Research Update for the Treated Wood Reusing Program at the Calhoun Research Station

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ABSTRACT

The reusability of decommissioned treated wood is primarily dependent on residual preservative retention and residual strength of the wood after service. Therefore, determining the residual preservative retention, bonding performance, and residual strength of spent treated wood can provide vital information to further recycling efforts. This report summarizes the latest research results on the recycling of decommissioned CCA treated wood at the Calhoun Research Station in Calhoun, LA. Nine decommissioned southern pine (*Pinus*, spp.) distribution poles and pole sections were evaluated for bending strength across and along the poles. Laminated crossarms made from spent utility pole wood and solid sawn crossarms made from virgin wood were compared for bending strength after retreated with penta. It was found that the strength of most decommissioned utility poles varied across, along each pole, and among the poles that were studied. The average modulus of rupture (MOR) and modulus of elasticity (MOE) of the utility pole wood in this study were 16.2% and 12.4%, respectively, lower than MOR and MOE values of longleaf pine virgin wood. However, the MOR and MOE of laminated crossarms made from decommissioned utility pole wood were comparable to the MOR and MOE of solid sawn crossarms made from virgin wood. This study was conducted using decommissioned distribution poles, which are small in the entire longleaf pine pole population. Further studies are warranted to examine the bending properties of decommissioned CCA treated transmission utility pole wood.

Keywords: utility poles, recycling, chromated copper arsenate, CCA, growth rings, CCA retention, bending strength, small clear samples, crossarms, Calhoun Research Station, CRS

INTRODUCTION

The Decommissioned Treated Wood Reusing Program at the Calhoun Research Station (CRS) was initiated in 2007 in Calhoun, LA as part of a research effort for recycling decommissioned preservative treated wood in Louisiana. This report provides an update for the recycling research at the CRS.

In the last two years, the treated wood reusing research at the CRS focused on the reusing of decommissioned chromated copper arsenate (CCA) treated wood utility poles. The following four research areas were investigated:

(a) Determine CCA retention across and along decommissioned utility poles,
(b) Evaluate the bonding performance of spent CCA treated wood,
(c) Determine the bending strength of decommissioned wood utility poles, and
(d) Evaluate the mechanical properties of laminated utility pole crossarms made from decommissioned treated wood.

Studies (a) to (c) (i.e. CCA retention, bonding and bending evaluations) were pre-studies for the Study (d), which is an on-going study. The preliminary results of the first two studies (CCA retention and bonding) were presented in a previous report (Piao et al. 2008). This report summarizes the preliminary results from Studies (c) and (d).

The reusability of decommissioned wood utility wood is primarily dependent on the residual preservative retention and residual strength of the wood after service. Because preservatives protected wood in service, a large portion of decommissioned wood utility poles removed from service is still mechanically sound and reusable for other purposes (5, 6, 8, 9, 10, 12, 13). However, wood poles deteriorate with time (15). Determining the residual strength of decommissioned preservative treated wood can provide vital information for further re-use and recycling efforts. Few studies were found evaluating the strength of an entire decommissioned pole and manufacturing laminated crossarms made from decommissioned treated wood. The objectives of this study were to: (A) evaluate the bending strength across and along each of nine decommissioned CCA treated wood utility poles, and (B) evaluate the strength of laminated crossarms made from decommissioned treated wood.

MATERIALS AND METHODS

Nine CCA-treated, decommissioned southern pine (*Pinus*, spp.) utility poles and pole sections were obtained from local power companies. Various properties for these poles are given in Table 1. Of these poles and pole sections, Poles 2 to 9 were collected in 2007. Pole 1 (section) was obtained in 2008. All ranged between Grades 3 and 6, and year marks between 1992 and 2000, making the estimated service ages anywhere from 8 to 17 years. Poles 1, 3, 4, 5, 6, and 8 were incomplete. These poles were missing either the top or the bottom sections or both. The remaining poles were complete, remaining their initial sizes. All were distribution poles.

Due to the variable sizes of decommissioned utility poles and posts available for evaluation, small clear samples were widely used in assessing the flexural properties of these spent treated wood products (5, 10, 13). Smith and Morrell (14) demonstrated a good correlation of small clear sample bending strength with full length pole strength of decommissioned Western red cedar poles. This study used the small clear sample testing procedure to evaluate the bending strength of the decommissioned CCA treated southern pine (*Pinus*, spp.) poles according to ASTM standard D143-94 (2).

