EFFECT OF CCA-TREATING AND AIR-DRYING ON THE PROPERTIES OF SOUTHERN PINE LUMBER AND PLYWOOD[1]

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ABSTRACT

Matched samples of southern pine lumber and plywood were treated with CCA-preservative and then air-dried. When conditioned at the same relative humidity and temperature, the treated lumber and plywood had significantly higher moisture content than untreated samples. The CCA-treating and air-drying did not affect the bending and shear properties of lumber when retention level was 0.6 PCF. Compressive strength of treated lumber was reduced by 9% and it was attributed to the higher EMC associated with treated lumber. Bending and glueline properties of treated plywood were reduced by about 10% because of the increased EMC of treated material.

Keywords: Southern pine, plywood, CCA-treating, air-drying, bending, compression, shear, glueline shear, equilibrium moisture content.

The use of chromated copper arsenate (CCA) for treating lumber and plywood has increased in recent years. This is mainly due to the promotion of wood foundations and natural finish outdoor decks. An early study (Countryman 1957) indicated that CCA-treated Douglas-fir plywood with 1 pound per cubic foot (PCF) retention had slightly lower bending properties and glueline shear strength than untreated plywood. These reductions were attributed to higher equilibrium moisture content (EMC) of the treated material. A recent report (Barnes and Mitchell 1983) revealed that CCA-treated and kiln redried southern pine lumber with 0.3 PCF retention had a significant reduction in bending strength.

Most CCA-treating plants in this area use air-drying for treated material because of facilities and economic reasons. The air-drying takes place at the treating plant as well as on the construction site. The purpose of this study was to determine the effect of CCA-treating and air-drying on the properties of southern pine lumber and plywood. The matching sample technique was used to reduce the effect of material variation.

MATERIALS AND METHODS

Lumber

A total of fifteen No. 2 southern pine studs (nominal 2 in. by 4 in. by 8 ft long) was obtained from a local lumber yard. Each stud was cross-cut into six pieces (approximately 16 in. long), which were alternatively assigned, one for CCA-treatment and one for control (no treatment). The alternative assignment was used to minimize the effect of material variation within and among studs. The CCA-treatment was done at a commercial plant using type C CCA-preservative

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TABLE 1. *Density and equilibrium moisture content (EMC) of CCA-treated and untreated No. 2, 2 by 4 southern pine studs.*[1]

Stud no.	Density[2] (g/cm³)	EMC (%) at 50% RH, 75 F	
		CCA-treated	Untreated
1	0.53	12.97	12.78
2	0.61	13.05	10.45
3	0.54	12.74	11.08
4	0.59	13.24	9.07
5	0.60	13.26	10.24
6	0.48	13.00	9.75
7	0.47	13.08	9.13
8	0.48	13.15	11.09
9	0.52	12.91	11.17
10	0.48	13.04	10.13
11	0.64	13.55	12.22
12	0.51	13.32	12.68
13	0.52	13.57	11.94
14	0.59	13.00	10.48
15	0.46	13.14	9.85
Average	0.53	13.13	10.81
t-value		7.853**[3]	

[1] Each value is the average of 6 specimens.
[2] Density is based on oven-dry weight and volume at 75 F, 50% RH of untreated materials.
[3] ** designates highly significant difference (0.01 level).

with 1.4% concentration. The retentions were calculated by the weight gain method (Winandy et al. 1983). The target retention was 0.6 PCF, while the actual retention was 0.57 PCF.

After treating, a 3-week air-drying was followed immediately. The temperature ranged from 74 F to 102 F, and the relative humidity (RH) ranged from 30% to 90% during those three weeks in July and August. The air-drying reduced the moisture content from approximately 120% to 30%.

One static bending specimen, 2 compression specimens, and 2 shear specimens were then obtained from each piece of treated and untreated lumber, according to ASTM D 143—secondary methods (1978). The specimens were conditioned at 75 F, 50% RH until reaching constant weights. The mechanical tests were performed according to the same ASTM standard. The compression specimens were also used for density and EMC measurements.

