

Metallurgical Engineering Services

845 E. Arapaho Road | Richardson, Texas 75081

August 25, 2014

REPORT OF: Fastener Analyses

REPORT TO:



BUILDING PRODUCTS

216 N. Interurban
Richardson, Texas 75081

DATE APPROVED: August 7, 2014

IDENTIFICATION: 1 ea. Lot of OWT Bolts: P/N: 56650

- Threaded Shank
- Sleeve
- Plug
- Hex Cap (P/N: 56621)
- Hex Cap Plug (P/N: 56621)

1 ea. Lot of 4" Screws: P/N: 56627

PROCEDURES :

Test setups were constructed from client supplied wooden planks. Specific gravity of the wood sample was performed per ASTM 2395-14, Method A. Moisture content of the wood was performed per ASTM D4442-07.

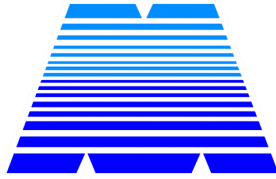
Chemical composition was determined on the OWT bolt and screw samples per ASTM E 415-08 using a SpectroMaxx Optical Emission Spectrograph, S/N: 118288/05, calibration due 8/14/14, with a verification performed prior to use.

Withdrawal and lateral load testing were performed per ASTM D1761-12 on screw samples using a Satec Systems Model Apex 22EMF, S/N: 1017, calibration due 7/31/15.

Pull through testing was performed per ASTM D1037-12 the unthreaded shank of the screw sample using a Satec Systems Model Apex 22EMF, S/N: 1017, calibration due 7/31/15.

A bending yield test was performed per ASTM F1575-03 on the samples using a Satec Systems Model Apex 22EMF, S/N: 1017, calibration due 7/31/15.

Tensile testing was performed per ASTM E 8-11 the unthreaded shank of the screw sample using a Satec Systems Model Apex 22EMF, S/N: 1017, calibration due 7/31/15.



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A screw sample was cut, mounted in cross section (M11949), wet ground and polished per ASTM 3-11. Vickers microhardness testing was performed in accordance with ASTM E 384-11e1 standards using a Buehler Micromet hardness test machine (S/N: 643-MIT5-00129, calibration due 7/31/15).

RESULTS:

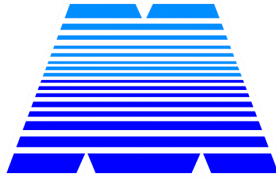
Specific Gravity – ASTM D2395

The customer supplied wood specimens were measured for specific gravity. All samples were consistent with cedar materials.

Sample	Density (before oven drying), g/cm ³	Density (after oven drying), g/cm ³
1	0.4022	0.3610
2	0.3959	0.3519
3	0.3749	0.3375

Moisture Content – ASTM D4442

Wood Sample	Moisture Content, %
1	11.35
2	11.43
3	11.54



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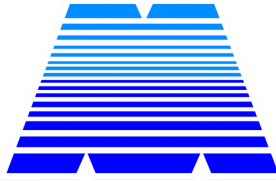
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Chemical Composition Analysis - The referenced samples were submitted to chemical content evaluation with the following quantitative results:

Element, Wt.%	P/N: 56650			
	Threaded Shank	UNS G10340	Sleeve	UNS G10200
Carbon	0.37	0.32-0.38	0.22	0.18-0.23
Silicon	0.14	--	0.23	--
Manganese	0.73	0.50-0.80	0.53	0.30-0.60
Phosphorus	0.016	0.030 max.	0.017	0.030 max.
Sulfur	0.004	0.050 max.	0.007	0.050 max.
Chromium	0.05	--	0.07	--
Nickel	0.004	--	0.03	--
Molybdenum	<0.002	--	<0.002	--
Aluminum	0.015	--	0.010	--
Copper	0.016	--	0.013	--
Cobalt	<0.0015	--	<0.0015	--
Titanium	0.004	--	0.04	--
Niobium	0.005	--	0.004	--
Vanadium	0.007	--	0.008	--
Tungsten	<0.010	--	<0.010	--
Lead	<0.003	--	<0.003	--
Boron	<0.001	--	<0.001	--
Tin	0.002	--	<0.001	--
Zinc	<0.002	--	0.03	--
Arsenic	0.014	--	0.003	--
Bismuth	0.0024	--	<0.002	--
Calcium	0.0023	--	0.002	--
Cerium	<0.003	--	<0.003	--
Zirconium	0.005	--	0.004	--
Lanthanum	<0.001	--	0.0012	--
Iron	Remainder	Remainder	Remainder	Remainder