Fig. 1 shows the schematic diagram of sampling small clear specimens from a pole. Each pole section was cut into boards and planned to a final thickness of 19 mm. The central piece containing the pith was selected from the boards of each section (Fig. 1b). A 41 cm segment along the length of each central board was cut. The location of each segment from the top of the pole was measured. About a 3 mm wide edge was removed along the length of each segment and discarded. Each segment was then consecutively cut into 41 cm long x 19 mm square beams (Fig. 1c) that were used to measure bending properties across the diameter of the pole. The beam specimens were conditioned at room temperature for 5 weeks. Each specimen was measured for length, width, thickness, and weight. Growth rings of each specimen were counted and recorded. All specimens were loaded to failure using an Instron testing machine according to standard D143-94 (2) except the dimension of the samples and crosshead speed. The sample dimensions were 19 mm x 19 mm x 41 cm instead of 25 mm x 25 mm x 41 cm as required by the standard. The cross-

Table 1. Properties of decommissioned CCA-treated wood utility poles used for bending strength evaluation.

Pole #	Year marked	Grade	Ori. L[1] (m)	Act. L[2] (m)	Sect. missing[3]	Est. Years of service[7]	DBH[8] (cm)	HD[9] (cm)	Rings/ cm
1	1991	5	12.2	8.4	T[4] & B[5]	16	24.9	10.2	2.7
2	1992	6	10.7	10.7	NA[6]	15	22.5	7.0	3.9
3	1993	5	12.2	9.1	T	14	25.7	11.1	4.4
4	1995	3	13.7	7.6	T	13	29.8	12.7	5.2
5	1995	3	13.7	11.3	B	13	29.5	4.1	4.1
6	1999	5	13.7	6.7	T & B	8	25.9	1.3	4.3
7	1999	5	10.7	10.7	NA	8	23.2	7.6	2.6
8	2000	3	15.2	13.4	B	7	31.8	3.2	1.6
9	2000	5	9.1	9.1	NA	7	22.1	1.3	5.6

[1] Original length. [2] Actual length. [3, 4, 5] Missing section. [4] Top. [5] Bottom. [6] Not applicable. [7] Estimated years of service. [8] Diameter at breast height. [9] Heartwood diameter at DBH.

head speed was reduced from 1.3 mm/min to 1 mm/min. Of the nine poles, a total of 374 small clear specimens were prepared. After the test of each treated wood specimen, a section 2.5 cm in length was cut from the specimen near the point of failure. The specimen was weighed and then put in an oven at 103 ± 2°C for 24 h. Each specimen was weighed again after drying. The moisture content (MC) at test was calculated for each specimen. For comparison purposes, MOR and MOE at test MC were converted to the MOR and MOE at 12% MC using an equation from the Wood Handbook (7).

After central piece removal, the remaining boards wider than 105 mm were used as materials for laminated crossarm production. Each board was trimmed to remove a margin from the entire length of the piece. One or two 102 mm wide plies were cut from each board, depending on the width of the board. The resulting 102 mm wide x 19 mm thick x 2.4 m long pieces were used as plies for the production of laminated crossarms. Each ply was measured for volume, weight, moisture content, and acoustic properties. The acoustic properties were measured using a hand-hold acoustic meter and a hammer. When measured, each ply was stopped at one end by a rubber stopper on a table. Then, the acoustic meter receiver was pushed against the other end of the ply. A sound wave produced by the hammer on the same end as the meter traveled through the ply, reflected by the stopper end of the ply, and received by the meter. Sound traveling speed through the ply was calculated and shown on the meter's LCD screen. The measured sound speed was used to determine the location of the ply in a crossarm (surface ply or core ply). Plies with a greater sound speed were stronger and used as surface plies. The plies were then glued together with resorcinol phenol formaldehyde (RPF) resin to form laminated crossarms, six plies per arm. Prior to gluing, both glue surfaces of each ply were treated in one of three different ways: not treated (i.e. control), incised, or primed with a surface primer, a chemical used to improve the bonding of CCA treated wood. Of the fifteen crossarms made with treated wood plies, five arms consisted of plies that had been primed only; five arms consisted of plies that had been incised only; while the plies that comprised the others were not treated. The three surface preparations were randomly assigned to the plies cut from the treated wood. In the priming treatment, sample surfaces were brushed with the primer at 116 g/m^2 (.024 lb/ft.^{2}). For incised beams, sample surfaces were incised at 10,000 incisions/m^2 (929 incisions/ft.^{2}). The RPF resin and primer were obtained from Hexion Co. (Springfield, OR). Prior to test, all laminated crossarms were retreated with pentachlorophenol (penta) at the Dis-Tran Wood Products, LLC in Pineville, LA.

