



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

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

Archived

In Reply Refer To:  
HSST/B-219

Mr. Mark R. Burkhead  
Standards and Criteria Engineer  
Pennsylvania Department of Transportation  
Roadway Quality Assurance Division  
400 North Street, 7<sup>th</sup> Floor  
Harrisburg, PA 17120

Dear Mr. Burkhead:

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

Name of system: W6 x 8.5 Steel Guiderail Post over Ground Structures  
Type of system: Permanent Guiderail Component  
Test Level: National Cooperative Highway Research Program (NCHRP) Report 350  
Test Level 3 (TL-3)  
Testing conducted by: Texas Transportation Institute (TTI)  
Date of Request: December 28, 2010  
Drawing Designator: SGR04-d

You requested that we find this system acceptable for use on the NHS under the provisions of NCHRP Report 350 "Recommended Procedures for the Safety Performance Evaluation of Highway Features."

### Requirements

Roadside safety systems should meet the guidelines contained in the NCHRP Report 350. FHWA memorandum "ACTION: Identifying Acceptable Highway Safety Features" of July 25, 1997, provides further guidance on crash testing requirements of longitudinal barriers.

### Decision

The following device was found acceptable, with details provided below:

- W6 x 8.5 Steel Guiderail Post over Ground Structures

### Description

The Pennsylvania Department of Transportation (PennDOT) currently specifies W6 x 8.5 Steel Guiderail Post over Ground Structures detail in their existing construction standards. The detail includes the W6 x 8.5 steel post (post) positively anchored to a 4 ft x 4 ft x 8 in thick reinforced



Only

concrete footing (R.C. footing). The current standard detail shows the R.C. footing is placed at a minimum depth of 6 in in compacted soil over the top of the R.C. footing. The post were welded to 12 in x 12 in x 3/4-in thick base plate, anchored to the R.C. footing with four (4) 7/8-in diameter A325 bolts cast within the R.C. footing. These anchor bolts are 8 in in length and are embedded a minimum of 6 in into the R.C. footings. Concrete compressive strength tests performed the day of the testing yielded an average compressive strength of 3669.0 psi.

Details of this system are provided as enclosure to this correspondence.

### **Crash Testing**

The proposed PennDOT W6 x 8.5 Steel Guiderail Post over Ground Structures (system) was analyzed at the test facilities at the TTI Proving Grounds Riverside Campus. Two pendulum tests were performed on the system. One test specified the standard R.C. footing and one test specified a proposed 5 ft x 5 ft x 8 in depth R.C. footing section. The objective of the pendulum test is to document the impact performance of the system and assess the potential for meeting the recommended safety performance guidelines set forth in the NCHRP Report 350 for TL-3.

The following full-scale pendulum tests were performed on two R.C. footing designs. The post was loaded in bending about the strong axis.

#### **I. 4 ft x 4 ft x 8 in Thick R.C. Footing**

The pendulum bogie, traveling at an impact speed of 21.5 mph (34.6 kph), impacted the guardrail post with the centerline of the pendulum nose aligned with the centerline of the steel post. The height of the nose was measured at 20.5 inches. At 0.020 s, the steel post began to deform, and at 0.032 s, the concrete footing began to lift up in the soil. The pendulum bogie lost contact with the steel post at 0.144 s, and exit speed at loss of contact was 7.8 mph. The base of the pendulum contacted the steel post at 0.332 s, and then loses contact with the steel post at 0.398 s. At 0.537 s, the base contacted the steel post again, and at 0.562 s, the pendulum went over the steel post. Maximum deflection of the steel post during the test was 29.1 inches, and the final deformation of the post was approximately 6.5 inches. The footing was moved as a result of the pendulum impact on the post. The leading edge of the footing (traffic face edge) was uplifted and came to rest approximately 6.0 inches above the grade surface. After the test, no visible distress was observed in the concrete footing, post base plate, or anchor bolts. Maximum rise of the nose of the pendulum during the test was 23.6 inches, and maximum crush of the honeycomb nose of the pendulum was 10.7 inches. Longitudinal occupant impact velocity was 20.7 ft/s (6.3 m/s), longitudinal ridedown acceleration was -2.9 g, and maximum 50-ms average was -8.5 g. Change in velocity at loss of contact was 20.1 ft/s (6.1 m/s).

