Influence of short-term load duration and moisture content on the strength of CCA-treated lumber

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Abstract

Previous studies on the effects of preservative treatments on allowable design stresses have only evaluated the effects of CCA treatment at load durations of 60 to 200 seconds and at 12 percent moisture content (MC). Delineation of these relationships is needed by design engineers to define the effect of CCA treatments on bending strength. Thus, the influence of short-term load duration (3 to 6 sec., 30 to 60 sec., and 300 to 600 sec.) and MC at test (10%, 15%, and $\geq$ 40% (green)) on the effect of CCA preservative treatments on strength were studied.

Results show important differences in bending strength due to load application rate between No. 1 and Better untreated and CCA-treated southern pine 2 by 4s. This infers that existing design guidelines for duration of load which are based on untreated lumber should not be applied to CCA-treated lumber. The bending strength of CCA-treated lumber tested at 10 percent MC was 10 to 15 percent lower than matched untreated 2 by 4s. When tested at 15 percent MC, the treated 2 by 4s were about 5 to 12 percent lower in strength. When tested green, few differences were found between CCA-treated and untreated lumber.

Methods

The test material was 8-foot-long (2.3-m-long), No. 1 and Better southern pine nominal 2- by 4-inch (38 by 89-mm) lumber. The experiment employed a 3 × 3 × 2 factorial design. The factors were short-term load duration, moisture content (MC) at test, and CCA treatment.[1] The design had approximately 110 specimens per treatment / load duration / MC combination. The treated material was pressure-treated to a retention of 0.4 pcf (6.4 kg / m^3). Mechanical testing followed ASTM D 198 except for speed of load application.

Untreated results

For untreated material, the effect of load duration on the bending strength distribution is shown in Figure 1 for 10, 15, and 23 (green) percent MC. As load duration decreased from 300 to 600 seconds to 30 to 60 seconds, bending strength generally increased uniformly across the entire bending strength distribution at all MCs. As load duration decreased from 30 to 60 seconds to 3 to 6 seconds, bending strength again generally increased, with the exception of load duration of 3 to 6 seconds and 10 percent MC. As untreated lumber dried from 15 percent to 10 percent, it clearly lost its ability to absorb impact-type loads. Considering that the differential effect on strength between load durations of 30 to 90 seconds and 3 to 6 seconds, applicability of the load duration factor (C_D) for impact loads to untreated lumber at low MCs below 10 to 12 percent might be

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[1] Winandy, J.E. 1993. Effect of waterborne preservative treatments on allowable stress design values. Ch. 3. Influence of loading rate and moisture content on CCA treatment effects. Ph.D. thesis. Dept. of Forest Prod., Oregon State Univ., Corvallis, Oreg.

questioned, especially because of the uniformity of the strength loss across the entire MOR distribution at very short load duration. Furthermore, this uniformity of the effect of decreasing load duration across the bending strength distribution indicates that future studies for untreated materials need only address mean effects. This would greatly reduce the number of specimens required or increase the number of ancillary factors studied using the same number of specimens.

CCA-treated results

For CCA-treated material the load duration effect is quite significant. The effect of load duration on the bending strength distribution is shown in Figure 2 for 10, 15, and 23 (green) percent MC. As load duration decreases, bending strength is no longer uniformly affected across the entire bending strength distribution as it was with untreated material. In the upper half to three-quarters of the bending strength distribution, as load duration decreases, bending strength also increases. But in the lower quarter of the bending strength distribution there is no apparent increase in strength as load duration decreases.

Load duration factor

The lack of load duration-related or time-to-failure related increase in strength for 0.4 pcf (6.4 kg / m^3) CCA-treated 2 by 4 southern pine (Fig. 2) is different then has been shown for untreated material (Fig. 1). As CCA-treated lumber dries from 23 percent to 15 percent to 10 percent, a larger percentage of material losses its ability to absorb loads by rapidly disseminating internal stress away from the localized area of adjacent to the point of load application. When green, only the lower 10 percent of the MOR distribution fails to exhibit increased strength as load duration decreases, but by the time CCA-treated material is dried to 10 percent MC, well over 25 percent of the bending strength distribution fails to exhibit any time-dependent increase in strength. Because of the consistent lack of time-to-failure related strength increases through the lower 10 to 25 percent of the MOR distribution going from load duration of 300 to 600 seconds to 30 to 90 seconds to 3 to 6 seconds, applicability of the load duration factor (C_D) for impact loads to CCA-treated lumber at any CCA retention and at any MC must be questioned. Based on the consistent lack of strength increase exhibited in the lower tails of the bending strength distribution between load duration of 300 to 600 seconds and load duration 30 to 60 seconds and the fact that loads of this nature are dynamic,

