

Residual Strength and Stiffness of Lumber from Decommissioned Chromated Copper Arsenate–Treated Southern Pine Utility Poles

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Abstract

The reusability of decommissioned treated wood is primarily dependent on the residual strength of the wood after service. Determining the residual strength can provide useful information for structural design and reuse of the decommissioned treated wood. This study evaluated the residual strength of decommissioned chromated copper arsenate–treated utility pole wood. Eleven decommissioned southern pine (*Pinus* spp.) distribution poles and pole sections were evaluated, using small clear samples, for bending strength and stiffness across and along each pole. Results showed that the strength of the decommissioned treated wood varied across and along each pole and among the poles. Average modulus of rupture (MOR) was 80.9 percent of the typical MOR of longleaf pine (*Pinus palustris*) virgin wood, and average modulus of elasticity (MOE) was 83.9 percent of the typical MOE. Average MOR of the samples in the outer surface (first test zone) was 7.5 percent lower than the average MOR of the adjacent samples toward the pith (second test zone) on each side of the pole surfaces, but average MOE showed no significant difference between the two zones. Older poles lost more strength in the first test zone. Results demonstrated that spiral grain substantially reduced the strength of utility pole wood.

Wood utility poles are removed from service primarily because of system revisions, mechanical damage, decay and insect attacks, wildfires, and/or damage from adverse weather conditions. Preservatives protect the poles while in service; therefore, a large portion of decommissioned poles are still mechanically sound and reusable for other purposes (Smith and Morrell 1989, Stewart and Goodman 1990, Huhnke et al. 1994, Cooper et al. 1996, Falk et al. 2000, King and Lewis 2000, Shi et al. 2001, Wang et al. 2001, Leichti et al. 2005). However, because wood poles deteriorate with time (Stewart and Goodman 1990), the reusability of decommissioned wood utility poles is primarily dependent on the residual strength of the timber, which is affected by service age, environmental conditions, and preservative type and treatment quality, and on the variability inherent in wood, such as species, age and growth rate, juvenile wood, etc. Determining the residual strength of poles can provide a useful reference for reuse and recycling of quality decommissioned treated wood.

Cooper et al. (1996) studied the potential of 456 poles and pole sections for reuse as round poles, posts, sawn posts, timber, lumber, or cedar roof shingles. Pole species included cedar (western red cedar [*Thuja plicata*] and northern white cedar [*Thuja occidentalis*]), red pine (*Pinus resinosa*), jack

pine (*Pinus banksiana*), southern pine (*Pinus* spp.), Douglas-fir (*Pseudotsuga menziesii*), and lodgepole pine (*Pinus contorta*). Treatment chemicals included all three major preservatives (i.e., creosote, pentachlorophenol [penta], and chromated copper arsenate [CCA]). The authors found that about 50 percent of the pole volume could be converted to sawn products and shingles and that 8 percent of the poles could be reused without reprocessing. Their study also demonstrated that the modulus of rupture (MOR) and modulus of elasticity (MOE) of the decommissioned treated wood were comparable to the average MOR and MOE of untreated virgin wood of the same species. Wang et al. (2001) and Shi et al. (2001) evaluated the residual strength of Douglas-fir and southern pine sawn timber that

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was cut from decommissioned creosote-treated marine posts. Both studies used nondestructive approaches and static bending tests, and both found a good quality of the recycled timber for secondary structural utilization. Leichti et al. (2005) studied the potential of producing structural timber from decommissioned Douglas-fir utility poles treated with penta or creosote and evaluated both small clear samples and structural size timber (3.8 m long by 150 mm square) for residual strength. Their results showed that the visual grades of timbers sawn from decommissioned poles ranged from Select Structural to Off-Grade. Bending strength and stiffness of the decommissioned treated wood were 10 percent below those of untreated virgin wood materials.

