Texas A&M Transportation Institute
Proving Ground

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TECHNICAL MEMORANDUM

Contract No.: **T4541 (CF) (MN-91)**
Test Report No.: **604671-S1-S18**
Project Name: **W-Beam Wood Post Strength Analysis of Preservation Treatment Methods**
Sponsor: **Roadside Safety Pooled Fund**

DATE: **June 10, 2015**

TO: **Michael Elle, P.E.**
Design Standards Engineer
Minnesota Department of Transportation

COPY TO: Epifania Davila / Erlinda Olivarez, TTI RDO
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Rebecca Heck, TTI Roadside Safety & Physical Security Systems

FROM: **Dusty R. Arrington**, Associate Transportation Researcher, Texas A&M Transportation Institute, Roadside Safety & Physical Security Division
Dean C. Alberson, Ph.D., P.E., Research Engineer, Texas A&M Transportation Institute, Roadside Safety & Physical Security Division

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SUMMARY REPORT:

DISCLAIMER

ACKNOWLEDGEMENTS

TTI would like to thank Mr. Charlie Coleman of S.I. Storey Lumber Company, Inc. for his assistance and providing the Breakaway Control Terminal (BCT) posts used for this project. TTI would also like to thank Mr. Michael Elle, P.E., of the Minnesota Department of Transportation (MnDOT) for his guidance and cooperation on this project.

INTRODUCTION

MnDOT specifications no longer allow chromated copper arsenate (CCA) treated timber products. A preliminary investigation into other types of timber preservatives indicates strength varies with the type of preservation treatment used. This creates a situation where the field performance of breakaway timber posts used in safety hardware is unknown. This has left MnDOT with no viable alternative to replace existing timber posts installations. Some systems can be completely replaced with a steel post option. However, other systems have no tested steel post option.

CCA treated timber products have been used extensively in roadside safety hardware for many years, mostly in the support of W-beam and thrie-beam guardrail systems including terminals. Recently, while not proven, the effects of using CCA as a preservative on the environment has come into question. This increase in focus on environmental issues has created the need for other options to reduce or eliminate the use of CCA.

The objective of this study was to investigate the viability for the use of other treatment types for roadside safety hardware. Since CCA is being discontinued from use in at least one state, acceptable alternatives have been identified. CCA has been the most cost-effective preservative treatment for roadside safety hardware. The second most cost-effective preservative treatment is the water-based treatment alkaline copper quaternary-type D (ACQ-D).

The most critical application for timber posts in safety hardware is in breakaway applications such as BCT (a timber post in a steel sleeve) or Controlled Release Terminal (CRT) post (a full-size timber post with weakening holes). If the fracture strength of the post is greatly affected by the preservative treatment, the performance of the system may be altered.

A controlled series of static tests were used to compare the relative breakaway strength of raw wood posts, CCA treated posts, and ACQ-D treated posts. BCT posts were selected with the most similar ring density and as knot free as possible and could be mounted in a rigidly anchored ground sleeve to eliminate the variability introduced by soil properties during testing.

TTI investigated and determined the rupture characteristics of the BCT posts using static testing. A BCT foundation tube was rigidly anchored to, and supported by, a static load frame at ground level to remove variability of soil characteristics. Untreated posts were tested to provide a baseline post capacity to be compared to a CCA and ACQ-D treated post. The testing was performed in weak and strong axes.

STATIC TESTING FACILITY

The wood posts were tested at TTI Proving Ground's indoor static testing facility. The test setup is shown in Figure 1. Further details of the test setup are provided in Attachment A.