#### **II. 5 ft x 5 ft x 8 ins Thick R.C. Footing:**

The pendulum bogie, traveling at an impact speed of 21.6 mph (34.7 kmh), impacted the guardrail post with the centerline of the pendulum nose aligned with the centerline of the steel post. The center height of the nose was 20.5 inches above finished grade. At 0.005 s, the steel post began to deform, and at 0.046 s, the concrete footing began to lift up in the soil. The pendulum bogie lost contact with the steel post at 0.155 s, and exit speed at loss of contact

was 8.5 mph. At 0.260 s, the concrete footing began to rotate, and at 0.352 s, the base of the pendulum contacted the post. The pendulum bogie came to rest on top the steel post at 0.994 s. Maximum dynamic deflection of the steel post during the test was 20.0 inches, and the final deformation of the steel post was approximately 12.25 inches. The footing was moved as a result of the pendulum impact on the post. The leading edge of the footing (traffic face edge) was uplifted and came to rest approximately 3.0 inches above the grade surface. After the test, no visible distress was observed in the concrete footing, post base plate, or anchor bolts. Maximum rise of the nose of the pendulum during the test was 24.1 inches, and maximum crush of the honeycomb nose of the pendulum was 10.1 inches. Longitudinal occupant impact velocity was 24.6 ft/s (7.5 m/s), longitudinal ridedown acceleration was -3.6 g's, and maximum 50-ms average was -8.7 g's. Change in velocity at loss of contact was 19.2 ft/s (5.9 m/s).

In addition to these pendulum tests, a further comparison was made between the posts and concrete foundations tested for this project to standard W-beam guardrail line posts embedded in the NCNRP Report 350 strong soil (strong soil). Two pendulum tests were performed on W6 x 8.5 steel posts embedded approximately 43.4 inches in strong soil (TTI Project Number 220547). For both tests, the center height of the pendulum was 18.0 in above grade. The force versus displacement curves for both posts tested for this project compared very closely to the force versus displacement curves for the same steel posts embedded in strong soil.

Testing details of this system are provided as enclosure to this correspondence.

### Findings

The analysis of the systems described herein is as follows:

- A. The 5 ft x 5 ft footing rotated approximately 6 degrees from the pendulum impact. The dynamic rotation of the post was approximately 30 degrees. Plastic failure occurred in the W6 x 8.5 steel posts for this design tested. No distress was observed in the anchor bolts or concrete. The Occupant Risk Value Impact Velocity, longitudinal direction is 24.6 ft/s (7.5 m/s). The Ridedown Acceleration for longitudinal direction is -3.6 g, with a maximum change in velocity of 19.2 f/s.
- B. The 4 ft x 4 ft footing rotated approximately 15 degrees from the pendulum impact. The dynamic rotation of the post was in excess of 30 degrees. Plastic failure occurred in the W6 x 8.5 steel posts for this design tested. No distress was observed in the anchor bolts or concrete. The Occupant Risk Value Impact Velocity, Longitudinal direction is 20.7 ft/s (6.3 m/s). The Ridedown Acceleration for Longitudinal direction is -2.9 g, with a maximum change in velocity of 20.1 f/s.

The posts anchored to the footings exhibited greater strength than those tested in strong soil over 0 to 2 ft of displacement. The dynamic rotation of 5 ft x 5 ft R.C. footing was approximately 30 degrees, and greater than 30 degrees for the 4 ft x 4 ft R.C. footing tested for this project. The dynamic rotation of the 4 ft x 4 ft R.C. footing and post was deemed undesirable since the footing came to rest approximately 6 in above grade surface.

Based on the results of this testing, the researcher recommended the W6 x 8.5 steel post anchored to the 5 ft x 5 ft R.C. footing for use in cases where a single post in a guardrail length of need interferes with an underground obstruction. The researcher further recommends a full-scale crash test be performed to validate the performance where multiple posts in succession anchored to shallow 5 ft x 5 ft concrete footing as tested herein is required.

FHWA therefore concurs with recommendation of 5 ft x 5 ft x 8 in R.C. footing system as 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 such use is acceptable to a highway agency.

