

DEGRADATION OF CONVENTIONAL AND CO₂-INJECTED CEMENT-BONDED PARTICLEBOARD BY EXPOSURE TO FUNGI AND TERMITES

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DE SOUZA, M. R., GEIMER, R.L. & MOSLEMI, A.A. 1997. Degradation of conventional and CO₂-injected cement-bonded particleboard by exposure to fungi and termites. Low and high density cement-bonded particleboards (CBPs) made conventionally and with carbon dioxide (CO₂) injection were tested against white (*Trametes versicolor*) and brown rot fungi (*Postia placenta*). There was no measurable wood degradation (weight loss). After 12 weeks, the fungi were able to grow on the surface and interstitial spaces of the boards, despite the high alkalinity. Boards produced with the two fabrication processes (conventional and CO₂-injection), the two test conditions (aged and non-aged) and tested with both brown and white rot fungi, rather than weight loss, actually showed substantial weight gains. Similar boards were exposed to termites (*Reticulitermes flavipes*). All the termites died of starvation at the end of the test since they were unable to feed on cement boards. These two tests show that both conventional and CO₂-injected CBPs are very durable against the most common wood destroying organisms. Therefore, CPB is suitable for use in tropical countries where moisture is wood's greatest enemy.

Key words Wood - cement - particleboard - fungi - termites - durability

DE SOUZA M.R., GEIMER, R.L. & MOSLEMI, A.A. 1997. Degradasi papan serpai berikatan simen konvensional dan yang disuntik dengan CO₂ oleh kulat dan anai-anai. Papan serpai berikatan simen berketumpatan rendah dan tinggi yang dibuat secara konvensional dan dengan suntikan karbon dioksida telah diuji ketahanannya terhadap kulat reput putih (*Trametes versicolor*) dan kulat reput perang (*Postia placenta*). Degradasi kayu (kehilangan berat) tidak dapat dikesan. Selepas 12 minggu, kulat dapat tumbuh pada permukaan dan ruang antara sel papan walaupun pada kealkalian yang tinggi. Papan yang dihasilkan dengan kedua-dua proses (konvensional dan suntikan CO₂) dan diuji dengan kulat reput perang dan putih sebenarnya menunjukkan pertambahan berat yang cukup banyak dan bukannya kehilangan berat. Papan yang serupa juga didedahkan kepada anai-anai (*Reticulitermes flavipes*). Kesemua anai-anai mati kebuluran kerana tidak dapat memakan papan serpai simen. Kedua-dua ujian menunjukkan

bahawa papan serpai berikatan simen konvensional dan yang disuntik dengan CO₂ tahan kepada organisma perosak yang paling banyak terdapat pada kayu. Oleh itu papan serpai berikatan simen sesuai digunakan di negara tropika ki mana lembapan merupakan musuh utama kayu.

Introduction

The increasing use of wood composites mainly for structural purposes in building construction requires better understanding of their durability. Moisture, associated with fungi attack, accounts for most of the degradation in wood. Water is considered wood's worst enemy (Winandy & Morrell 1990). However, water, by itself, does not cause deterioration.

Fungi primarily use the cellulose, hemicellulose and lignin components of wood. Wood loses strength shortly after colonisation caused by a reduction in polymerisation of cellulose. Contrary to white rot, brown rot fungi cause degradation without degrading the lignin. However, lignin is modified (Highley & Illman 1991).

Cement-bonded particleboard (CBP) is a composite made primarily of cement, wood and small amounts of additives. Conventionally made CBP has all internal pH of above 12. This high pH is not favorable to brown rot fungi attack (Illman & Highley 1989). However, fungi have the ability of modifying their environment to create acceptable conditions for their growth. Also, CO₂-injected CBP has lower pH (average pH of 10) than the conventional ones. These two factors may show that CO₂-injected boards are prone to fungus attack.