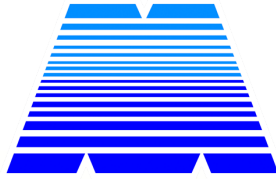
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Element, Wt.%	P/N: 56621	
	Hex Cap Plug	UNS G10070
Carbon	0.08	0.02-0.10
Silicon	0.025	--
Manganese	0.36	0.50 max.
Phosphorus	0.016	0.030 max.
Sulfur	0.005	0.050 max.
Chromium	0.09	--
Nickel	0.04	--
Molybdenum	<0.002	--
Aluminum	0.029	--
Copper	0.056	--
Cobalt	<0.0015	--
Titanium	<0.001	--
Niobium	<0.003	--
Vanadium	0.005	--
Tungsten	<0.010	--
Lead	<0.003	--
Boron	<0.001	--
Tin	0.015	--
Zinc	<0.002	--
Arsenic	0.012	--
Bismuth	0.007	--
Calcium	0.002	--
Cerium	<0.003	--
Zirconium	0.004	--
Lanthanum	<0.001	--
Iron	Remainder	Remainder



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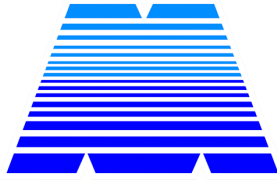
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P/N: 56621	
Element, Wt.%	Hex Nut Cap
Silicon	2.22
Iron	0.33
Copper	1.53
Manganese	0.08
Magnesium	6.05
Chromium	0.023
Nickel	0.03
Zinc	0.12
Titanium	0.04
Boron	0.0300
Beryllium	<0.001
Bismuth	<0.001
Calcium	0.048
Gallium	0.0196
Lithium	0.008
Sodium	0.0120
Phosphorus	<0.001
Lead	0.038
Antimony	<0.001
Tin	0.020
Strontium	<0.001
Vanadium	0.038
Zirconium	0.032
Aluminum	Remainder

P/N: 56627-4" Screw			
Element	Weight %	Wt.% Sigma	UNS G10220
Carbon	0.21	--	0.18-0.23
Molybdenum	<0.001	--	--
Chromium	0.12	0.014	--
Tungsten	<0.001	--	--
Sulfur	0.001	0.001	0.05 max.
Phosphorus	<0.001	--	0.03 max.
Titanium	0.02	0.025	--
Vanadium	0.02	0.005	--
Aluminum	0.04	0.003	--
Lead	0.010	0.017	--
Manganese	1.08	0.007	0.7-1.00
Nickel	0.08	0.007	--
Niobium	<0.001	--	--
Cobalt	0.09	0.001	--
Copper	0.020	0.013	--
Iron	Remainder	--	Remainder



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Screw Withdrawal -

Screw withdrawal testing per ASTM D1037 was performed using a 4" x 4" wood sample. In all cases, the screw withdrew from the wood with no splitting.

Sample ID	Peak Load, lbs	Observations
56627-1	2,136	Screw pulled through/out with no splitting in wood
56627-2	1,777	
56627-3	2,125	