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

- This acceptance is limited to the crashworthiness characteristics of the system 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 system 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 system 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 FHWA and the NCHRP Report 350.
- To prevent misunderstanding by others, this letter of acceptance is designated as number B-219 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 system for which the applicant is not the patent holder. The acceptance letter is limited to the crashworthiness characteristics of the candidate system, 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,

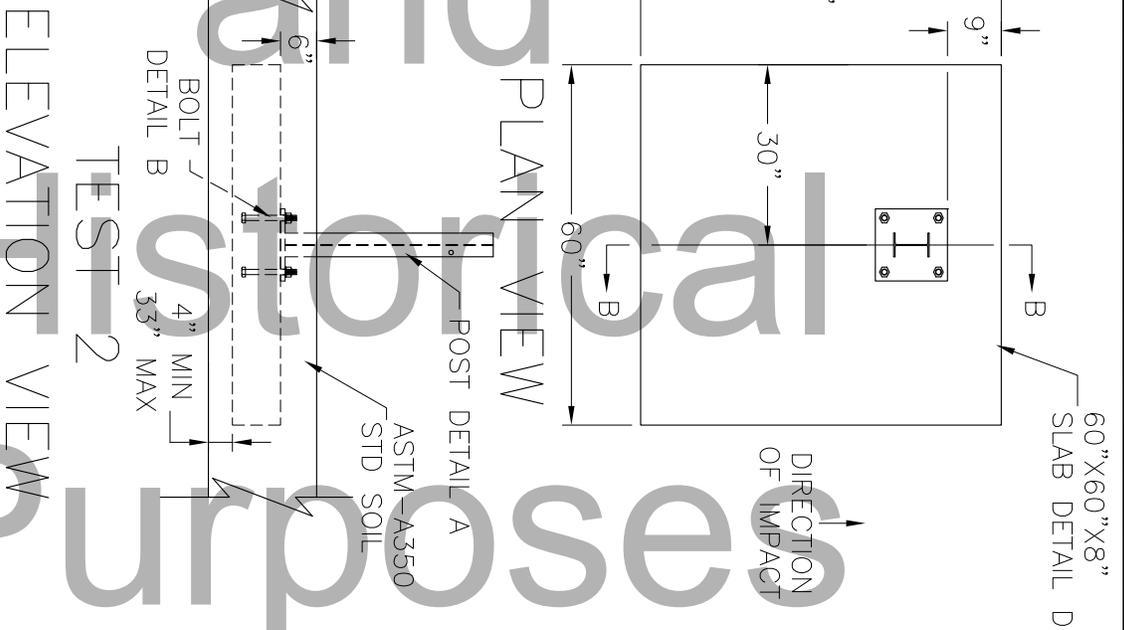
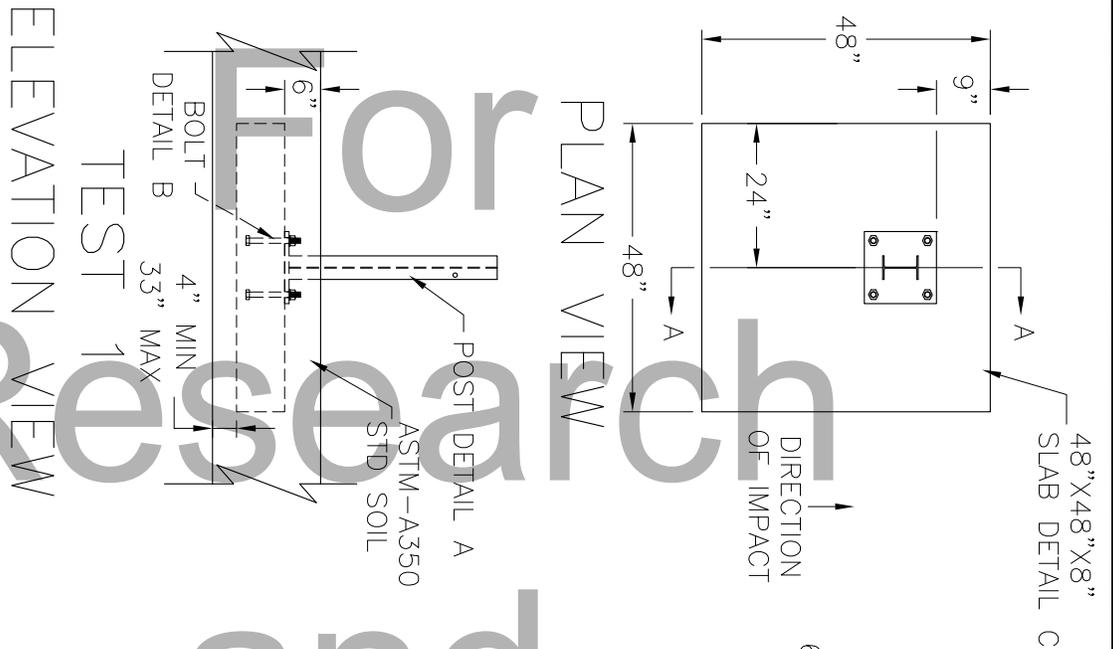