Investigation of CBP degradation by fungi and termites is not very common. Some tests done in the UK suggest that conventionally made CBP is very resistant to attack by white and brown rot fungi as well as termites (Dinwoodie & Paxton 1991). In fact, the samples in a fungus test gained about 8% in mass which was attributed to carbonation of cement. However, samples of CBP buried for more than 30 years were found with a surface attack of soft and white rot fungi (Parameswaran & Broker 1979). No published information is available on the durability of CO₂-injected CBP. Investigation of aspen phenolic-bonded particleboards indicated a weight loss between 15 and 30%, depending on fungal species (Kamdem & Sean 1994).

The purpose of this study is to evaluate the durability of low and high density conventional and CO₂-injected aspen CBPs to white and brown rot fungi as well as termites.

Materials and Methods

Board preparation

Boards were produced in two densities (low and high density) and two treatments (conventional and CO₂ gas injection). Before board fabrication, all particles were soaked in water for 24 h and dried to reduce the concentration of water soluble sugars and tannins.

Low density board

Low-density CBPs measuring $660 \times 600 \times 25$ mm were fabricated to a specific gravity (SG) of 0.5. The boards were made using commercial aspen (*Populus* sp.) excelsiro 0.3×6 mm. The original particle, approximately 40 cm long, was reduced to 10 to 15 cm, to simplify blending and to achieve better cement coverage over the particles. Type I Portland cement was used as matrix (binder). Two types of boards were fabricated) i.e. conventional pressing using 2% calcium chloride (CaCl_2) and CO_2 gas injection pressing using 5% calcium hydroxide [$\text{Ca}(\text{OH})_2$]. All additives were based on cement weight. In the conventional system, boards were cold pressed to thickness and restrained by clamps for 24 h. For the CO_2 system, boards were pressed in a gas injection press with a sealed system using a gas pressure of 400 kPa. The gassing time was 220 s and pressing cycle 400 s. More information on CO_2 injection can be found in Souza (1992). All boards had similar wood/cement ratio of 0.5 and similar water/cement ratio of 0.6.

High density board

High density boards measuring $660 \times 600 \times 13$ mm thick were fabricated from aspen (*Populus* sp.) particles, to a SG of 1.2 based on oven-dried hydrated weight. Type I Portland cement was used as matrix.

Two types of boards were fabricated, i.e. conventional pressing using 2% CaCl_2 and CO_2 gas injection pressing using 5% $\text{Ca}(\text{OH})_2$. The conventionally pressed boards were fabricated to a wood/cement ratio of 0.25 and a water/cement ratio of 0.40. They were cold pressed to thickness and restrained by clamps for 24 h. The CO_2 -injected boards were made with similar wood/cement ratio but a water/cement ratio of only 0.25. They were cold pressed in a gas injection press with a sealed. system using a gas pressure of 600 kPa. Gassing time was 220 s and total pressing time 400 s.

The ageing process and testing

The boards were cured at 27 °C and 80% relative humidity (RH) for 28 days. Two sets of samples were cut from each board. One set was used for testing without exposure and the other was exposed to 21 cycles of accelerated ageing. Each cycle consisted of immersion in water at 20 °C for 24 h; freezing at -17 °C for 24 h; thawing for 2 h at 50 °C; and oven-drying at 100 °C for 22 h. This accelerated ageing regime was developed based on the works of Gram (1986) and adapted after exploratory work. After ageing, the specimens were conditioned at 21 °C and 67 % RH. A soil-block test was conducted according to ASTM D 2017-81 (ASTM 1981). Untreated aspen samples prepared from the same logs as the wood furnish used in the cement particles were included in each soil container as reference.

The samples were tested against cultures of *Tramete versicolor* (white rot) and *Postia placenta* (brown rot). An Analysis of Variance (ANOVA) was used to detect any difference between the fabrication processes (conventional and CO_2) and

test conditons (aged and on-aged) for both types of boards (low and high density). The two fungi were evaluated in a separate ANOVA.

The termite test was conducted for 12 weeks or until the termites died in a no-choice, forced-feeding system. Each board sample was placed in a simulated soil substrate, consisting of 6% vermiculite, 65% sand and 30% water with 100 *Reticulitermes flavipes* workers per container.