Wood utility poles are widely used in the power transmission and telecommunication fields. Consequently, a large amount of treated wood is decommissioned and flows into the waste stream annually. A substantial amount of decommissioned utility pole wood could be reused to produce value-added, structural engineering components. Solid sawn and laminated utility pole crossarms, for example, are some of the potential products that can be made from decommissioned utility pole wood. However, the residual strength of the decommissioned utility pole wood, which is dependent on its service age, largely determines the recycling potential of the treated wood materials for structural applications. The quality of the wood along and across a decommissioned pole may differ from what is expected from the wood across and along a virgin log because of degradation of the decommissioned treated wood after long-term exposure in the environment. Therefore, evaluating the bending strength and stiffness across and along a decommissioned utility pole can provide important data for structural design and reuse of the decommissioned treated wood. However, little information is available regarding the strength and stiffness of wood across and along an entire pole after service.

This study was part of a larger research project to recycle and reuse decommissioned preservative-treated wood. The goal of the larger project was to reengineer the spent treated wood into laminated products for industrial applications. The first industrial product for which the recycled wood was believed to be suitable was laminated utility pole crossarms. For this purpose, we evaluated CCA retention and distribution in the decommissioned treated wood (Piao et

al. 2009a), the effect of CCA on the gluability of treated wood (Piao et al. 2009b, 2009c), and the physical and mechanical properties of laminated utility pole crossarms made from decommissioned CCA-treated wood (Piao and Monlezun 2010). However, the strength data along an entire decommissioned utility pole are needed before the pole can be used for the fabrication of industrial products, such as laminated crossarms. For instance, the low-strength utility pole lumber could be designated for use as central plies (low-stress areas) in a laminated crossarm, while stronger lumber can be designated for use as top and bottom plies (high-stress areas) of the crossarm. The objective of this study was to evaluate the residual strength and stiffness of wood cut across and along decommissioned CCA-treated southern pine utility poles.

Because of the variable sizes of the decommissioned treated wood that are available for evaluation, small clear samples have been widely used to assess the flexural properties of decommissioned utility poles and posts (Smith and Morrell 1989, Cooper et al. 1996, Leichti et al. 2005). Smith and Morrell (1989) demonstrated that the bending strength of small clear samples agreed well with the bending strength of decommissioned western red cedar poles. Therefore, small clear samples were used to assess the mechanical properties of utility poles in this study.

Materials and Methods

Eleven CCA-treated, decommissioned southern pine utility poles and pole sections were obtained from local power companies. The properties of these poles are given in Table 1. Poles 2 through 9 were obtained in 2007, Pole 1 (section) was obtained in 2008, and Poles 10 and 11 were obtained in 2009. All were distribution poles that carried power from local substations to customers.

Figure 1 shows a schematic diagram of sampling small clear specimens from a utility pole. Consecutive 2.44-m segments were marked off along the entire length of each pole or pole section. Before segments were cut, the location of each segment from the top of the pole was measured or estimated. After the segments were removed from the pole, each segment was cut into boards, and each board was planed to a final thickness of 19 mm. The center board containing the pith was selected from the boards of each segment (Fig. 1b), and a 41-cm section along the length of

Table 1.—Summary data of the CCA-treated decommissioned southern pine utility poles.

Pole no.	Year marked	Grade	Length (m)		Section missing ^a	Estimated service (y)	DBH (cm) ^b	HD (cm) ^c
			Original	Actual				
1	1991	5	12.2	8.4	T & B	16	24.9	10.2
2	1992	6	10.7	10.7	NA	15	22.5	7.0
3	1993	5	12.2	9.1	T	14	25.7	11.1
4	1995	3	13.7	7.6	T	13	29.8	12.7
5	1995	3	13.7	11.3	B	13	29.5	4.1
6	1999	5	13.7	6.7	T & B	8	25.9	1.3
7	1999	5	10.7	10.7	NA	8	23.2	7.6
8	2000	3	15.2	13.4	B	7	31.8	3.2
9	2000	5	9.1	9.1	NA	7	22.1	1.3
10	2007	7	9.1	9.1	NA	2	19.0	10.1
11	2007	4	13.7	13.7	NA	2	28.3	14.0

^a T = top; B = bottom; NA = not applicable.

^b DBH = diameter at breast height.

^c HD = heartwood diameter at breast height.

