA and SYTP prior to testing.....	9
Figure 6. Vehicle/installation geometrics for test 400001-ETP2.....	12
Figure 7. Vehicle before test 400001-ETP2.....	13
Figure 8. Vehicle position after test 400001-ETP2.....	15
Figure 9. Installation after test 400001-ETP2.....	16
Figure 10. Vehicle after test 400001-ETP2.....	17
Figure 11. Interior of vehicle after test 400001-ETP2.....	18
Figure 12. Summary of results for <i>NCHRP Report 350</i> test 2-30 on TL-2 ET-PLUS with HBA and SYTP.....	19
Figure C1. Vehicle properties for test 400001-ETP2.....	37
Figure D1. Sequential photographs for test 400001-ETP2 (rear oblique and frontal views).....	41
Figure D1. Sequential photographs for test 400001-ETP2.....	42
Figure E1. Vehicle angular displacements for test 400001-ETP2.....	43
Figure E2. Vehicle longitudinal accelerometer trace for test 400001-ETP2 (accelerometer located at center of gravity).....	44
Figure E3. Vehicle lateral accelerometer trace for test 400001-ETP2 (accelerometer located at center of gravity).....	45
Figure E4. Vehicle vertical accelerometer trace for test 400001-ETP2 (accelerometer located at center of gravity).....	46
Figure E5. Vehicle longitudinal accelerometer trace for test 400001-ETP2 (accelerometer located over rear axle).....	47
Figure E6. Vehicle lateral accelerometer trace for test 400001-ETP2 (accelerometer located over rear axle).....	48
Figure E7. Vehicle vertical accelerometer trace for test 400001-ETP2 (accelerometer located over rear axle).....	49