Michael S. Griffith  
Director, Office of Safety Technologies  
Office of Safety

Enclosures

Only

# Archived



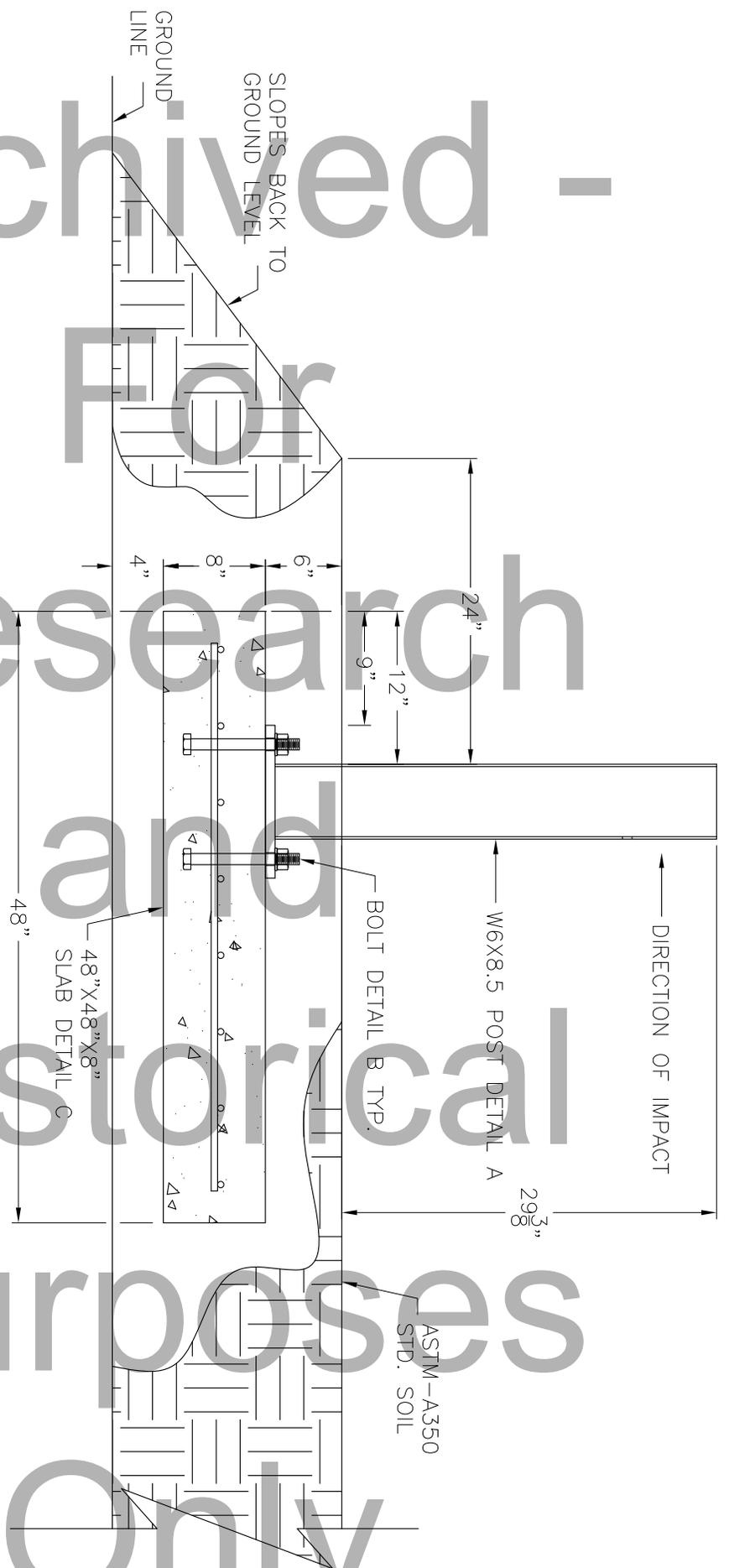
The Texas A&M University System			
REVISIONS			
NO.	DATE	BY	CHK.
1.	2009/01/09	NDE	WW
2.			
3.			
4.			
5.			
Project No.		Date	Drawn By
405160-12		2008/08/07	NDE
Scale			
STEEL POST OVER UNDERGROUND STRUCTURES		Sheet No.	1 of 6
APPROVED: WILLIAM WILLIAMS: 2008/08/07			