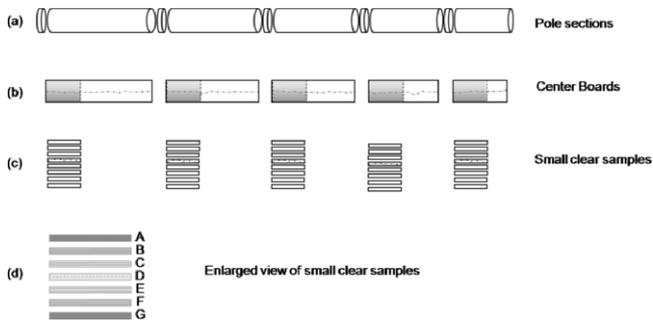


Figure 1.—Diagram of sampling small clear samples from a decommissioned utility pole: (a) pole segments and discs, (b) center boards containing the pith, (c) small clear samples removed from the center boards, and (d) a group of diametric small clear samples obtained from a center board.

each central board was removed from one end. From this section, small clear bending samples were produced by first removing a 3-mm-wide edge along the length of each section and then cutting what remained into 41 cm long by 19-mm square beams (Fig. 1c). These beams were the small clear samples used to measure the bending properties across and along each pole. Before the bending test, beam samples were conditioned in an air-conditioned room for 5 weeks. Each sample was then measured for length, width, thickness, and weight. The specific gravity of each small clear sample was calculated as follows:

$$SG = \frac{W_{scs} - W_w}{V_{scs}D_w} \quad (1)$$

where

SG = specific gravity of the small clear sample,

W_{scs} = weight of the sample at test,

W_w = weight of moisture in the sample at test,

V_{scs} = volume of the sample, and

D_w = density of water (1 g/cm³).

The growth rings of each sample were counted and recorded. All of the small clear samples were loaded to failure using an Instron testing machine according to ASTM Standard D143-94 (American Society for Testing and Materials [ASTM] 2000) except for the dimension of the samples and the crosshead speed: The sample dimensions were 19 mm wide by 19 mm high by 41 cm long instead of 25 mm wide by 25 mm high by 41 cm long, as required by the standard, and the crosshead speed was reduced from the standard 1.3 to 1 mm/min. The span length was 35.6 cm, and the span-to-depth ratio was 18.7. Each sample was loaded through the bearing block to the tangential surface nearest the pith. From the 11 poles, a total of 467 small clear samples were prepared and tested. The personnel were well protected with personal safety devices during the handling and processing of the treated wood materials. The processing residuals were carefully disposed in a landfill.

After testing, a 2.5-cm section was immediately cut from the sample near the point of failure and was used for measurement of moisture content (MC) and CCA retention. The section was weighed and then put in an oven at 103°C ± 2°C (mean ± standard error) for 24 hours. Each section was weighed again after drying, and the MC of each sample

at test was calculated. Each section was then ground into powder with a Wiley mill for the CCA retention evaluation according to the American Wood-Preservers' Association (now American Wood Protection Association) Standard A9-01 (2006b). For comparison purposes, the MOR and MOE at test MC were converted to the MOR and MOE at 12 percent MC. The equation used for the conversion was derived from an equation in the *Wood Handbook* (Forest Products Laboratory [FPL] 1999):

$$P_{12\%} = e^{(\ln P + C \times \ln P_g)/(1+C)} \quad (2)$$

where

$P_{12\%}$ = MOR or MOE at 12 percent MC,

P = MOR or MOE at test M (%),

$C = (12 - M)/(M_p - 12)$,

P_g = MOR or MOE of green wood, and

M_p = MC at the intersection of a horizontal line representing the strength of green wood and an inclined line representing the logarithm of the strength–MC relationship for dry wood.

The P_g values of longleaf pine (*Pinus palustris*) are 59 MPa for MOR and 10.7×10^3 MPa for MOE. The value of M_p for longleaf pine is 21 percent (FPL 1999).

Analysis of variance (ANOVA) was used in the data analyses. The SAS procedure GLM was used to analyze the bending strength and stiffness data (SAS 2008). A significance level of 0.05 was used for each analysis.