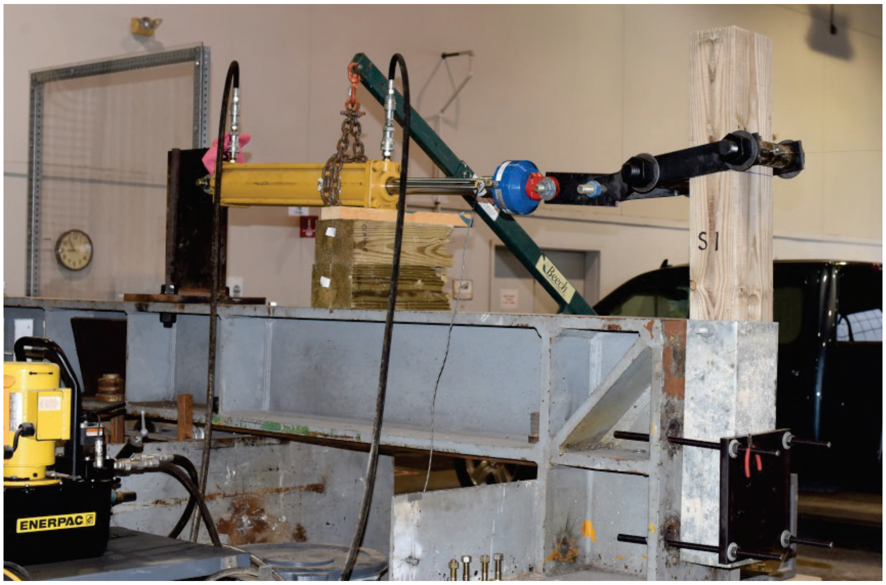


Figure 1. Static Testing Setup.

TEST ARTICLE DESIGN AND CONSTRUCTION

The test setup consisted of a 24-inch long foundation tube that was rigidly anchored to TTI's indoor static testing facility with four ⅝-inch diameter threaded rods. A ¾-inch thick securing plate was used to distribute the restraining force among the four threaded rods. Each test sample was inserted into the rigid foundation tube. Each BCT test sample post consisted of a 48¼-inch long 6×8 inch (nominal) timber post with a 2½-inch diameter weakening hole located parallel to the strong axis of the post 30¾ inches from of top of the post. Three sample types were tested, each with a different treatment type, untreated (NT), CCA, and ACQ-D. All BCT posts were provided by S.I. Storey Lumber Company, Inc. S.I. Storey Lumber Company, Inc. performed the CCA and ACQ-D treatments at their facility in Armuchee, Georgia. They also provided moisture content values for the posts at the time of shipping. These values are provided in Attachment B.

Static load was applied to the post perpendicular to either the strong or weak axes, 16 inches above the top of the foundation tube. The load was applied using a hydraulic ram and a steel yoke. The yoke was allowed to rotate but was restricted from sliding along the post. The applied load was measured using an inline load cell and deflection was measured at the point of load application using a string potentiometer.

TEST DESCRIPTIONS

Three tests were performed on each of the CCA, ACQ, and NT timber posts in the weak axis and then the strong axis. In the weak axis, tests S1-S3 used the CCA treated posts, tests S4-S6 used the ACQ treated posts, and tests S7-S9 used the NT posts. In the strong axis, tests S10-S12 were on the CCA posts, tests S13-S15 were on the ACQ posts, and tests S16-S18 were on the NT posts. A summary table of maximum static load and displacement (Table 1) can be found within the summary and conclusions section of this report.

Weak Axis Tests Results

The maximum load on the CCA posts ranged from 8956 lb to 11,647 lb, with the average being 10,468 lb. The measured deflection was 1.68 inches to 2.07 inches and average was 1.91 inches. The maximum load on the ACQ posts ranged from 6597 lb to 7814 lb, with the average being 7356 lb. The measured deflection was 1.44 inches to 1.78 inches and average was 1.60 inches. The maximum load on the NT posts ranged from 7060 lb to 11,394 lb, with the average being 9428 lb. The measured deflection was 0.90 inches to 2.02 inches, and average was 1.48 inches.

The results of these tests in the weak axis are shown in Figure 2. Photographs for each test are provided in Attachment C, Figures C1 through C3.