Plywood

Five ½-in., 4-ply CDX southern pine plywood panels (4 ft by 8 ft) were used to obtain all the test specimens. Each plywood panel was first cut into six pieces measuring 24 in. wide by 32 in. long. One piece was assigned for control, while the adjacent piece was assigned for CCA-treatment. The treating was identical to that used for lumber. The actual CCA retention was 0.52 PCF. After treating, the plywood was air-dried for 3 weeks as previously described. Four bending specimens (6 in. wide by 32 in. long) were then cut from each piece of treated and untreated plywood. All bending specimens were conditioned to reach constant weights at 75 F, 50% RH. The bending test was then conducted according to ASTM D 3043—Method A (1978). From an undamaged portion of each bending

TABLE 2. *Compressive strength and shear strength of CCA-treated and untreated No. 2, 2 by 4 southern pine studs.*[1]

Stud no.	Compressive strength (psi)		Shear strength (psi)	
	CCA-treated	Untreated	CCA-treated	Untreated
1	6,506	6,425	1,328	1,331
2	7,224	8,176	1,477	1,731
3	7,293	7,102	1,502	1,618
4	5,977	7,658	1,845	1,640
5	5,824	6,634	1,819	1,845
6	6,191	6,812	1,395	1,513
7	6,010	6,640	1,502	1,500
8	4,641	5,237	1,494	1,596
9	6,376	7,029	1,481	1,405
10	4,939	5,982	1,521	1,529
11	8,138	8,948	2,141	1,849
12	5,773	5,356	1,666	1,484
13	5,554	5,429	1,506	1,398
14	7,034	8,502	1,539	1,428
15	5,664	6,530	1,474	1,615
Average	6,210	6,831	1,579	1,565
t-value	4.006**[2]		0.361[NS3]	

[1] Each value is the average of 6 specimens.
[2] ** designates highly significant difference (0.01 level).
[3] NS designates no significant difference.

specimen, three glueline shear specimens were prepared and tested according to ASTM D 906 (1978). One EMC specimen (6 in. by 6 in.) was also obtained from an undamaged portion of each bending specimen.

RESULTS AND DISCUSSION

Lumber

Table 1 presents the density and EMC of CCA-treated and untreated southern pine lumber. The average EMC of CCA-treated and untreated lumber are 13.13% and 10.81%, respectively. A t-test indicates that the difference in EMC is highly significant. The average compressive strength of CCA-treated southern pine is 9% lower than that of untreated lumber (Table 2). Again, a t-test reveals a highly significant difference. However, the reduction in compressive strength due to CCA-treating is attributed to the higher EMC of the treated material. The shear strength was apparently not affected by CCA-treating and air-drying (Table 2).

Bending properties are presented in Table 3. Neither modulus of elasticity (MOE) nor modulus of rupture (MOR) shows any significant difference between CCA-treated and untreated lumber. These results agree well with a most recent report (Bendtsen et al. 1983).

Plywood

Similar to the treated lumber, the treated plywood has a significantly higher EMC than untreated plywood (Table 4). It is concluded that CCA-treatment increases the hygroscopicity of southern pine lumber and plywood. Bending properties of CCA-treated and untreated plywood are listed in Table 5. The treated plywood has a 9.8% reduction in MOE and an 11.5% reduction in MOR. Ac-

TABLE 3. *Bending properties of CCA-treated and untreated No. 2, 2 by 4 southern pine studs.*[1]