Fifteen penta treated, virgin southern pine solid sawn crossarms were obtained from Dis-Tran Wood Products, LLC in Pineville, LA. These solid sawn virgin wood arms were used as controls to the laminated crossarms made from spent treated wood.

In accordance with American Standard for Testing Materials D 198-02 (3) and American National Standard (1), flexural strength of laminated and solid-sawn crossarms was measured and evaluated.

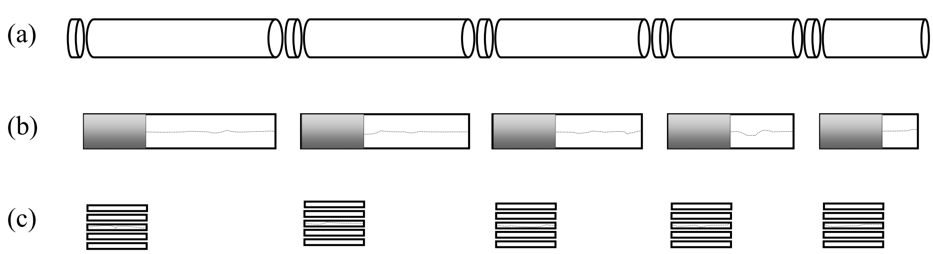


Fig. 1. Schematic diagram of sampling small clear specimens from a decommissioned utility pole: (a) pole sections and discs, (b) central boards containing the pith; (c) small clear specimens.

RESULTS AND DISCUSSION

Table 2 shows minimum, maximum, and average specific gravity (CCA inclusive) measured at a distance from the bottom for each pole. As expected, the minimum was the specific gravity of samples close to the pith, while the maximum was the specific gravity of the wood on the outer surfaces of the poles. Of the nine poles, Poles 7 and 8 had specific gravity less than 0.60 and were classified as low density poles; Poles 3 and 5 had average specific gravity more than 0.70 and were classified as high density poles; the remainders were medium density poles. As expected, high density poles usually had greater rings/cm (Table 1). As shown in Table 2, Pole 8 showed the lowest specific gravity and rings/cm, while Pole 3 showed the highest specific gravity and ring/cm.

Average MOR and MOE of the nine poles tested are presented in Table 3. Considerable variations were observed in the strength of these poles. MOR ranged from a minimum of 57.8 Mpa (Pole 8) to a maximum of 96 Mpa (Pole 9), while MOE ranged from 7.2 x 10^3 Mpa to 13.5 x 10^3 Mpa. Average MOR of the nine poles was 83.8 Mpa and average MOE of the nine poles was 12 x 10^3 Mpa. Comparing the residual strength of the spent treated wood to the strength of untreated virgin wood may provide useful information for structural design. For southern pine utility poles, most poles are made from longleaf pine. The Wood Handbook values for longleaf pine are 100 Mpa for MOR and 13.7 x 10^3 Mpa for MOE (7). Average MOR and MOE of the treated wood in Table 3 were 16.2% and 12.4% less than the MOR and MOE of the Wood Handbook values, respectively.

The low strength of the spent treated wood was attributed to three factors: 1) the outer wood of spent treated utility poles was weathered after 8 to 17 years in service, 2) most poles in Table 1 were distribution poles, which were smaller in size (more percentage of juvenile wood) in the entire longleaf pine pole population, and 3) some were sections of the original poles that either the top or the bottom sections or both were missing. Therefore, further studies are warranted to evaluate the strength of decommissioned, completed CCA treated transmission utility pole wood.

Table 2. Specific gravity of small clear samples cut from decommissioned CCA-treated wood utility poles.