Archived

For Research

Historical

Purposes



SECTION A-A

The Texas A&M University System

REVISIONS

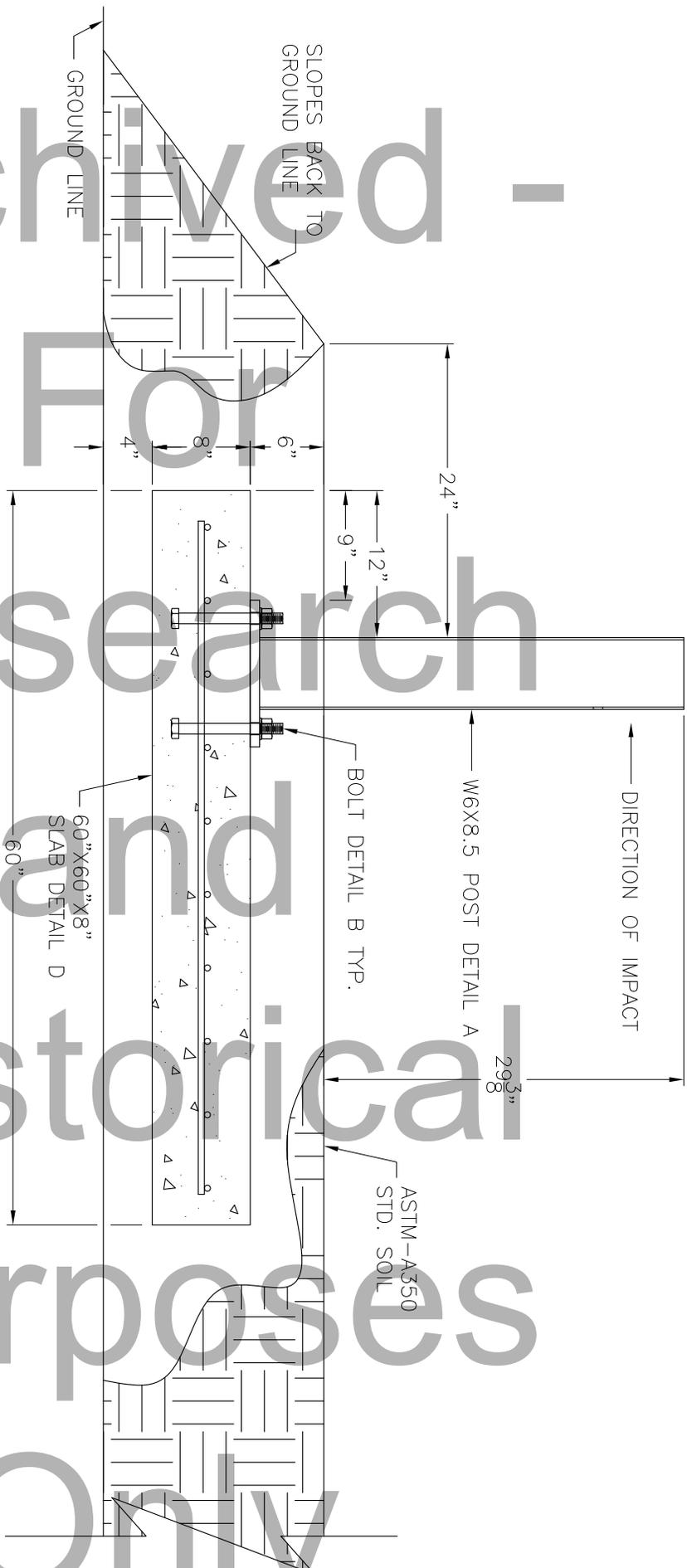
NO.	DATE	BY	CHK.
1.			
2.			
3.			
4.			
5.			