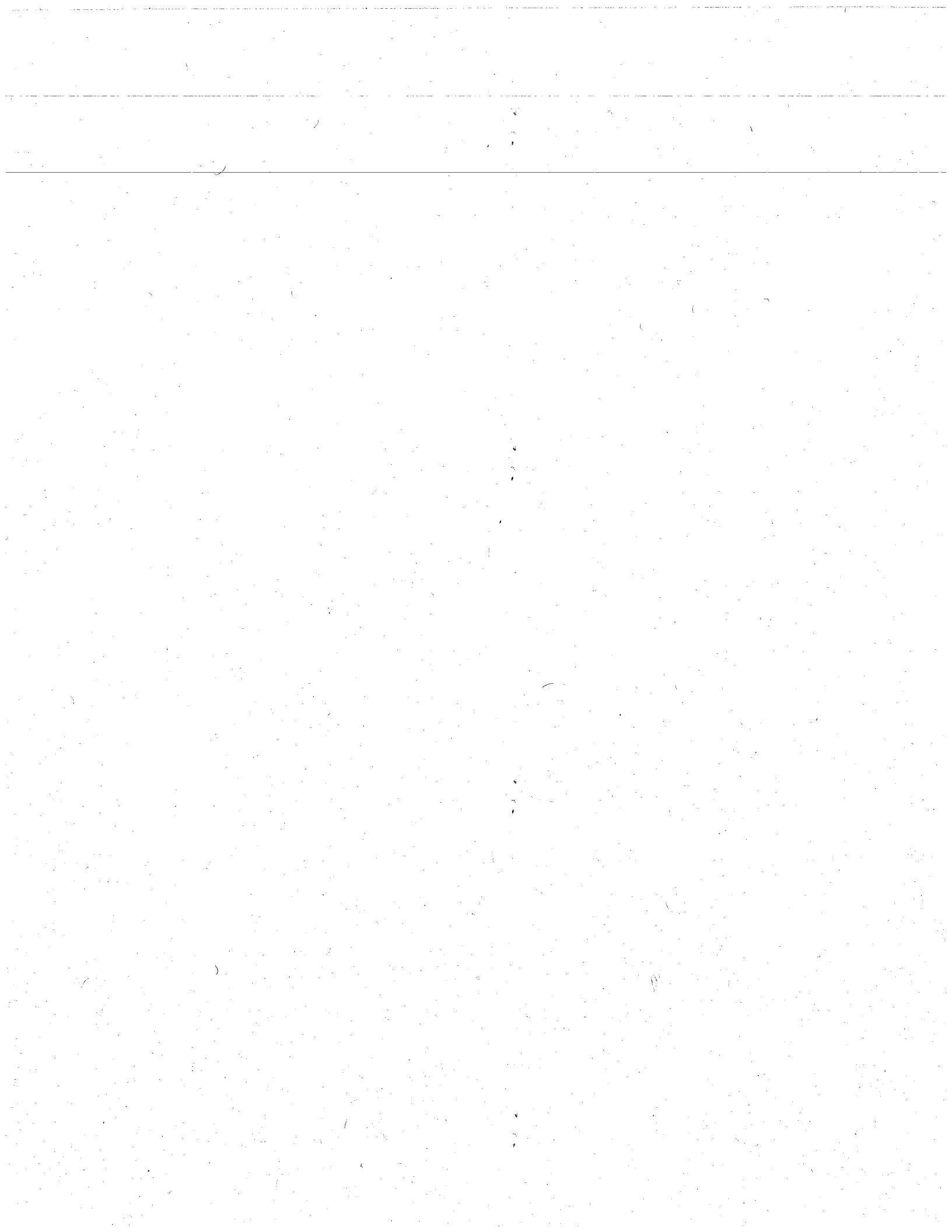
LIST OF TABLES

	<u>Page</u>
Table 1. Performance evaluation summary for <i>NCHRP Report 350</i> test 2-30 on the TL-2 ET-PLUS with HBA and SYTP.....	24
Table C1. Exterior crush measurements for test 400001-ETP2.....	38
Table C2. Occupant compartment measurements for test 400001-ETP2.....	39

INTRODUCTION

At the request of Trinity Highway Products, LLC, National Cooperative Highway Research Program (NCHRP) *Report 350* test designation 2-30 was performed on a Test Level 2 (TL-2) ET-PLUS guardrail end treatment. This test involves an 820 kg 1808-lb) small passenger car impacting the TL-2 ET-PLUS at a nominal impact speed and angle of 70 km/h (43.5 mi/h) and 0 degrees, respectively, with the vehicle quarter-point centered on the terminal.

This report presents details of test installation, a description of the test, test results, and an evaluation of the TL-2 ET-PLUS based on relevant criteria recommended in *NCHRP Report 350*.



TECHNICAL DISCUSSION

TEST PARAMETERS

Test Facility

The full-scale crash test was performed at Texas Transportation Institute's (TTI) Proving Ground. TTI Proving Ground is an ISO 17025 accredited laboratory with American Association for Laboratory Accreditation (A2LA) mechanical testing certificate 2821.01. The crash test was performed according to quality procedures developed for ISO 17025 accreditation and according to the *NCHRP Report 350* guidelines and standards.

The test facilities at the TTI Proving Ground consist of an 809 hectare (2000-acre) complex of research and training facilities situated 16 km northwest of the main campus of Texas A&M University. The site, formerly an Air Force Base, has large expanses of concrete runways and parking aprons well suited for experimental research and testing in the areas of vehicle performance and handling, vehicle-roadway interaction, durability and efficacy of highway pavements, and safety evaluation of roadside safety hardware. The site selected for the placement of the ET-PLUS with HBA and SYTP was off the edge of a wide out-of-service apron. The apron consists of an unreinforced jointed concrete pavement in 3.8 m by 4.6 m (12.5 ft by 15 ft) blocks nominally 203-305 mm (8-12 inches) deep. The apron is about 50 years old and the joints have some displacement, but are otherwise flat and level.

Test Article – Design and Construction

The installation consisted of a 7.62-m (25-ft long) ET-PLUS end terminal attached to a W-beam guardrail installation. Post number 1 was a hinged breakaway (HBA) post (see figure 1). A standard ET-PLUS anchor cable and cable anchor bracket were used to anchor the W-beam rail at post 1. The bearing plate at HBA post number 1 had two tabs designed to engage the top portion of the post, as shown in figure 1. Posts 2 through 4 were steel yielding terminal posts (SYTPs) fabricated from W150×13 (W6×8.5) structural steel shapes (refer to figure 2). These posts were 1829 mm (72 inches) in length and had two 13-mm (0.5 inch) diameter holes drilled in each flange. These holes were located 727 mm (28.6 inches) from the top of the posts, which corresponds to the approximate ground line location once the posts are installed. The holes are incorporated to enhance the performance of the terminal in end-on impacts, and also serve as attachment points for the 76×76×5 mm (3×3×1/4 inch) steel angle ground strut connected on the field side of the terminal between post 1 and post 2. The posts in the guardrail length of need were standard W150×13 (W6×8.5) steel guardrail posts.

