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RECYCLING OF DECOMMISSIONED CCA-TREATED WOOD INTO VALUE-ADDED ENIGNEERED WOOD PRODUCTS

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ABSTRACT

Chromated copper arsenate (CCA) treated wood has been most widely used in North America since the 1970's for many exterior application such as decks, fences, playground equipment, utility poles, and others. A large volume of CCA-treated wood is currently coming out of service. Traditional disposal methods such as landfilling and incineration are not without adverse environmental outcomes. Recycling CCA-treated wood into value-added engineered wood products is one alternative to ease the disposal problem. On-going collaborative research between the Louisiana State University Agricultural Center School of Renewable Natural Resources and USDA Forest Service Southern Research Station is exploring various recycling options. One product that is currently being investigated is structural flakeboard. In this study, the effects of different ratios of recycled CCA-treated wood and untreated virgin wood on flakeboard mechanical and physical properties were determined. Panels were manufactured from five different ratios of recycled CCA-treated wood and untreated virgin southern pine wood. The ratios were 100:0, 75:25, 50:50, 25:75, and 0:100. The median ratio with 50% of CCA-treated wood and untreated wood was found to be the optimum combination based on the results of this study and those of other on-going studies by the authors.

INTRODUCTION

Preservative-treated wood products are well known to significantly prolong service life, and thereby extend the forest resource and enhance its sustainability. Inevitably, however, the treated products will become unserviceable either due to mechanical damage or failure, biological deterioration, or obsolescence. It is estimated that about 5 million tons of spent preserved wood is disposed of annually into landfills in the United States (Falk 1997). These CCA-treated posts and sleepers have an average working life of approximately 25 years, therefore the release of CCA-treated wood products is expected to increase continuously over the next decades.

Disposal of the spent CCA-treated wood has become a major concern because of its residual toxic CCA content, in particular the arsenic and chrome. Conventional waste disposal options for spent preserved wood, such as burning and landfilling, are becoming more and more costly or even impractical because of increasingly strict regulatory requirements. The burning of treated wood may be extremely dangerous and even more so when the wood has been treated with CCA and this not only in respect to the possible environmental pollution but also where the health of persons is concerned. Studies have shown that burning of the preservative-treated wood waste emits highly toxic smoke and fumes in the environment (Fehrs and Donovan. 1995). Studies have also shown that CCA-treated wood exposed aboveground to natural rain will leach all three of the preservative metals (Hingston et al. 2001; Taylor et al. 2001; Taylor and Cooper 2003). Moreover, there is also the space issue when landfilling treated wood.

MATERIALS AND METHODS

Twenty-five highway guardrail posts manufactured from southern pine (*Pinus* sp.), were obtained from Arnold Forest Products Company in Shreveport, Louisiana. The posts, which had been treated with CCA, went in service in

May, 1986 in Abilene, Texas and were removed in September 1999. These posts were about 69 inches (175.3 cm) long with diameter range of 6 ½ - 8 ¾ inches (16.5 – 22.2 cm). They were treated to 0.5 pcf (8.0 kg/m^3) and had been placed 38 inches (96.5 cm) into ground. The fresh southern pine lumber was purchased at a local retail lumber store.

Flake Manufacture

The posts were sawn into lumber, then randomly selected boards were cut into blocks 3-in. (7.6 cm) wide and 1-in. (2.5 cm) thick. The blocks were submerged in tap water for 24 hrs. and flaked with a laboratory ring-flaker to produce flakes measuring approximately 3 x 1 x 0.05 in. (7.6 x 2.5 x 0.1 cm). Although a longer soaking time would have resulted in higher quality flakes, it would have also resulted in leaching of the preservative and water-soluble wood extractives. The 24-hour soaking time was used to minimize the leaching effect. Virgin untreated flakes were produced with the same procedures. All flakes were dried in a forced-air oven maintained at 217 ± 4°F (102 ± 2°C) to obtain a mean moisture content (MC) of 4 %. The flakes were screened to remove fines (material passing through a screen with 1/4 in.^{2} (1.6 cm^2) openings).