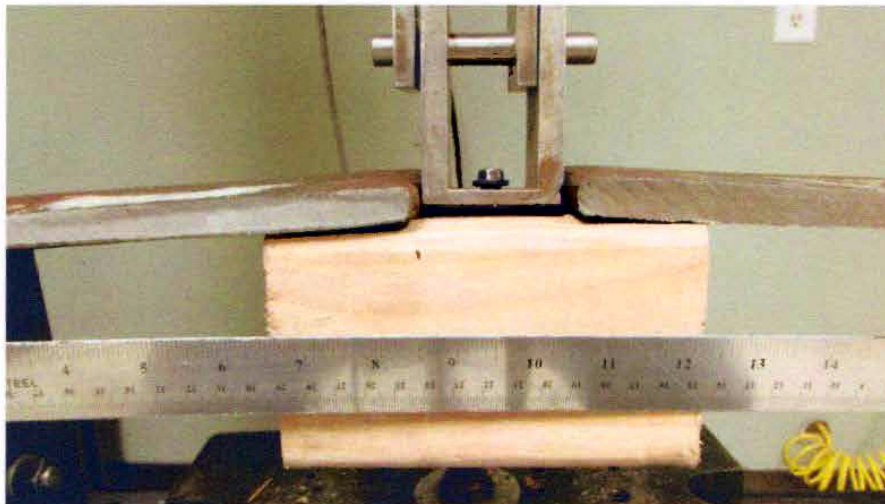


Figure 1: Screw withdrawal test setup

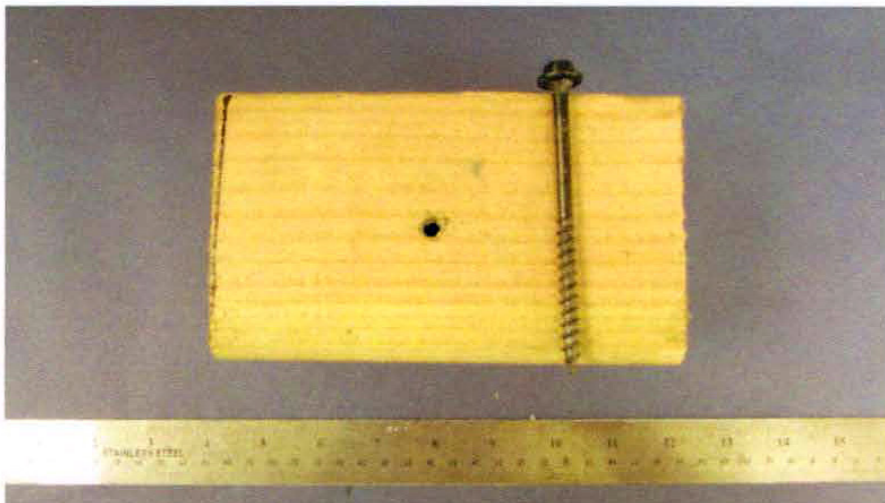
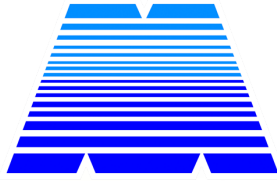


Figure 2: Screw withdrawal failure mechanism



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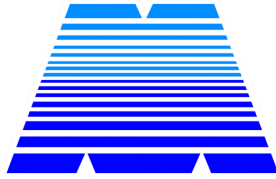
Screw Pull Through -

Screw pull through testing per ASTM D1037 was performed using a 2 x 4 wood sample. In all cases the screw pulled through the wood materials.

Sample ID	Peak Load, lbs	Observations
56627-1	1,514	Screw pulled through with wood splitting
56627-2	1,222	
56627-3	1,391	



Figure 3: Screw pull through test setup



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OWT Bolt Withdrawal -

Bolt withdrawal testing was performed on the OWT per ASTM D1037 with a 2 x 4 and 4 x 4 wood samples. In all cases, failure occurred in the hex nut.

Sample ID	Peak Load, lbs	Observations
56650-1	3,402	Hex nut failed @ bottom side of fixture
56650-2	3,472	
56650-3	3,822	