Results and Discussion

The 11 poles ranged from Grades 3 to 7, with year marks from 1992 to 2007, making the estimated service ages between 1 and 16 years. Poles 1, 3 to 6, and 8 were not intact when collected; sections were missing from either the top or the bottom of these poles. Poles 2, 7, and 9 to 11 were intact when collected and had the original length as marked on the poles. Checks and/or splits were found on the surface of all poles. For the nine older poles (Poles 1 to 9), surface checks and/or splits were typical and were parallel to the pole stem. The two newer poles (Poles 10 and 11) exhibited unusual checks and splits on the surfaces: Pole 10 showed large surface splits parallel to the pole stem, while Pole 11 showed left spiral checks and splits of about 25° to the pole stem. The spiral checks on Pole 11 were a typical result of spiral grain in the pole (Noskowiak 1963). The slope of grain on each sample was less than 1:12 except for the samples cut from Pole 11, which had a grain slope of about 1:2.1.

Minimum, maximum, and average specific gravity (CCA inclusive), MOR, and MOE of the 11 poles are summarized in Table 2. As expected, except for Pole 4, the specific gravity of the samples near the pith was low, while the specific gravity of the samples near the outer surface was high for all of the poles. The specific gravity of Pole 4 decreased from its pith to outer surfaces at all locations measured along the pole. The W_{scs} of Equation 1 includes the weight of both wood and CCA in the wood for each small clear sample; therefore, the actual specific gravity values (minimum, maximum, and average) of each pole would be a little lower than the specific values displayed in Table 2. In addition, the samples near the pole surfaces contained more CCA than the samples near the pith;

Table 2.—Physical and mechanical properties (at 12% moisture content) of small clear samples obtained from CCA-treated decommissioned southern pine utility poles.

Pole no.	Specific gravity ^a			Ring density (rings/cm)	Mean (SE)	
	Min	Max	Mean (SE)		MOR (MPa)	MOE (10 ³ MPa)
1	0.44	0.62	0.53 (0.01)	2.7	71.6 (2.53)	10.2 (0.41)
2	0.44	0.72	0.56 (0.01)	3.8	80.6 (3.04)	11.5 (0.45)
3	0.54	0.83	0.66 (0.01)	4.4	95.0 (4.55)	12.7 (0.67)
4	0.51	0.80	0.62 (0.01)	5.3	90.3 (3.38)	13.1 (0.42)
5	0.51	0.76	0.62 (0.01)	4.1	89.1 (3.02)	13.1 (0.40)
6	0.46	0.86	0.62 (0.03)	4.3	82.4 (7.21)	12.7 (1.11)
7	0.40	0.74	0.53 (0.01)	2.6	81.6 (2.89)	11.3 (0.55)
8	0.34	0.61	0.45 (0.01)	1.6	57.8 (3.15)	7.3 (0.45)
9	0.48	0.68	0.57 (0.01)	5.6	96.0 (2.49)	13.5 (0.43)
10	0.40	0.73	0.61 (0.02)	4.5	82.4 (6.57)	10.4 (0.90)
11	0.48	0.98	0.64 (0.01)	5.3	63.7 (4.05)	10.1 (0.48)
Avg	0.45	0.98	0.64 (0.01)	3.9	80.9 (3.90)	11.5 (0.56)

^a Samples were dried in an oven at 103°C ± 2°C for 24 hours.

therefore, the actual maximum and average specific gravity of each pole would be even lower than the values shown in Table 2.

In Figure 2, the MOR values of small clear samples are plotted versus ring density (rings per centimeter). Biblis et al. (2004) reported that the specific gravity and ring density of untreated virgin wood are positively correlated. Because both affect the mechanical properties of wood, a similar relationship was found between the specific gravity and ring density of the decommissioned poles in the present study (Table 2). Of the 11 poles, Poles 1, 7, and 8 showed an average specific gravity of less than 0.55 and were classified as low-density poles. These poles also displayed a low ring density (<3.0 rings per cm) and low strength and stiffness compared with the remaining poles. Pole 8, the largest pole collected in this study, exhibited the lowest specific gravity (0.45), the lowest ring density (1.6 rings per cm), the lowest MOR (57.8 MPa), and the lowest MOE (7.3 × 10³ MPa).