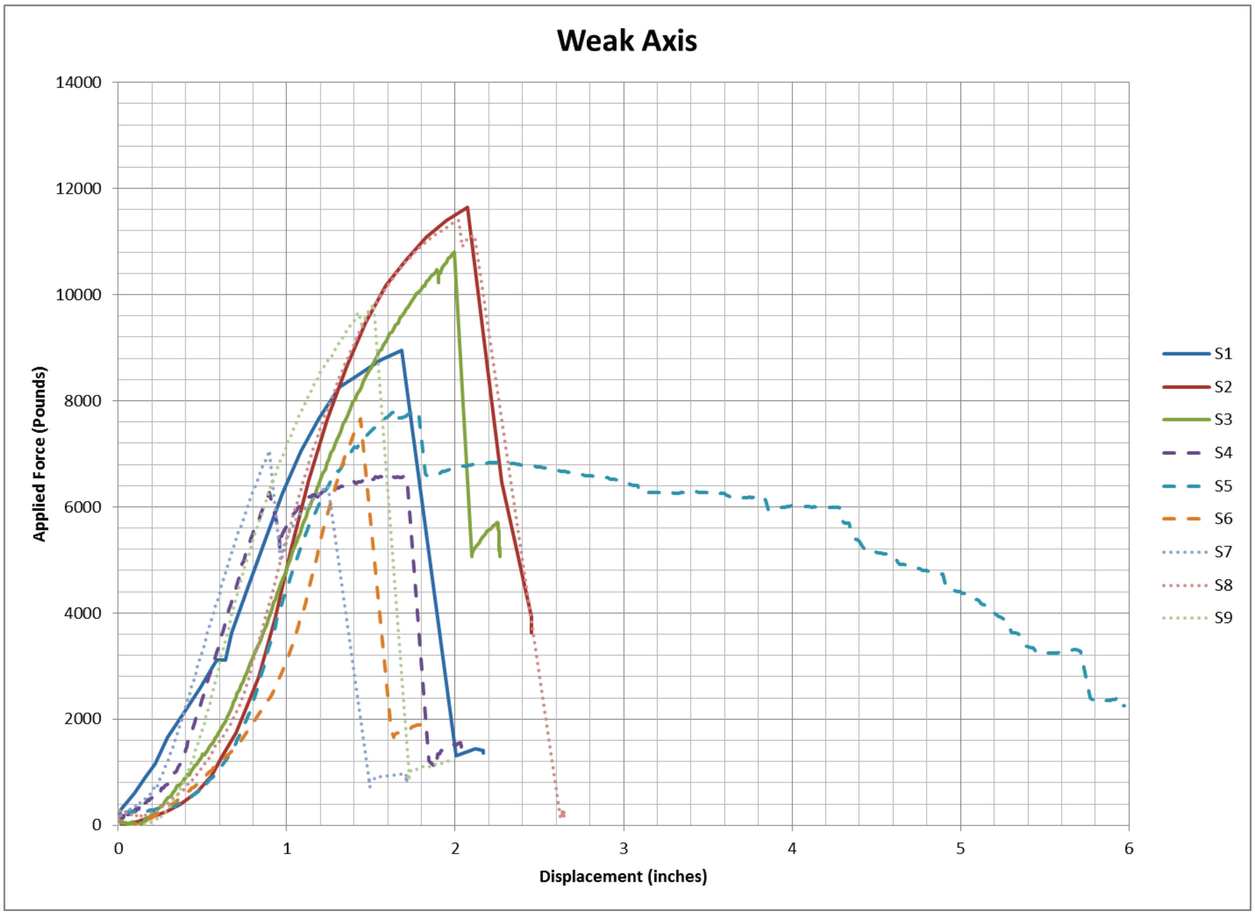


Figure 2. Results of Testing in Weak Axis Direction.

Strong Axis Tests Results

The maximum load on the CCA posts ranged from 8742 lb to 13,759 lb, with the average being 11,548 lb. The measured deflection was 2.59 inches to 3.49 inches, and average was 3.00 inches. The maximum load on the ACQ posts ranged from 9838 lb to 11,830 lb, with the average being 10,940 lb. The measured deflection was 1.58 inches to 3.20 inches, and average was 2.20 inches. The maximum load on the NT posts ranged from 10,655 lb to 12,535 lb, with the average being 11,390 lb. The measured deflection was 2.96 inches to 3.36 inches, and average was 3.14 inches.

The results of the tests in the strong axis are graphed in Figure 3. Photographs for each test are provided in Attachment C, Figures C4 through C6.