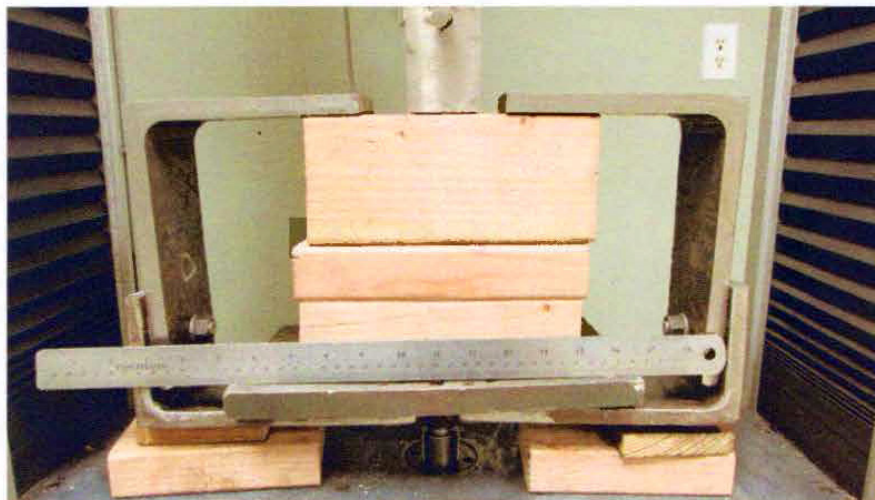


Figure 4: Bolt withdrawal test setup for OWT

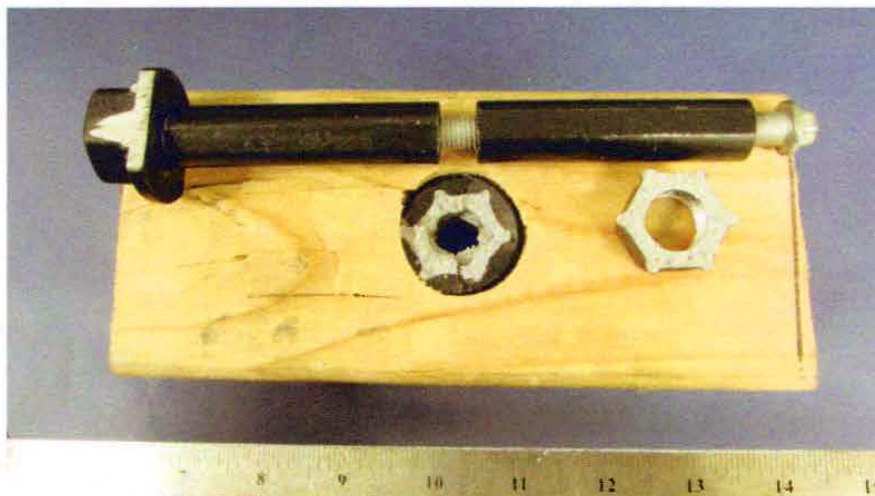
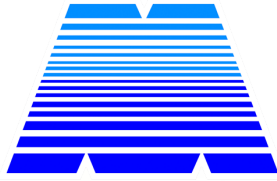


Figure 5: Bolt withdrawal failure mechanism for OWT



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Lateral Load Test - Screws

Lateral load testing was performed per ASTM D1761, which resulted in shearing of the wood materials prior to failure of the screws.

Sample ID	Peak Load, lbs	Observations
56627-1	1,015	Screw pulled through wood
56627-2	1,222	
56627-3	1,391	



Figure 6: Lateral load test setup for screw

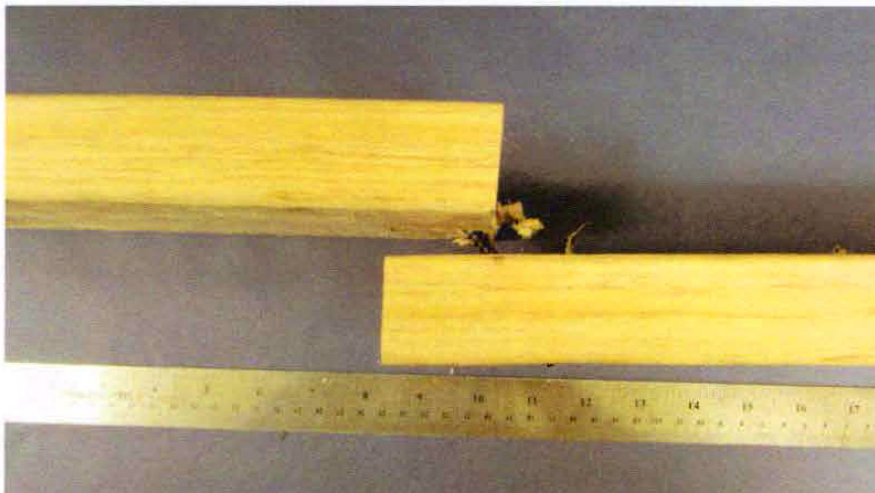
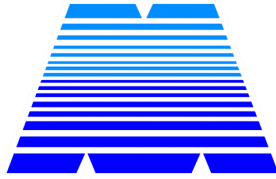


Figure 7: Lateral load test failure mechanism



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Lateral Load Test – OWT Bolts

Lateral load testing per ASTM D1761 produced two failure mechanisms. On the lower test values, the wood materials split, while the hex nut failed at the highest peak load.