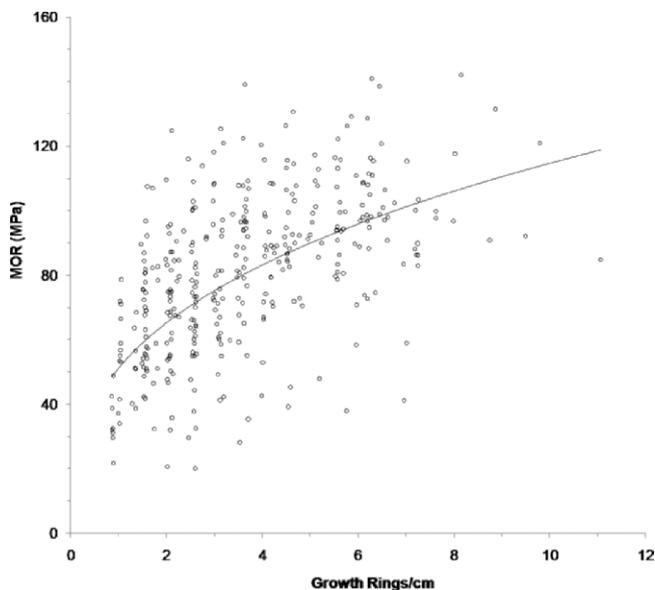


Figure 2.—Relationship between growth rings and strength of wood removed from decommissioned CCA-treated utility poles (Poles 1 to 9).

Poles 3 to 6 and Poles 10 and 11 displayed an average specific gravity of greater than 0.60 and were classified as high-density poles. These poles had an average of more than 4.1 rings per cm. Poles 3 to 6 were among the strongest poles in this study.

Poles 2 and 9 were medium-density poles. However, Pole 9 displayed the highest ring density (5.6 rings/cm) and was the strongest pole. The average CCA retention of Pole 9 was 13 kg/m³, which also was the highest among the 11 poles. As mentioned, specific gravity varied with CCA retention in the wood, while ring density remained the same as CCA retention changed. Therefore, ring density could be used as an additional criterion for pole evaluation. Based on the low ring density, for example, a rejection of Pole 8 (<2 rings per cm) before installation would have avoided an early decommission of the pole from a distribution line.

Considerable variation was observed in bending strength and stiffness within each pole and among the 11 poles. For a typical timber log, ring density, wood density, MOR, and

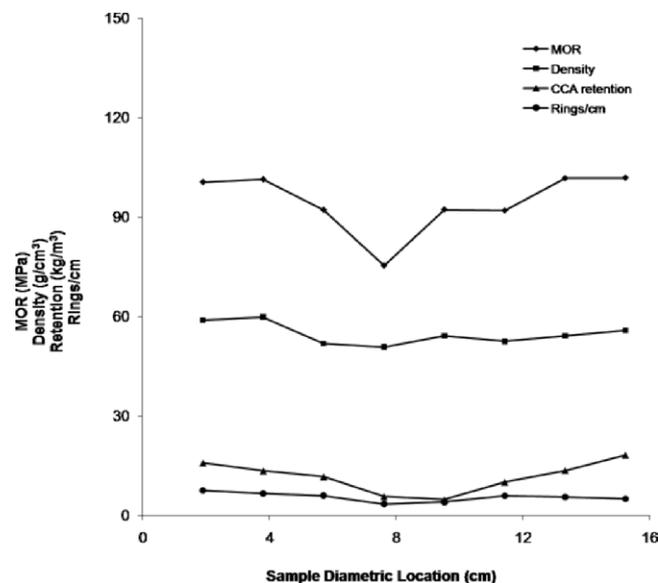


Figure 3.—Modulus of rupture, density, CCA retention, and ring density (rings per centimeter) of diametric samples of decommissioned wood utility Pole 9 (7 y in service).