Stud no.	Modulus of elasticity (1,000 psi)		Modules of rupture (psi)	
	CCA-treated	Untreated	CCA-treated	Untreated
1	1,370	1,318	12,700	12,300
2	1,270	1,566	11,300	12,700
3	1,485	1,486	11,700	13,800
4	1,138	1,287	10,500	14,500
5	736	1,028	9,900	11,700
6	1,341	1,180	12,000	9,100
7	1,336	1,358	11,100	12,600
8	826	903	9,300	11,300
9	1,513	1,692	12,300	14,000
10	1,328	822	11,300	8,500
11	2,088	2,033	17,300	18,000
12	908	1,293	10,200	11,800
13	967	1,012	9,700	10,100
14	1,748	1,660	14,700	17,300
15	1,177	1,143	10,500	10,300
Average	1,282	1,319	11,633	12,533
t-value	0.654[NS2]		1.863[NS]	

[1] Each value is the average of 3 specimens.
[2] NS designates no significant difference.

TABLE 4. *Density and equilibrium moisture content (EMC) of CCA-treated and untreated CDX southern pine plywood.*[1]

Panel no.	Density[2] (g/cm³)	EMC (%) at 50% RH, 75 F	
		CCA-treated	Untreated
1	0.576	12.02	8.49
2	0.575	12.14	8.50
3	0.575	11.48	8.42
4	0.565	12.12	8.22
5	0.577	11.54	7.97
Average	0.574	11.86	8.32
t-value		25.99**[3]	

[1] Each value is the average of 36 specimens.
[2] Density is based on oven-dry weight and volume at 50% RH, 75 F of untreated plywood.
[3] ** designates highly significant difference (0.01 level).

TABLE 5. *Bending properties of CCA-treated and untreated CDX southern pine plywood.*[1]

Panel no.	Modulus of elasticity			Modulus of rupture		
	CCA-treated (1,000 psi)	Untreated (1,000 psi)	Reduction (%)	CCA-treated (psi)	Untreated (psi)	Reduction (%)
1	1,242	1,405	11.6	6,400	7,800	17.9
2	710	812	12.6	4,000	4,100	2.4
3	1,081	1,147	5.8	4,600	5,000	8.0
4	961	1,086	11.5	5,400	6,200	12.9
5	981	1,065	7.9	5,000	5,600	10.7
Average	995	1,103	9.8	5,080	5,740	11.5
t-value	6,403**[2]			3.025*[3]		

[1] Each value is the average of 12 specimens.
[2] ** designates highly significant difference.
[3] * designates significant difference.

TABLE 6. *Glueline shear strength of CCA-treated and untreated CDX southern pine plywood.*[1]

Panel no.	Glueline shear strength			Wood failure	
	CCA-treated (psi)	Untreated (psi)	Reduction (%)	CCA-treated (%)	Untreated (%)
1	221	247	10.5	97	94
2	200	235	14.9	94	96
3	176	204	13.7	95	95
4	183	204	10.3	92	90
5	200	198	(1.0)	91	90
Average	196	218	9.9	94	93
t-value	3.421*[2]				

[1] Each value is the average of 36 specimens.
[2] * designates significant difference (0.05 level).

cording to an early report (Lee and Biblis 1979), southern pine plywood was reduced by 2% and 3.4% in MOE and MOR, respectively, for every 1% increase in MC. Therefore, the reductions in bending properties of CCA-treated plywood are mainly due to the increase in EMC of treated material. The glueline shear strength of treated plywood is reduced by 9.9% (Table 6). However, there is no reduction in percentage of wood failure.

CONCLUSIONS

The following conclusions can be drawn in regard to CCA-treating (0.6 PCF retention) and air-redrying:

1. CCA-treatment increases significantly the hygroscopicity of southern pine lumber and plywood.
2. CCA-treated southern pine lumber has equal shear strength, MOE, and MOR to those of untreated lumber. Although compressive strength of CCA-treated lumber is reduced by 9%, it is attributed to the higher EMC associated with treated material.
3. The MOE, MOR, and glueline shear strength of CCA-treated southern pine plywood are reduced by about 10%. These reductions are mainly due to the increase of EMC of treated material.
4. The glue bond itself shows no effect by the treatment.

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