Sample ID	Peak Load, lbs	Observations
56650-1	6,827	Hex nut and wood split failure
56650-2	5,448	Wood split
56650-3	6,202	Wood split



Figure 8: Lateral load test setup

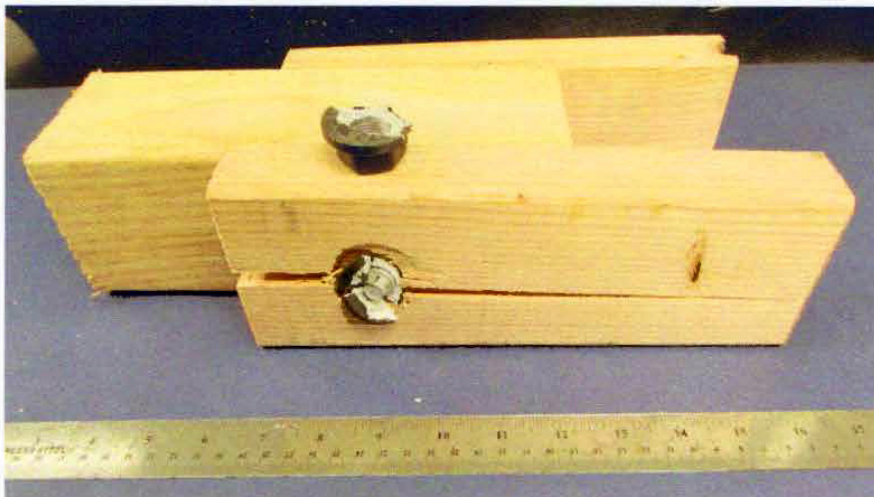
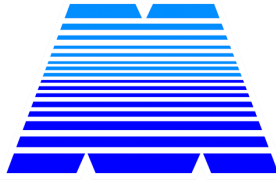


Figure 9: Lateral load failure mechanism



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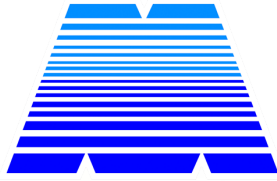
Screw Tensile Tests - 0.2% Offset Yield; Gage Length 0.4"

Tensile tests were performed on the screw shanks (P/N:56627) at laboratory-machined reduced areas.

RND Dimensions Inches			Ultimate Strength		Yield Strength		Elongation %	R.A. %
ID	Diameter	Area, In ²	Load, Lbs	PSI	Load, Lbs	PSI		
1	0.1675	0.0220	3,465	157,500	2,704	122,913	19.8	49.5
2	0.1585	0.0197	4,582	232,589	3,770	191,389	17.6	55.3
3	0.1725	0.0234	4,390	187,607	3,421	146,201	19.1	48.7

Screw Shear Test -

Sample ID	Peak Load, lbs
56627	6,005



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Bend Test –

Bend testing was performed on screw shanks per ASTM F1575 (modified).

Screw Sample ID	Peak Load, lbs	Peak Stress, psi
56627-1	1,385	44,107
56627-2	1,310	41,730
56627-3	1,419	45,182

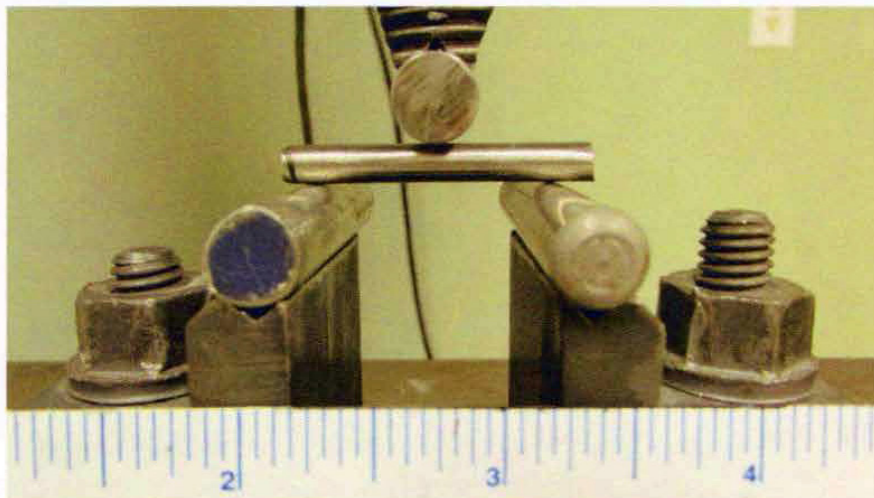
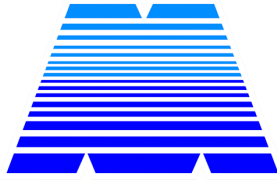


Figure 10: Bend test setup for screw shank



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Bend testing was performed on OWT bolts per ASTM F1575 (modified).