MOR are expected to increase from the pith to the outside surface. Figure 3 shows a typical variation of MOR, density, CCA retention, and ring density across the diameter of most of the nine older poles (Poles 1 to 9) in this study. MOR and MOE decreased from one surface of a pole to the pith and then increased from the pith to the other surface, following the same pattern as specific gravity and ring density across the diameter of the poles. The MOR and MOE of Poles 3, 7, and 9, for example, were nearly symmetric about their piths at most locations along each of the three poles. The MOR and MOE of Pole 4 were symmetric about its pith at the top two of the four locations that were measured along the pole. A notable exception to this symmetric variation of MOR and MOE was observed on Poles 1, 2, 5, 6, and 8, which were medium- to low-density poles. In these poles, MOR and MOE decreased from one surface of the pole, through the pith, and to the other surface at some locations along each. Figure 4 shows the MOR of the diametric samples of Pole 1 at 5.6 m (full pole length, 12.2 m) below the top of the pole. Also shown in Figure 4 are the CCA retention and ring density of the samples. For comparison purposes, values for CCA retention and ring density in Figure 4 were enlarged by fivefold (i.e., the actual CCA retention and ring density of these samples were five times smaller than the values shown). It can be seen from the figure that both MOR and CCA retention decreased along the diametric direction. The CCA retention of the low-strength side was 6.9 kg/m³, which was lower than the 9.6 kg/m³ required by American Wood-Preservers' Association Standard U1-06 (2006a) for southern pine poles. Therefore, before being decommissioned, one side of Pole 1 had likely decayed and failed to keep the same strength as the other side, which had a CCA retention of 13.3 kg/m³ and likely had not decayed. Similar decreases of MOR and MOE were found on some locations along Poles 2, 5, 7, and 8. In each occurrence of the unbalanced or low MOR and MOE, the CCA retention of the first diametric sample on one or both sides of the diameter was less than 9.6 kg/m³. Leaching and surface degradation might be among the reasons that led to the low CCA retention on the surface zones and decay of these medium- and low-density poles. It is recommended that, when reused as materials for a laminated product, the

treated wood that has decayed not be used on the stressed sides of the product. In addition, before being exposed to an exterior environment, laminated or solid products made from decommissioned treated wood should be retreated with preservatives to protect the wood from fungal and insect attack.

Variations in the MOR and MOE across the diameter of each pole could also have resulted from the testing setup according to the procedure described in ASTM D143-94 (ASTM 2000). Based on the standard procedure, each small clear sample was loaded through the bearing block to the tangential surface nearest to the pith. The MOR and MOE of a sample may vary depending on the earlywood or latewood of the stressed surfaces. The earlywood and latewood effects would become more pronounced as the sample moved toward the pith. It was reported that loading on the radial surface would reduce such variability (Bendtsen et al. 1983, Winandy et al. 1985, LeVan et al. 1990).

Barnes (1985) demonstrated that high CCA retention had a detrimental effect on the MOR of southern pine wood. In the present study, the CCA retention of each small clear sample was measured (Figs. 3 and 4). However, because the strength of the small clear samples before CCA treatment was not known, the effect of CCA retention on the MOR of decommissioned utility pole wood was not assessed.

It was also found that the samples on pole surface (outer test zone) showed lower MOR compared with the MOR of the adjacent samples (adjacent test zone) on each side of the pole surfaces, regardless of the density and CCA retention of the samples. Figure 1d shows the diametric locations of small clear samples removed from a pole. Sample locations began with a sample from the surface (Sample A), increased inward to the sample in the pith (Sample D), and increased outward to the sample on the other surface (Sample H). Samples A and H were surface samples in the outer test zone, and Sample D was the central sample, containing the pith, in a deep inner test zone. According to a typical behavior of virgin pine logs, Sample A is often stronger than Sample B, because Sample A contains narrower growth rings and more latewood than Sample B. Based on the same rule, Sample H is stronger than Sample G. For decommissioned utility pole wood, the MOR of most samples in the outer test zone (Sample A or H) was lower than the MOR of their adjacent samples (Sample B or G) in the adjacent test zone. This finding was common at most locations along each of the nine older poles (Poles 1 to 9) in sections above the ground line. If a negative sign is assigned to a decrease in MOR from Sample A (or H) to Sample B (or G) and a positive sign is assigned to an increase in MOR from Sample A (or H) to Sample B (or G), then the percentage change of the strength between a sample in the outer test zone and its adjacent sample was calculated using the following formula:

$$P_{\text{drop}} = \frac{P_{\text{second}} - P_{\text{first}}}{P_{\text{second}}} \times 100 \quad (3)$$

where

P_{drop} = percent change of a property (MOR or MOE) of the first (outer) test zone compared with the second (adjacent) test zone,