TEXAS TRANSPORTATION INSTITUTE  
COLLEGE STATION, TEXAS 77843

Project No. 405160-12 Date 2008/04/26 Drawn By NDE Scale

STEEL POST OVER UNDERGROUND STRUCTURES Sheet No. 2 of 6

Archived -  
For  
Research  
and  
Historical  
Purposes  
Only



SECTION B-B

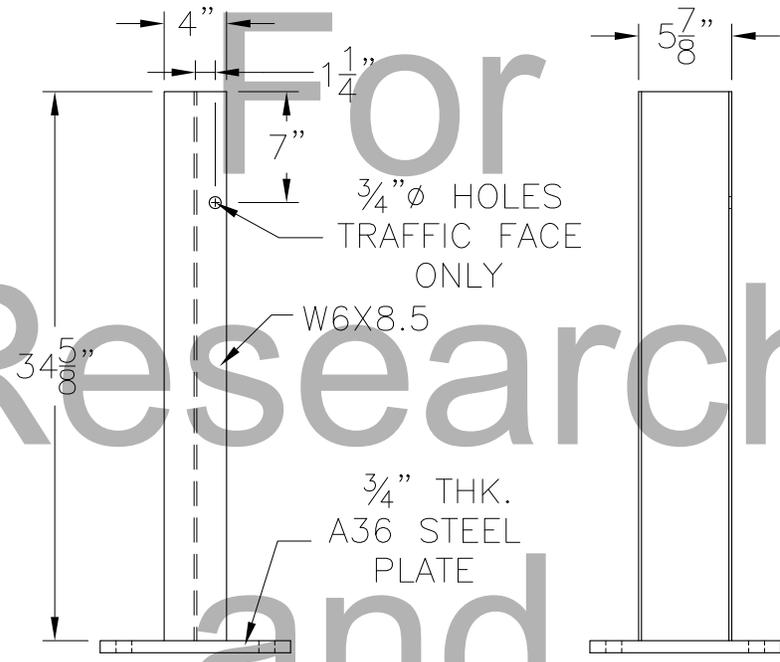
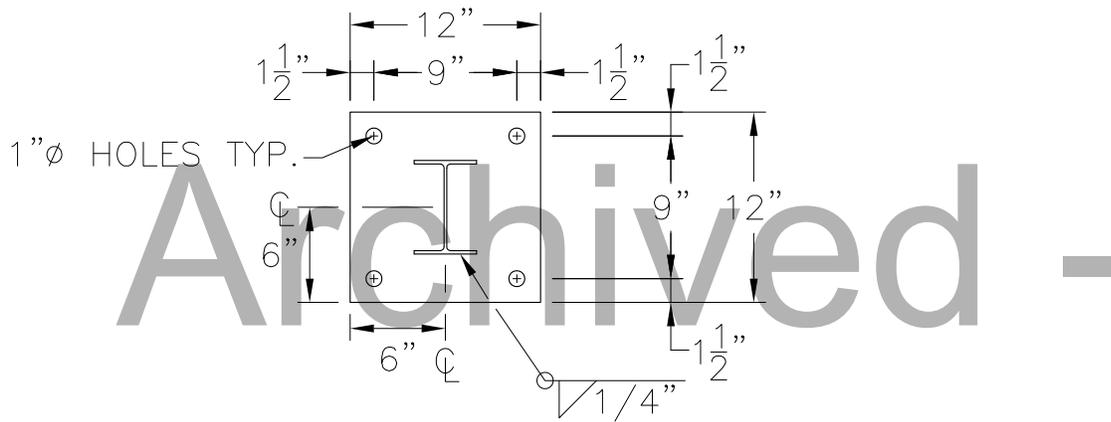
The Texas A&M University System

REVISIONS			Project No.			Date			Drawn By			Scale		
NO.	DATE	BY	CHK.	405160-12			2008/04/26			NDE				
1.														
2.														
3.														
4.														
5.														