Pole #	Dis. from butt[1] (m)	Minimum	Maximum	Average	Standard Error
1	3.0	0.62	0.70	0.65	0.01
2	0.5	0.59	0.78	0.69	0.02
3	2.1	0.66	0.91	0.78	0.02
4	2.4	0.63	0.73	0.68	0.01
5	2.4	0.65	0.84	0.76	0.02
6	4.0	0.51	0.78	0.66	0.03
7	3.1	0.44	0.65	0.55	0.02
8	3.0	0.40	0.68	0.52	0.02
9	2.8	0.57	0.69	0.63	0.02

[1] Distance from the butt of the poles.

Table 3. Average MOR and MOE of wood removed from decommissioned wood utility poles.

Pole #	MOR (Mpa)	Std Err[1] (Mpa)	MOE (10^3 Mpa)	Std Err (10^3 Mpa)
1	71.6	2.53	10.2	0.41
2	80.6	3.04	11.5	0.45
3	94.9	4.55	12.7	0.67
4	90.3	3.38	13.1	0.42
5	89.1	3.02	13.1	0.33
6	82.4	7.21	12.7	1.11
7	81.6	2.89	11.3	0.55
8	57.8	3.16	7.2	0.45
9	96.0	2.49	13.5	0.43
Average	**83.8**		**12.0**	

[1] Standard error.

For decommissioned treated wood, MOR and MOE were affected by wood specific gravity and rings/cm. It has been reported that specific gravity of untreated virgin wood and rings/cm are positively correlated (4). Fig. 2 shows a curvilinear relationship between sample specific gravity and number of growth rings of the sample. Fig. 3 shows both MOR and MOE curvilinearly increased with an increase of rings/cm. Of all the poles, Pole 8, which had the lowest specific gravity and rings/cm, showed the lowest average MOR and MOE among the nine poles; while Pole 9, which had the highest specific gravity, showed the greatest MOR and MOE.

Average MOR along six poles or pole sections starting from the top is presented in Fig. 4. Pole 8 shows decreased MOR from the top to about the groundline. The minimum MOR of Pole 8 in the 3.8 cm deep surface zone at one location was only 21 Mpa. The low strength was likely one of the reasons that Pole 8 was decommissioned after only 7 years in service. Pole 1 shows increased MOR from about 2 m at the top to about 3 m from the bottom of the pole. Pole 3 was one of the densest poles and exhibited one of the greatest MORs among the nine poles (Tables 2 and 3). The MOR of Pole 3 increased from 3.2 m from the top to 6.4 m and then decreased to about the ground line. Pole 7 had a similar pattern to the MOR along Pole 3 but showed lower specific gravity, rings/cm, and bending strength. For the remaining poles and pole sections, MOR was relatively uniform along these poles.

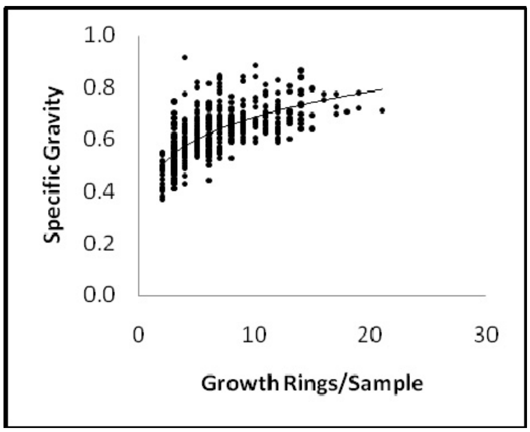
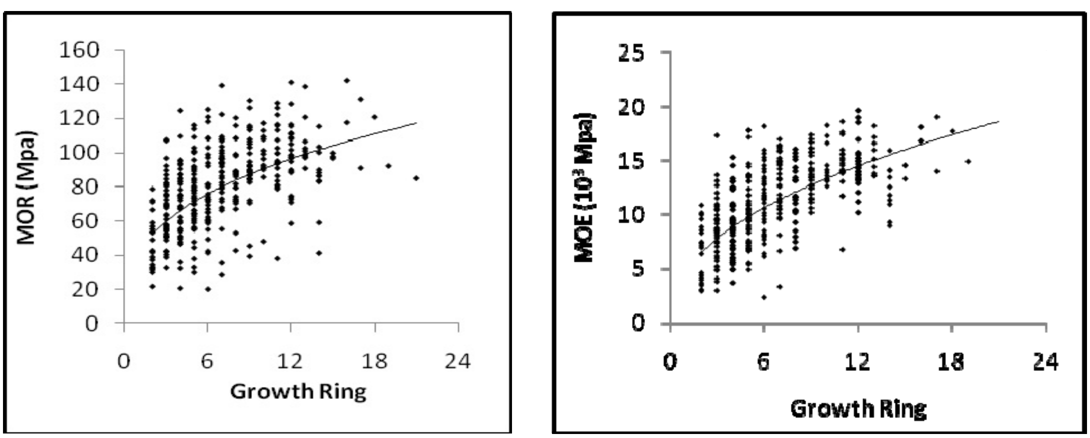