Panel Fabrication

Recycled CCA-treated flakes and untreated flakes were mixed at five ratios by weight: 100, 75, 50, 25, 0 percent treated wood content (Table 1). To prepare each panel, flakes were weighed and placed in rotating drum blender. Phenol formaldehyde (PF) adhesive obtained from Borden Chemical, Inc., in an amount equal to 4.5 % of the ovendry weight of flakes, was weighed and applied by air-atomizing nozzles. The resin was a typical 50% resin solids commercial PF resin for oriented strand board (OSB). The mean MC of the flakes after spraying was 8 %.

After blending, the randomly oriented flakes were carefully hand felt into a 16.5 x 20 in. (41.9 x 50.8 cm) box to form the mat. The mats were then immediately transferred to a 20 x 20 in. (50.8 x 50.8 cm) single opening hot press with the platen temperature regulated at 370° F(187.8° C). Sufficient pressure, approximately 550 psi (3.79 MPa), was applied so that the platen closed to 0.5 in. (1.27 cm) thickness and stopped in approximately 30 seconds. Press time was 3.5 minutes after closure. Panels were conditioned for 1 week at ambient conditions prior to testing. Each of the five treatments combinations was replicated twice.

Physical and Mechanical Property Tests

Flakeboards were trimmed to 14 x 18 in. (35.6 x 45.7 cm) and cut into specimens for testing according to American Society for Testing Materials (ASTM) standard D 1037-93 (1998), APA - The Engineered Wood Association Standard P-1 (1997), and American Wood-Preservers' Association (AWPA 2000) standard E-10. A minor modification was that the sample dimensions for the static bending tests and dimensional stability tests were 2 × 14 in. (5.0 × 35.6 cm). There were two samples for bending strength tests, two samples for dimension stability tests and twelve samples (2.0 × 2.0 in. (5.1 × 5.1 cm) for internal bond (IB) for each panel.

Statistical Analyses

Data of mechanical and physical properties and decay resistance were subjected to analysis of variance (ANOVA), to evaluate the effect of CCA-treated wood content in furnish of flakeboard. In mechanical and physical property tests, Group 5 with 100% untreated virgin wood content was considered as a control. Statistical significance of difference between the groups was analyzed at $\alpha = 0.05$ level.

RESULTS AND DISCUSSION

Mechanical and Physical Properties

The mechanical and physical properties of flakeboards are summarized in Table 1 and Table 2, respectively. The ANOVA did not detect statistical significant for modulys of rupture (MOR) or modulus of elasticity (MOE).

Panels with 100 percent untreated flakes had the highest MOR and MOE values. Although, the analysis of variance showed that the group effect resulted in no significant difference, the mean MOR and MOE values decrease as the CCA-treated flake proportion increases (Table 1). This trend agrees with previous finding (Boggio and Gertjejansen 1982, Clausen et al. 2001, Felton and De Groot 1996, Hall et al. 1982, Jeihooni et al. 1994, Lebow and Gjovik 2000, Munson and Kamdem 1998, Vick et al. 1996). Malony (1986) stated that flake geometry exerts the dominant control over bending strength. The relatively undamaged, long, flat flakes afforded boards higher bending strength. During the flakeboard manufacturing, it was visually observed that untreated virgin flakes have a rectangular flat shape and uniform size. However, the flakes from recycled CCA-treated guard rails generated more fine particles. According to the rule of mixture, the higher percentage of CCA-treated flakes a panel contains, the lower the bending strength of the panel. Therefore, the bending strength value should increase as the percent of CCA-treated flakes decreased from Group 1 to Group 5. In general, this trend was observed with the exception of Group 4.

There are several reasons to explain why flakes produced from guardrails contained more fines. Firstly, the wood was largely obtained from plantation, small diameter trees, which have higher percent of juvenile wood content. Juvenile wood is known to be less desirable for most processing operations, because of its lower density, physical and mechanical properties. Secondly, the guardrails, have been in service in exterior conditions for 13 years. The quality of the wood was degraded due to weathering. Lastly, the 24-hr. water soaking of the CCA-treated wood was not sufficient to soften the wood to produce high quality flakes.