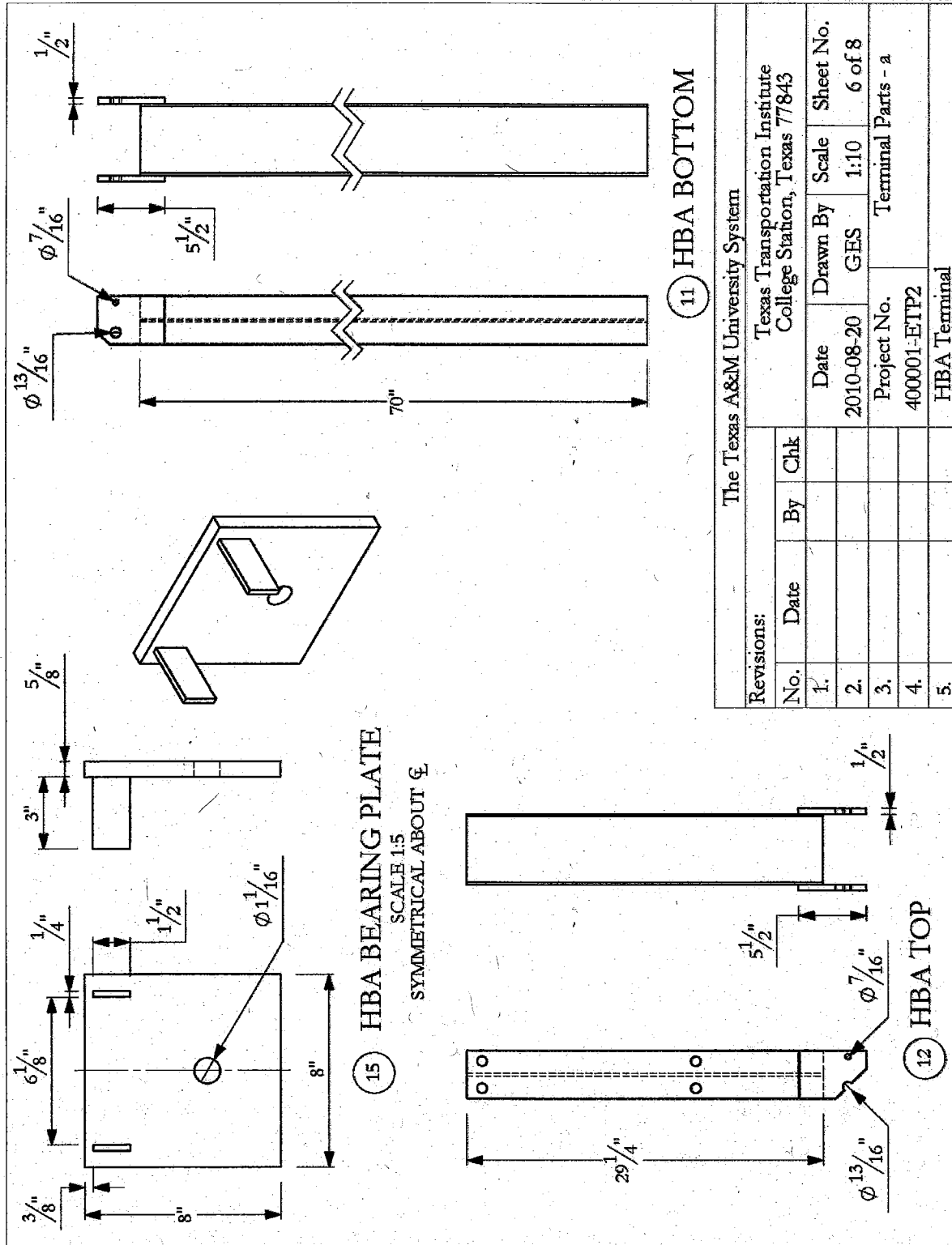


Figure 1. Details of the HBA Post.