Fig. 2. Relationship between annual rings and specific gravity of wood removed from decommissioned CCA treated utilty poles.



(a) (b)

Fig. 3. Relationship between annual rings and flexural properties of wood removed from decommissioned CCA treated utility poles.

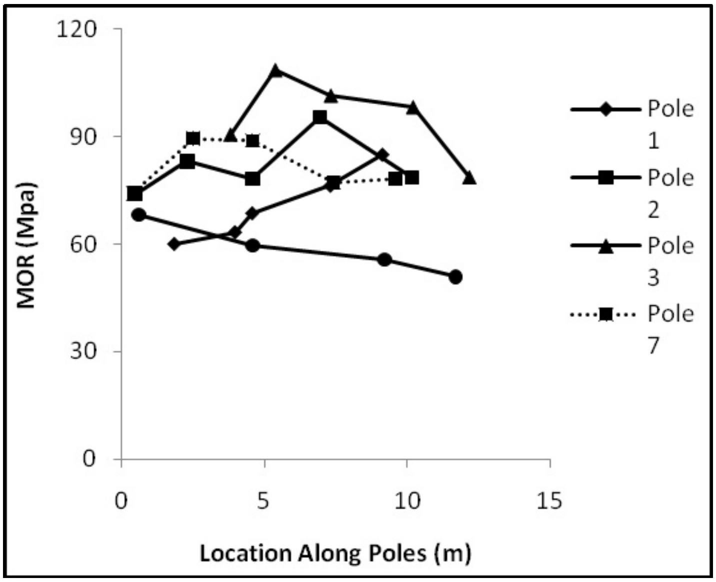


Fig. 4. Average MOR along some of the decommissioned utility poles starting from the top of each pole.

Table 4 shows the preliminary results of the study on laminated utility pole crossarms made from decommissioned utility pole wood. Each MOR or MOE value of the laminated crossarms in Table 4 was an average of five duplicate arms for each surface treatment group (i.e. priming, incising and control), while the MOR or MOE of virgin wood solid sawn crossarms was an average of fifteen duplicate arms. It can be seen from Table 4 that the bending strength of laminated crossarms made from decommissioned utility pole wood was comparable to the bending strength of solid sawn virgin wood crossarms, indicating that decommissioned utility pole wood can be reused to make laminated crossarms.

Table 4. Modulus of rupture (MOR) and modulus of elasticity (MOE) of laminated utility pole crossarms made from spent CCA treated wood and solid sawn virgin wood utility pole crossarms. Laminated crossarms were treated with surface priming, incising, and no treatment for the two adherent surfaces of each glue line in the arms.

	Priming	Incising	Control	Virgin
MOR (Mpa)	70.0	66.9	67.1	69.8
MOE (10^3 Mpa)	13.9	14.0	14.1	13.0

SUMMARY AND CONCLUSIONS

Nine decommissioned poles and pole sections were evaluated for the bending strength across and along these poles. Laminated crossarms made from spent utility pole wood and solid sawn crossarms made from virgin wood were compared for bending strength after retreated with penta. It was found that the strength of most decommissioned utility poles varied across, along each pole, and among the poles that were studied. The average MOR and MOE of the utility pole wood in this study were 16.2% and 12.4%, respectively, lower than MOR and MOE values of longleaf pine virgin wood. However, the bending properties (MOR and MOE) of laminated crossarms made from decommissioned utility pole wood were comparable to the bending properties of solid sawn crossarms made from virgin wood. This study was conducted using decommissioned distribution poles. Further studies are warranted to examine the bending properties of decommissioned CCA treated transmission utility pole wood.

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