The IB results are presented in Table 1. The ANOVA did reveal statistical significance for dry and ODVPS IB. Group 2, which contained 75% CCA-treated wood, had the lowest IB strength. These results differ from previous studies, which revealed similar trends for IB and bending strength (Boggio and Gertjejansen 1982, Clausen et al. 2001, Felton and De Groot 1996, Hall et al. 1982, Jeihooni et al. 1994, Lebow and Gjovik 2000, Munson and Kamdem 1998, Vick et al. 1996). Also, there is a relationship between the surface and volume ratio of flakes. In short, a greater flake surface area needs more adhesive for equivalent IB values.

Previous studies have also found that CCA interferes with the bonding properties of wood and adhesive. It is known that CCA-treated wood is incompatible with phenol-formaldehyde adhesives (Boggio and Gertjejansen 1982, Prasad et al. 1994, Vick and Christiansen 1993, Vick et al. 1990), and CCA-treated wood has limited available lumen space, which adversely affects bonding on fiber surfaces (Felton and De Groot 1996, Vick and Kuster 1992). The CCA treatment can also effect resin penetration and mobility, which will adversely affect panel bonding properties. Overall density and density distribution is another important effect factor on internal bond. Surprisingly and inexplicably, the IB strength with 100 percent CCA-treated flakes only had 5% reduction compared to those with 100 percent virgin flakes. It should be noted that the CCA furnish percents represent the amount of CCA-treated furnish and not the actual amount of CCA-treated wood due to the horizontal preservative gradient in the material. The entire guardrails were flaked, including the untreated inner core.

Thickness swell, linear expansion, and water absorption results are listed in Table 2. Thickness swell was statistically significant according to the ANOVA test. The ANOVA did not find any significant differences for linear expansion or water absorption. In general there was an increase of thickness swell as CCA-treated wood furnish content decreased. However, there were no discernable trends for linear expansion and water absorption with regards to CCA-treated wood furnish content. This results is partially consistent with previous study (Munson and Kamdem 1998)

CONCLUSIONS

It is clear that flakeboard made from recycled CCA-treated wood is technically feasible. As expected, most mechanical and physical properties improved as the percent of recycled treated wood in the furnish decreased. The intermediate ratio (50% : 50%) of recycled CCA-treated wood and virgin untreated wood did not substantially reduce the physical and mechanical properties of the panels. Moreover, research by Li et al (2004a, 2004b) has shown that this ratio gives satisfactory decay resistance and minimal leaching.

Future research will address the technical feasibility of developing composite poles for the telecommunication and utility industries from decommissioned preservative-treated wood. A separate on-going project is developing novel techniques to remove and reuse the metals from decommissioned CCA-treated wood. All efforts are part of a larger collaborative research program between the LSU AgCenter and the USDA Southern Research Station that seeks to establish an environmentally friendly and economically profitable closed-loop preservative-treated wood recycling program.

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TABLE 1. MECHANICAL PROPERTIES OF FLAKEBOARD MANUFACTURED WITH VARYING PERCENTAGES OF RECYCLED CCA-TREATED WOOD.

Group	Ratio[a]	IB[b] (psi)	MOR[c] (psi)	MOE[d] (1,000 psi)
1	100:0	85	4,441	673
2	75:25	65	4,894	693
3	50:50	74	5,137	721
4	25:75	72	4,743	700
5	0:100	89	5,803	773

[a]Ratio of CCA flakes vs. untreated flakes in percent.
[b]Internal bond.
[c]Modulus of rupture.
[d]Modulus of elasticity.

TABLE 2. PHYSICAL PROPETIES OF FLAKEBOARD MANUFACTURED WITH VARYING PERCENTAGES OF RECYCLED CCA-TREATED WOOD.

Group	Treatment	Ratio[a]	SG[b]	MC[c] (%)	Linear Expansion (%)	Thickness Swell (%)	Water Absorption (%)
1	Group 1	100:0	0.76	7.8	0.32	26.2	103
2	Group 2	75:25	0.76	7.6	0.31	28.4	100
3	Group 3	50:50	0.76	7.6	0.20	31.3	94
4	Group 4	25:75	0.76	7.3	0.26	33.2	98
5	Group 5	0:100	0.79	7.1	0.27	32.0	99

[a]Ratio of CCA flakes vs. untreated flakes in percent
[b]SG= specific gravity, oven dry based weight and air dry based volume.
[c]MC = moisture content at the time of testing.