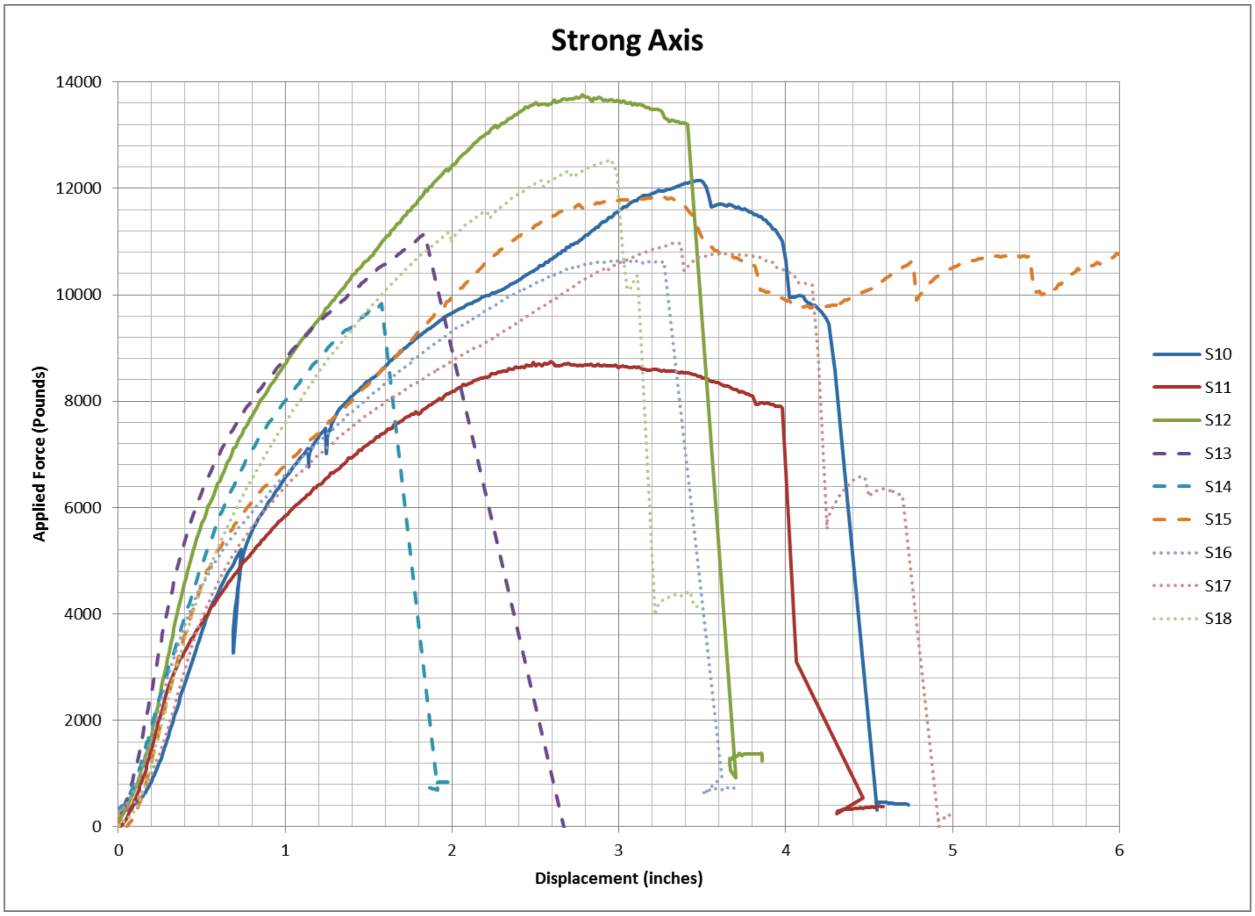


Figure 3. Results of Testing in the Strong Axis Direction.