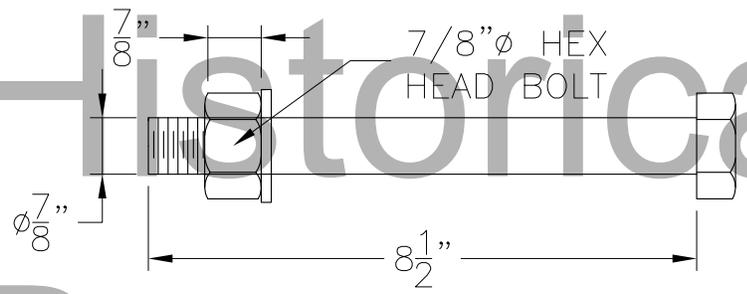
TEXAS TRANSPORTATION INSTITUTE  
COLLEGE STATION, TEXAS 77843

STEEL POST OVER  
UNDERGROUND STRUCTURES

Sheet No.  
3 of 6



POST DETAIL A



7/8"  $\phi$  X 8 1/2" A325  
HEX HEAD BOLT DETAIL B

The Texas A&M University System				
REVISIONS				
NO.	DATE	BY	CHK	
1.	2009/01/09	NDE	WW	
2.				
3.				
4.				
5.				
TEXAS TRANSPORTATION INSTITUTE COLLEGE STATION, TEXAS 77843				
Project No. 405160-12		Date 2008/04/26	Drawn By NDE	Scale
STEEL POST OVER UNDERGROUND STRUCTURES				Sheet No. 4 of 6

T:\2007-2008\2008\405160 Pooled Fund\405160-12-SPOUS-WFW\DRAWINGS\POST-PEDELUUM-DRAWINGS.dwg

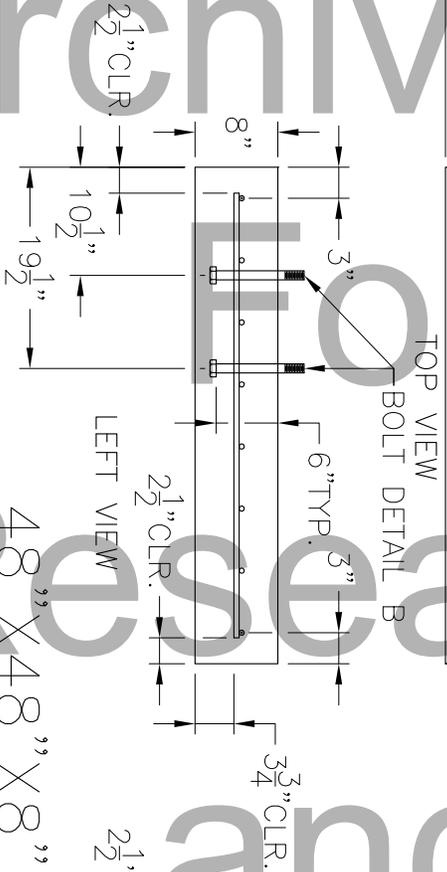
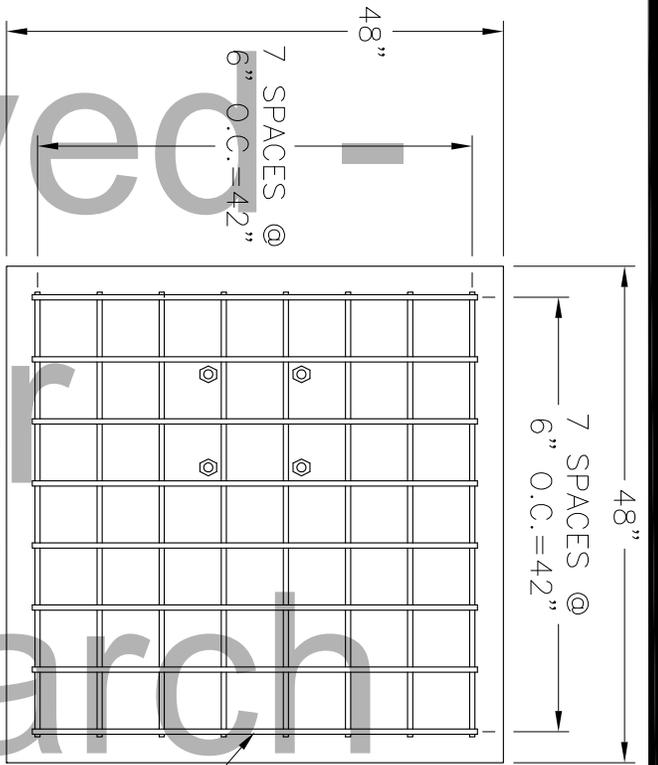
Archived