Bolt Sample ID	Peak Load, lbs	Peak Stress, psi
56650-1	948	10,764
56650-2	934	10,599
56650-3	953	10,812

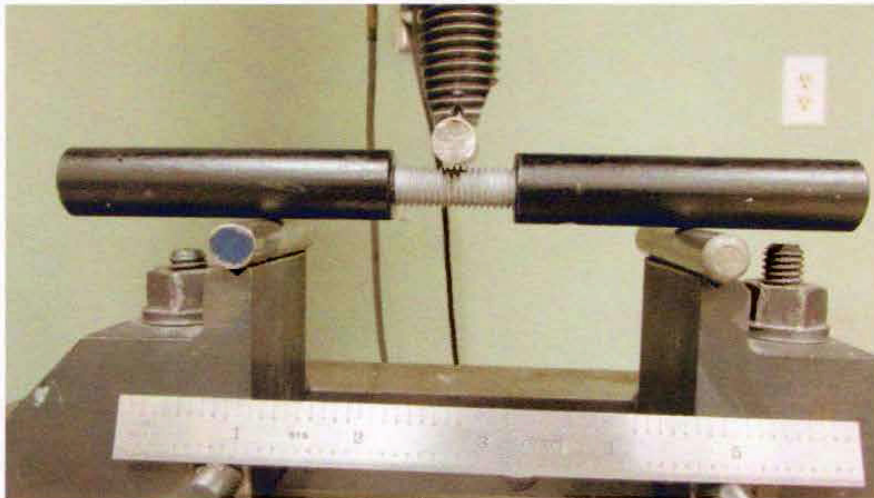


Figure 11: Bend test setup for OWT

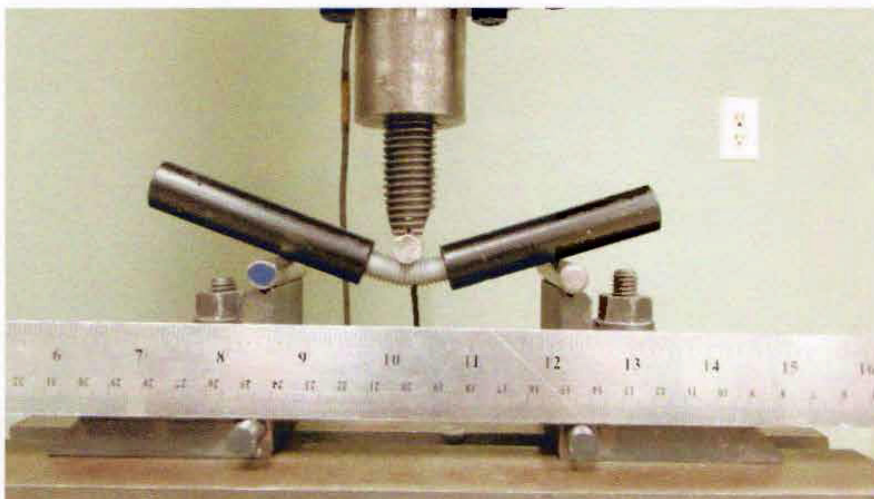
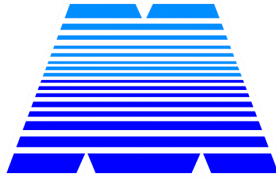


Figure 12: Failure mechanism for bend test of OWT



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Hardness Testing –

ID	Individual Hardness Values,						Average, HV _{500gf}	Conv.,* HRC
	HV _{500gf}							
Screw-56627	426.1	426.0	439.6	427.4	423.7	435.3	429.7	44

*Conversion performed per ASTM E140-12b^{e1}

These results and opinions are based on the tests performed and are subject to change upon the receipt of new or additional information.

Respectfully submitted,

METALLURGICAL ENGINEERING SERVICES, INC.
Firm Registration No. F-2674

Daniel Stolk, PE
President

Karen Goldstein
Quality Assurance Assistant