SUMMARY AND CONCLUSIONS

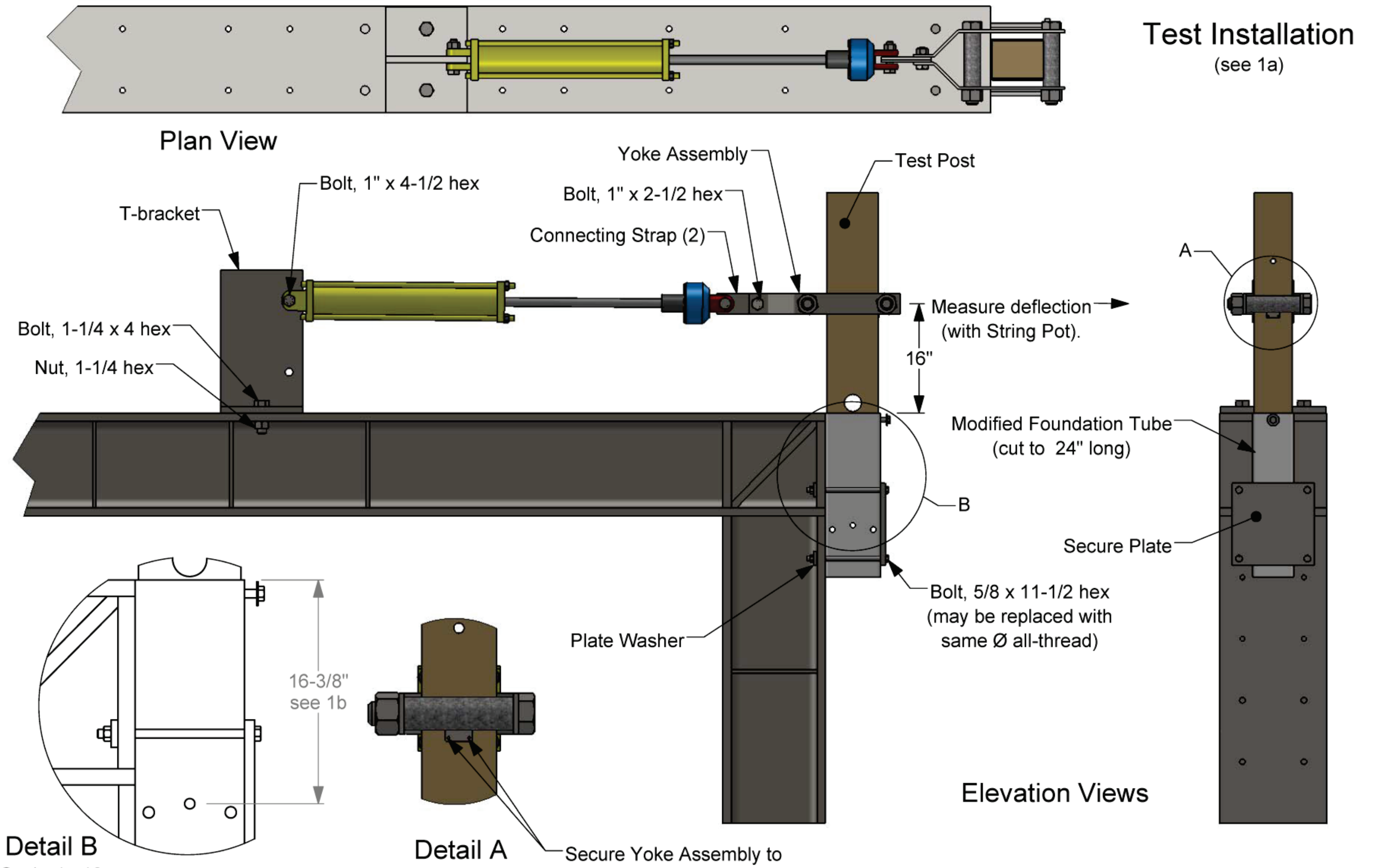
A summary of test results is presented in Table 1. Table 1 details the maximum load and deflection measured for each static test. Table 1 also indicates the average maximum force for each treatment type for each axis. A review of the test results indicates that all three treatment methods have similar strengths (standard deviation of 1405 lb) in the strong axis. The test results also indicate the ACQ-D has the weakest strength in the weak axis. While these results are from only a small number of samples, there is appears to be a pattern in the results.

When evaluating whether or not ACQ-D can adequately replace CCA, the expected application needs to be accounted for. The ACQ-D treated posts are of similar strength in strong axis and of similar or lesser strength in the weak axis. In most guardrail/terminal applications, the strong axis is the primary axis resisting the loads imparted by an impacting vehicle during a re-direction impact. The weak axis is primarily only loaded when the impacting vehicle makes direct contact with the post, usually during an “end-on” type impact or a wheel contacting the post during redirection. This post type is used extensively in W-beam guardrail terminal applications and in some non-proprietary long span applications. In this case the ACQ-D treated posts should perform similar to the previously tested CCA treated posts. The ACQ-D treated posts should breakaway more readily when impacted by the vehicle leading to a lower acceleration rate and therefore lower occupant risk values. For this reason the test results indicate the ACQ-D treated posts should be considered an acceptable replacement for CCA treated posts for roadside safety applications. It should be noted, to properly evaluate the performance of each preservative treatment applied to timber post requires a statistical analysis with a statically significant number of samples. This type of evaluation was not performed as part of this project.

Table 1. Summary of Max Load and Deflections.

	Weak Axis				Strong Axis			
	Test Number	Load lbs	Deflection in	Avg Load lbs	Test Number	Load lbs	Deflection in	Avg Load lbs
CCA	S1	8956	1.68	10468	S10	12142	3.49	11548
	S2	11647	2.07		S11	8742	2.59	
	S3	10802	1.99		S12	13759	2.78	
ACQ	S4	6597	1.59	7356	S13	11153	1.83	10940
	S5	7814	1.78		S14	9838	1.58	
	S6	7659	1.44		S15	11830	3.20	
NT	S7	7060	0.90	9428	S16	10655	3.09	11390
	S8	11394	2.02		S17	10979	3.36	
	S9	9828	1.52		S18	12535	2.96	