P_{first} = property of the sample in the first test zone (Sample A), and

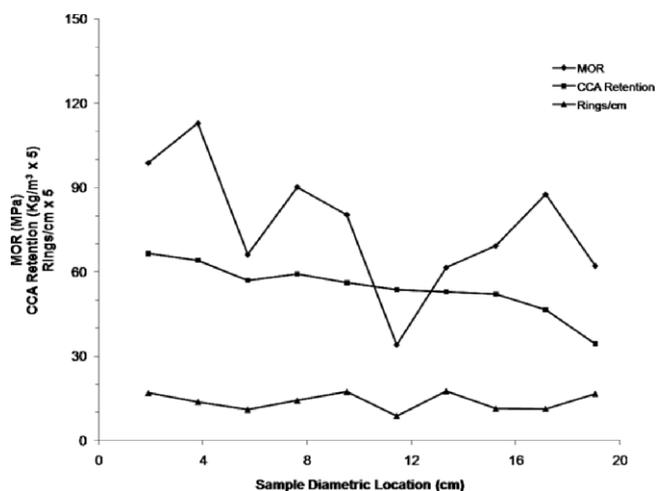


Figure 4.—Modulus of rupture, CCA retention, and ring density (rings per centimeter) of decommissioned utility Pole 1 at 5.6 m below the top (16 y in service).

Table 3.—Mean percent differences of MOR and MOE between diametric outer and adjacent diametric samples of decommissioned CCA-treated southern pine utility poles.

	Pole no.										
	1	2	3	4	5	6	7	8	9	10	11
MOR (%)	8.4	18.2	4.9	6.2	16.3	-2.4	5.5	6.4	3.6	-18.5	184.6
MOE (%)	-8.5	0.2	1.9	1.8	6.9	-8.8	-6.1	11.0	2.7	-19.7	70.2

P_{second} = property of the sample in the second test zone (Sample B, adjacent to the first sample).

Table 3 presents the results of the analysis. Each percent difference in Table 3 is an average of all percent differences (positive and negative) between the samples in the second and first test zones of a pole. The ANOVA results showed that, for the nine older poles, the MOR of the first test zone (outer zone) was significantly lower than the MOR of the second test zone (adjacent zone, $P = 0.0308$). The average percent difference between the second and first test zones of the nine older poles was 7.5 percent (i.e., the MOR of the samples in the first test zone was 7.5% lower than the MOR of samples in the second test zone). The strength reduction in the first test zones was largely attributed to the surface degradation and decay of the poles.

Poles 10 and 11 were new poles. Table 3 shows that the surface aging of Pole 10 was much less than that of the nine older poles. Pole 11 contained spiral grains, which severely impact the quality, strength, seasoning, and machining properties of wood (Noskowiak 1963, Jozsa and Middleton 1994, Acuna and Murphy 2006). Most samples in the first and second zones of Pole 11 showed diagonal splits that were caused by the spiral checks and splits on the surface of the pole. Some of the splits went as deep as to the sixth zone (114 mm) from the outer surface, and some bending samples in the outer zones failed before they were tested. The samples with checks were not tested and were excluded from the data analysis. Pole 11 was high in both ring density (5.3 rings per cm) and specific gravity (0.64), but it displayed lower MOR and MOE than other poles with high ring density (Table 3). The diagonal grains substantially reduced the bending strength of the pole.

The ANOVA results also showed that the MOE of the samples in the first test zone was not significantly different from the MOE of their adjacent samples in the second test zone ($P = 0.8785$) for the nine older poles.

No consistent strength variation pattern was found along the 11 poles (Fig. 5). Pole 8 showed a decreased MOR from the top to about the ground line, while Pole 1 demonstrated a constantly increased MOR from the top to about 9 m from the top (full pole length, 12.2 m). The MOR of the remaining poles varied. One pattern showed MOR increased from the top to about the middle of the poles, then decreased to about the ground lines; the MOR of Poles 2, 3, 7, 10, and 11 belonged to this pattern. Another pattern was that MOR decreased slightly from the top to about the middle of the pole, then increased to the ground line; the MOR of Poles 4, 5, and 9 belonged to this pattern. For poles with a complete underground section, only Poles 4 and 9 demonstrated the greatest MOR at the sections under the ground line; other poles showed that the MOR of the underground wood was weaker than or the weakest compared to the wood from above the ground line. Decay along some of the low-

medium-density poles probably played a role in the strength and stiffness variations along the poles.