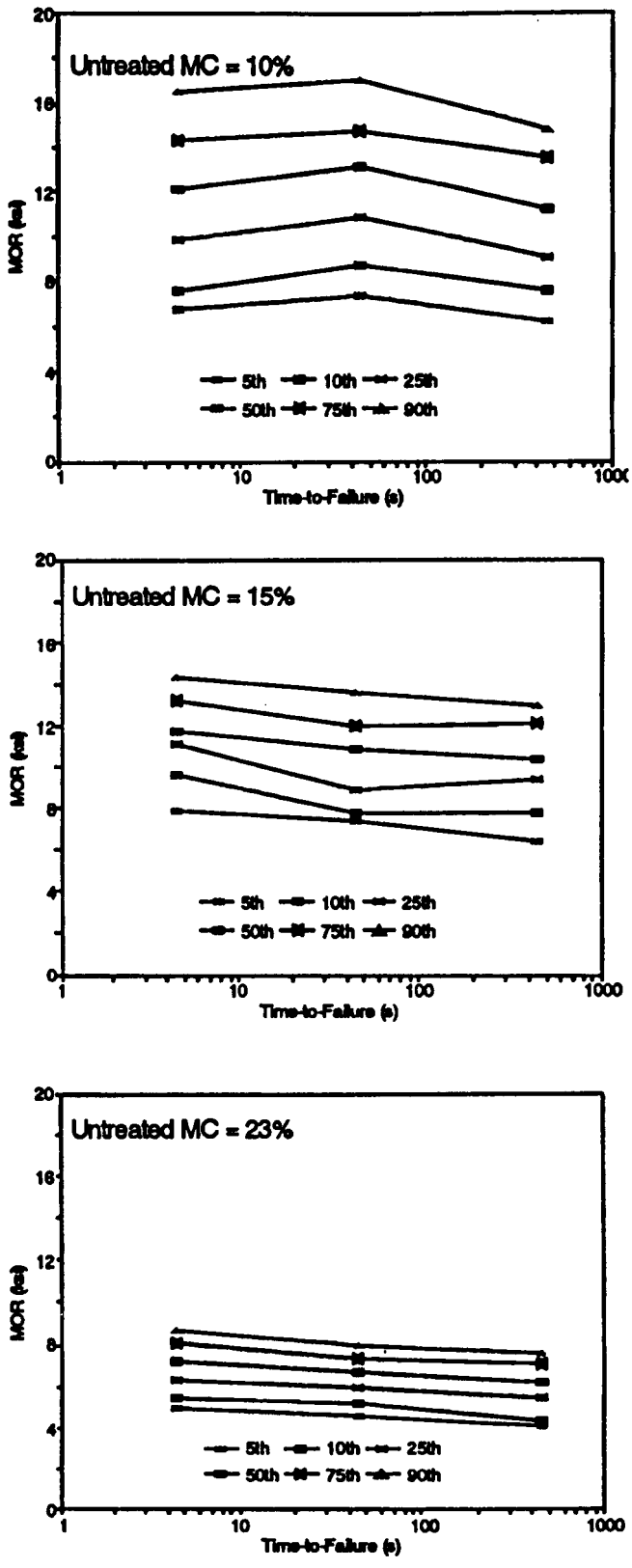

Figure 1. — *Effect of time-to-failure on bending strength of untreated southern pine 2 by 4s.*