ATTACHMENT A: DETAILS OF TEST ARTICLES



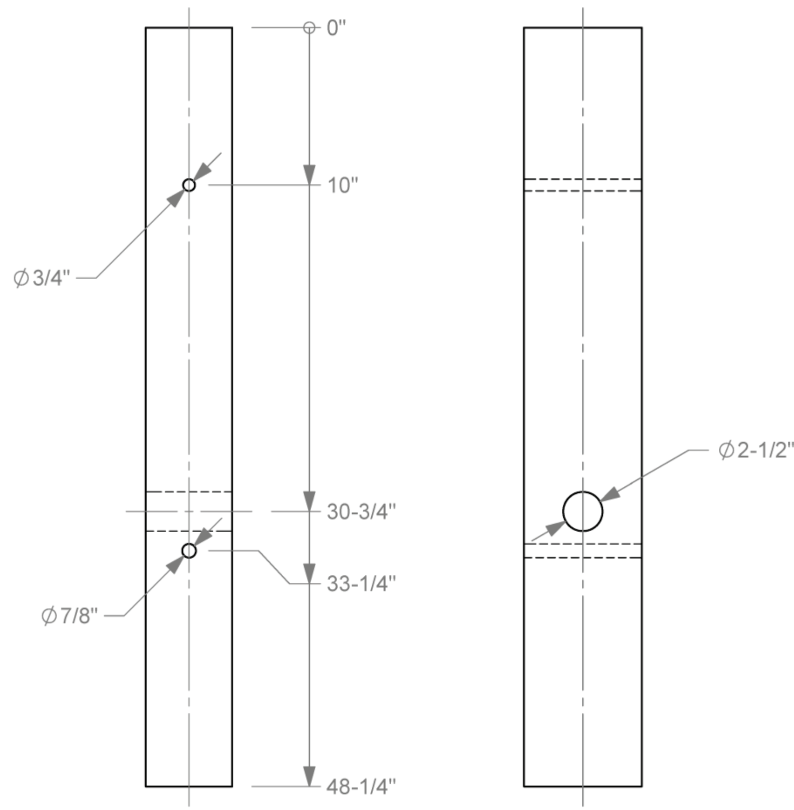
1a. Setup for Strong Axis tests is shown. Rotate Test Post and Foundation Tube 90° for Weak Axis tests.

1b. Drill hole for Ø5/8" Bolt in Foundation Tube to support Post if desired, in strong axis and weak axis.

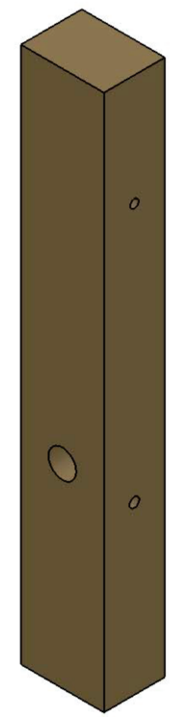
Texas A&M Transportation Institute	Roadside Safety and Physical Security Division Proving Ground -
Project 604671-S	Wood Preservative Comparison
Drawn By GES	Scale 1:20 · Sheet 1 of 4 · Test Installation
Approved: Dusty Arrington:	Date: 2015-02-09

Post Details

6 x 8 (nominal) Timber



Elevation Views



Isometric View

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Project 604671-S	Wood Preservative Comparison	2015-02-09
Drawn By GES	Scale 1:10	Sheet 2 of 4 Post Details

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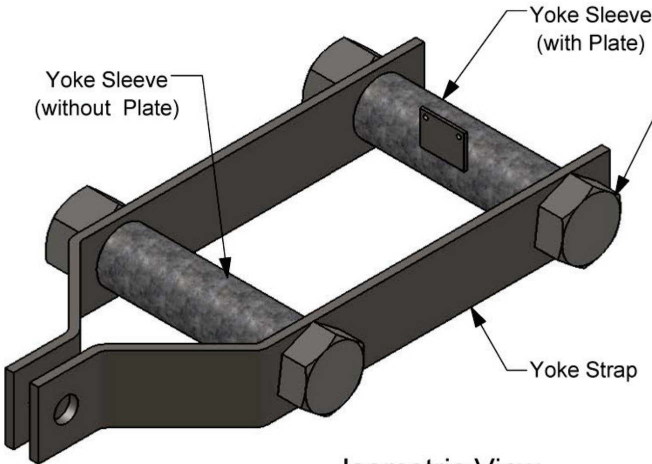
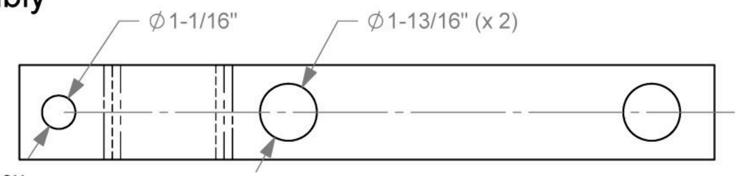
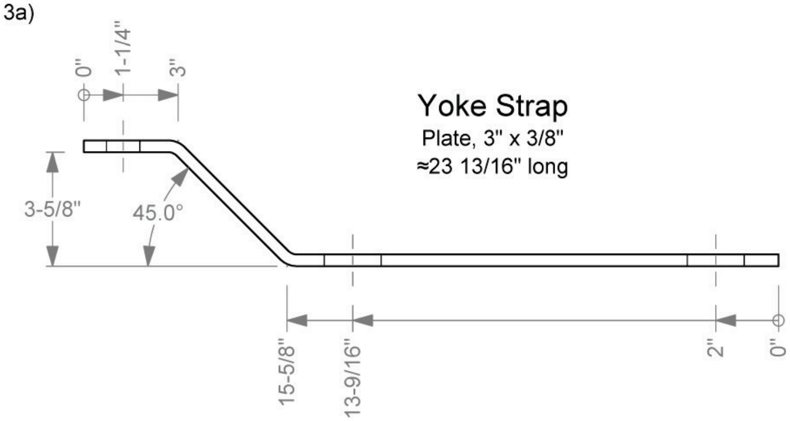
Yoke Assembly