Research and

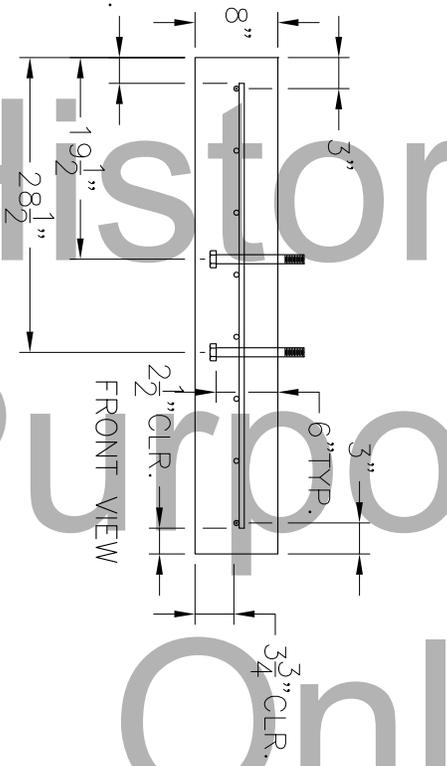
Historical

Proprietary

Uses Only



48" X 48" X 8" SLAB DETAIL C



The Texas A&M University System

REVISIONS

NO.	DATE	BY	CHK.	Project No.	Date	Drawn By	Scale
1.	2009/01/09	NDE	WW	405160-12	2008/04/26	NDE	
2.							
3.							
4.							
5.							

TEXAS TRANSPORTATION INSTITUTE  
COLLEGE STATION, TEXAS 77843

STEEL POST OVER UNDERGROUND STRUCTURES

Sheet No. 5 of 6

Archived  
 Only  
 and  
 Historical  
 Purposes

60" X 60" X 8"  
 SLAB DETAIL D



REVISIONS			
NO.	DATE	BY	CHK.
1.	2009/01/09	NDE	WW
2.			
3.			
4.			
5.			

The Texas A&M University System			
TEXAS TRANSPORTATION INSTITUTE			
COLLEGE STATION, TEXAS 77843			
Project No.	Date	Drawn By	Scale
405160-12	2008/04/26	NDE	
STEEL POST OVER UNDERGROUND STRUCTURES			Sheet No.
			6 of 6

**Table D1. Summary of results for pendulum test 405160-12 P1.**

 <p>0.000 s</p>	<p><b>General Information</b>                  Test Agency.....Texas Transportation Institute                  Test No. ....405160-12 P1                  Date .....2008-09-17</p> <p><b>Test Article</b>                  Type.....Steel Posts over Underground Structures                  Installation Height (m).....28.5 inches                  Material of Key Element.....W6x8.5 steel post</p> <p><b>Soil Type</b>.....60-inch Concrete footing in Standard Soil</p> <p><b>Test Vehicle</b>                  Type.....Bogie                  Designation.....Pendulum                  Test Inertia Mass .....839 kg</p> <p><b>Impact Conditions</b>                  Speed .....21.6 mi/h                  Angle .....90 deg</p> <p><b>Occupant Risk Values</b>                  Impact Velocity                  Longitudinal direction.....24.6 ft/s (7.5 m/s)                  Ridedown Accelerations                  Longitudinal direction.....-3.6 g's</p> <p><b>Maximum Change in Velocity</b> .....19.2 ft/s</p>
 <p>0.146 s</p>	
 <p>0.289 s</p>	
 <p>0.434 s</p>	