Across the 11 poles, MOR ranged from 57.8 MPa (Pole 8) to 96.0 MPa (Pole 9), while MOE ranged from 7.3×10^3 MPa (Pole 8) to 13.5×10^3 MPa (Pole 5). The mean MOR of the 11 poles was 80.9 MPa, and the mean MOE was 11.5×10^3 MPa. Comparing the residual strength of the decommissioned treated wood with the strength of untreated virgin wood may provide useful information for structural design. Most utility poles in the southern United States are made from longleaf pine, a species of southern pine. The *Wood Handbook* values for longleaf pine are 100 MPa for the MOR and 13.7×10^3 MPa for the MOE at 12 percent MC (FPL 1999). Compared with these values, average MOR of the decommissioned treated wood in Table 2 was 80.9 percent of the MOR value, and average MOE was 83.9 percent of the MOE value, in the *Wood Handbook* for longleaf pine, showing that the utility pole wood was weaker than untreated virgin wood. Besides weathering and decay, as mentioned, several other factors may be accountable for the low strength and stiffness of the decommissioned utility pole wood: (1) all poles in Table 1 were distribution poles, which were smaller poles (higher percentage of juvenile wood, especially at the top) in the entire longleaf pine pole population; (2) some of the poles tested were sections of the original poles from which either the top or the bottom sections (or both) were missing; and (3) all were early decommissioned poles, which might have been of poor quality before being placed in service (e.g.,

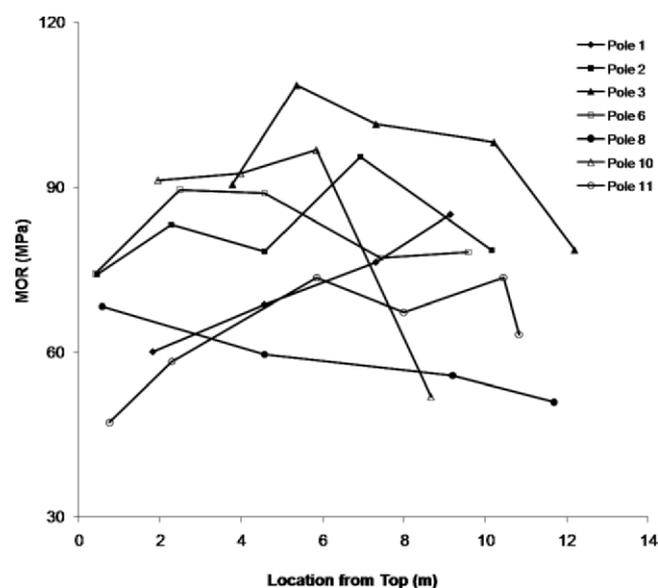


Figure 5.—Modulus of rupture along decommissioned CCA-treated southern pine utility poles.

Pole 8). Further studies are warranted to evaluate the strength of decommissioned CCA-treated transmission utility pole wood that has had an extended service life.

Summary and Conclusions

Eleven decommissioned CCA-treated southern pine utility poles and pole sections were evaluated, using the small clear sample approach, for bending strength and stiffness across and along each of the poles. The service ages of the poles were from 1 to 16 years, specific gravity (CCA inclusive) was from 0.45 to 0.66, and ring density was from 1.6 to 5.6 rings per cm. One pole (Pole 10) showed large splits along the pole, and one pole (Pole 11) showed spiral grains. The strength and stiffness were variable across and along each pole and among the poles that were studied. The average MOR and MOE of the 11 decommissioned poles were 80.9 and 83.9 percent, respectively, of those of longleaf pine virgin wood. The MOR of the samples in the surface test zone was 7.5 percent lower than the MOR of the adjacent samples in the adjacent test zone, but the MOE of the two groups of samples (surface and adjacent zones) showed no significant differences. Older poles lost more strength in the first test zone than newer poles that had a shorter service life. No consistent variation of strength was found along the poles, but spiral grains led to substantial strength reduction. Decay likely occurred in some low- to medium-density poles because of the low CCA retention on the surface of the poles. All poles tested in this study were distribution poles. Further studies are warranted to examine the bending properties of decommissioned CCA-treated transmission utility pole wood.

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