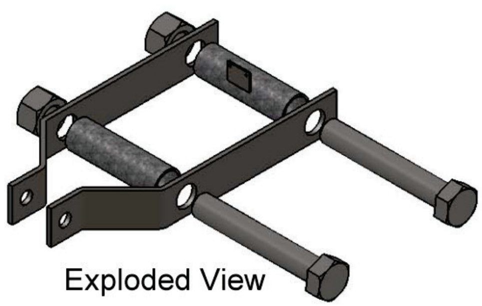


Isometric View

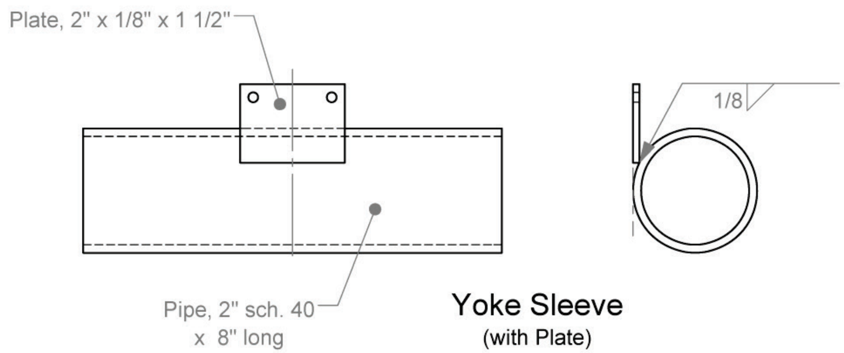




Yoke Strap
Plate, 3" x 3/8"
≈23 13/16" long



Exploded View



Yoke Sleeve
(with Plate)

3a. 1-3/4" Bolt may not be replaced with all-thread.

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Project 604671-S	Wood Preservative Comparison		2015-02-09
Drawn By GES	Scale 1:5	Sheet 3 of 4	Yoke Assembly

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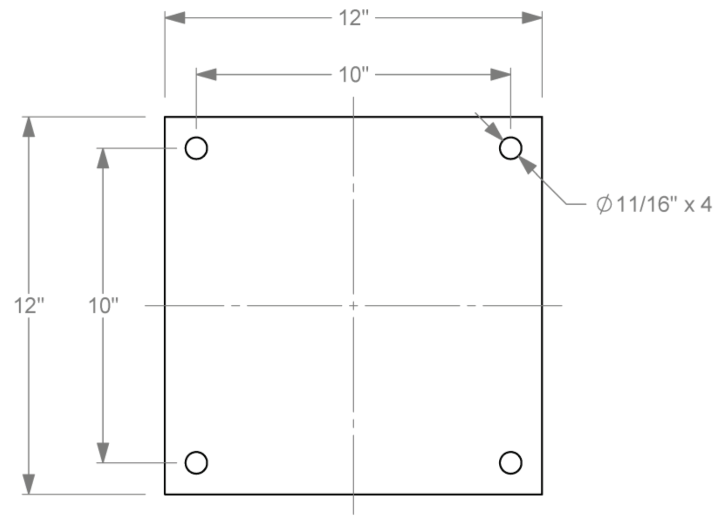
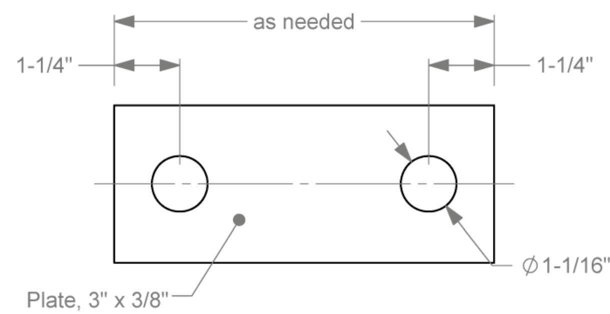
Test Parts