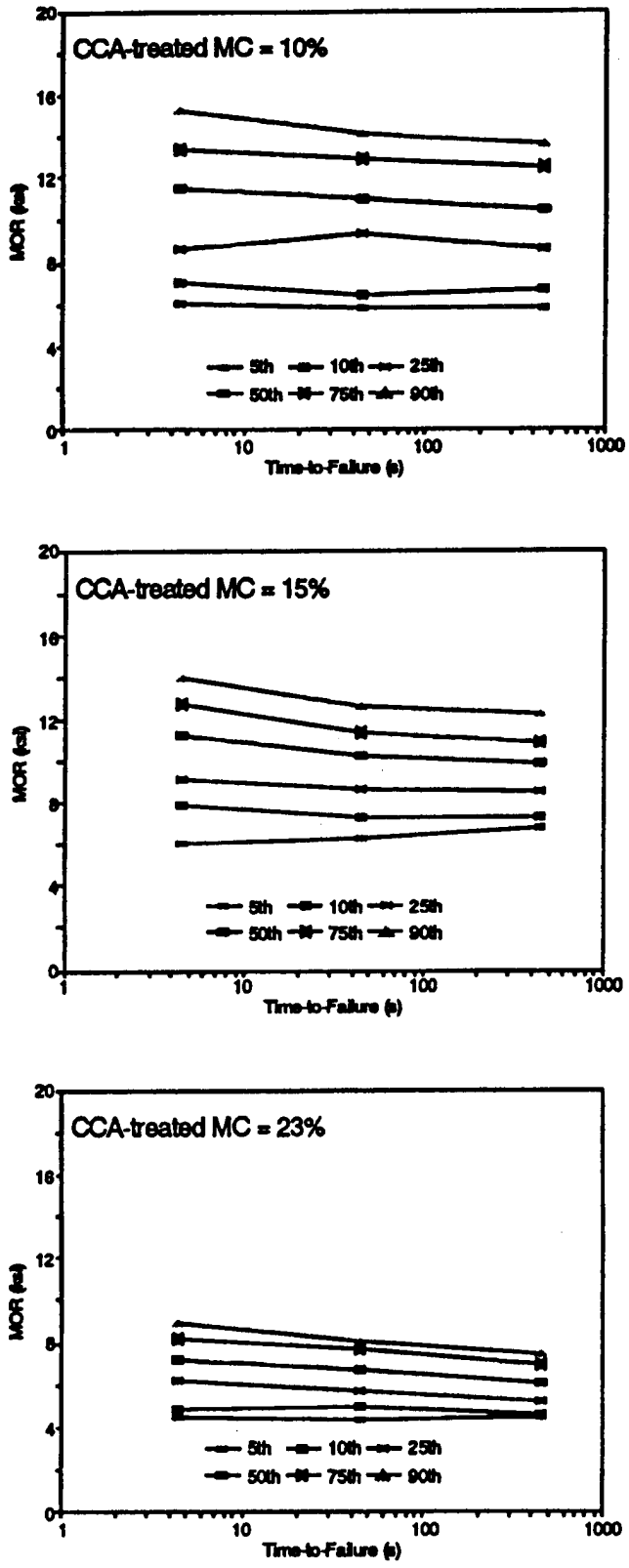

Figure 2. — *Effect of time-to-failure on bending strength of CCA-treated southern pine 2 by 4s.*

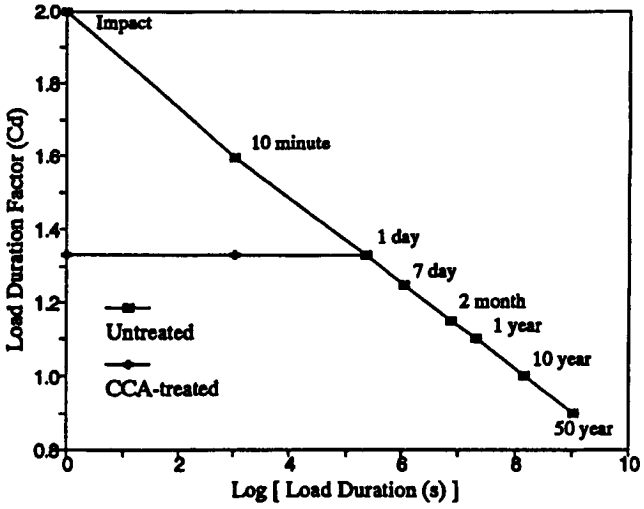

Figure 3. — *Proposed load duration model for CCA-treated lumber.*

the applicability of the load duration factor (C_D) for wind/earthquake loads (600 sec.) to CCA-treated material is questionable. A suggested modification to the existing load duration factor for CCA-treated lumber is shown in Figure 3.

Conclusions

1. The existing C_D factor may not apply to untreated lumber under impact loads at MCs of 10 percent or below.
2. The C_D factor should not be applied to CCA-treated lumber under impact loads at any MC.
3. Applicability of the C_D to CCA-treated material exposed to wind/earthquake loads might also be questioned.
4. A modified C_D factor may be needed for CCA-treated lumber regardless of grade.

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