Secure Plate
minimum 3/4" thick



Connecting Strap
(need 2)

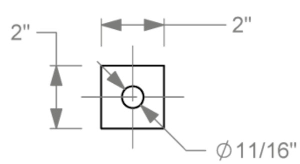


Plate Washer
minimum 1/2" thick
(need 4)

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Project 604671-S	Wood Preservative Comparison		2015-02-09
Drawn By GES	No Scale	Sheet 4 of 4	Test Parts

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ATTACHMENT B. MOISTURE CONTENT VALUES

Oven Dry Sample Report for Moisture Content 1/13/15

Sample		Original Weight	Minus	Dry Weight	Equal	Difference		Difference Divided by Original Weight X 100 equal %MC
CCAK-1		1.01		0.80		0.21		20.8
CCAK-2		0.88		0.73		0.15		17.0
CCAK-3		0.84		0.69		0.15		17.9
CCAK-4		0.75		0.61		0.14		18.7
CCAK-5		0.97		0.79		0.18		18.6
CCAK-6		0.84		0.69		0.15		17.9
CCAK-7		0.93		0.75		0.18		19.4
CCAK-8		0.84		0.70		0.14		16.7
ACQK-1		1.01		0.73		0.28		27.7
ACQK-2		0.97		0.76		0.21		21.6
ACQK-3		0.93		0.61		0.32		34.4
ACQK-4		1.1		0.73		0.37		33.6
ACQK-5		0.94		0.76		0.18		19.1
ACQK-6		0.93		0.70		0.23		24.7
ACQK-7		0.95		0.73		0.22		23.2
ACQK-8		0.95		0.69		0.26		27.4
NT-1		0.66		0.56		0.1		15.2
NT-2		0.92		0.76		0.16		17.4
NT-3		0.89		0.70		0.19		21.3
NT-4		0.66		0.55		0.11		16.7
NT-5		0.78		0.63		0.15		19.2
NT-6		0.92		0.74		0.18		19.6
NT-7		0.86		0.71		0.15		17.4
NT-8		0.84		0.70		0.14		16.7

Notes:
CCAK refers to CCA KDAT posts
ACQK refers to ACQ KDAT posts
NT refers to untreated posts
All weights are in grams

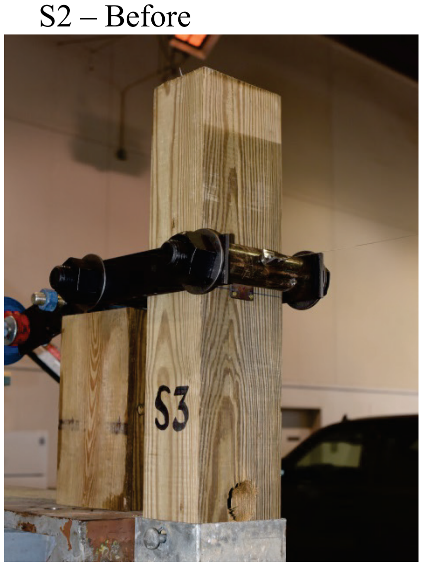
ATTACHMENT C. PHOTOGRAPHS OF TESTING

S1 – Before

S1 – After

S2 – Before

S2 – After



S3 – Before

S3 – After

Figure C1. CCA Posts – Weak Axis Tests

S4 – Before

S4 – After

S5 – Before

S5 – After

S6 – Before

S6 – After

Figure C2. ACQ Posts – Weak Axis Tests

S7 – Before

S7 – After

S8 – Before

S8 – After

S9 – Before

S9 – After

Figure C3. Untreated Posts – Weak Axis Tests

S10 – Before

S10 – After

S11 – Before

S11 – After

S12 – Before

S12 – After

Figure C4. CCA Posts – Strong Axis Tests

S13 – Before

S13 – After

S14 – Before

S14 – After

S15 – Before

S15 – After

Figure C5. ACQ Posts – Strong Axis Tests

S16 – Before

S16 – After

S17 – Before

S17 – After

S18 – Before

S18 – After

Figure C6. Untreated Posts – Strong Axis Tests