Results and discussion

The fungi test

After 12 weeks of exposure all samples are completely covered by fungal hyphae. Figure 1 shows the view of fungi growing on the surface of one of the test boards. They hyphae can grow over the board surface penetrating the voids without any difficulty. The high alkalinity of the boards is not a problem for fungal development (pH of 11.3 and 10.6 for conventional and and C O₂ boards respectively). Both low and high density boards, rather than wieght loss, show significant weight gains after 12 weeks of exposure (Figure 2 and 3). The fungi probably derived food from any wood particle not covered by cement. The control sample of aspen wood suffered high weight loss by both fungi (50 and 68% weight losses for white and brown rot respectively).

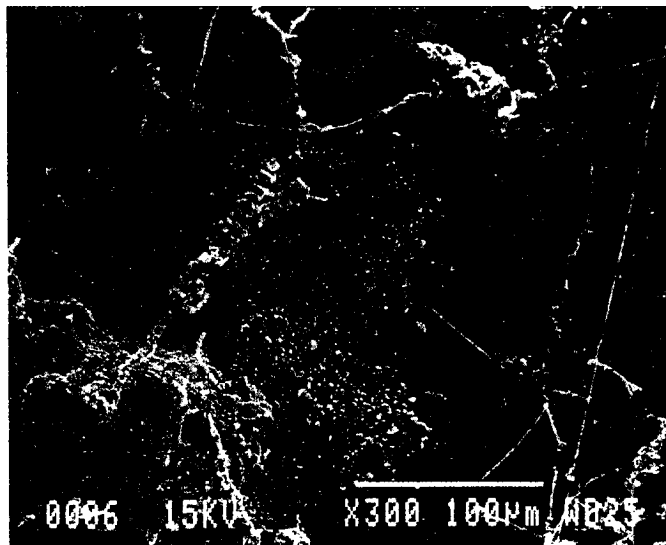


Figure 1. A brown rot (*Posita placenta*) hyphae penetrating the voids of a sample of low densitiy CBP

Figure 2 shows that conventional low density non-aged boards have higher weight gain than the CO₂-injected boards. Low-density non-aged boards show higher weight gain when exposed to the white rot fungus compared to the brown rot. Low-density aged boards were affected by the fungi without showing any definite pattern.

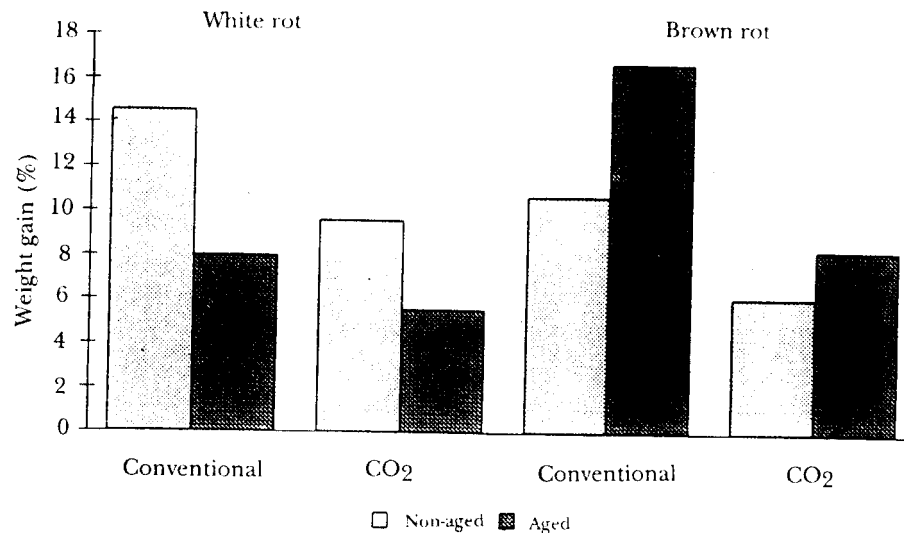


Figure 2. Results of a soil-block test of low density CBP

There is no significant difference in weight gain between the conventional and CO₂-injected high density boards (Figure 3). Neither is there any significant difference in weight gain between aged and non-aged boards (Figure 3). However, boards exposed to the white rot fungus show higher weight gain than those exposed to brown rot (Figure 3).

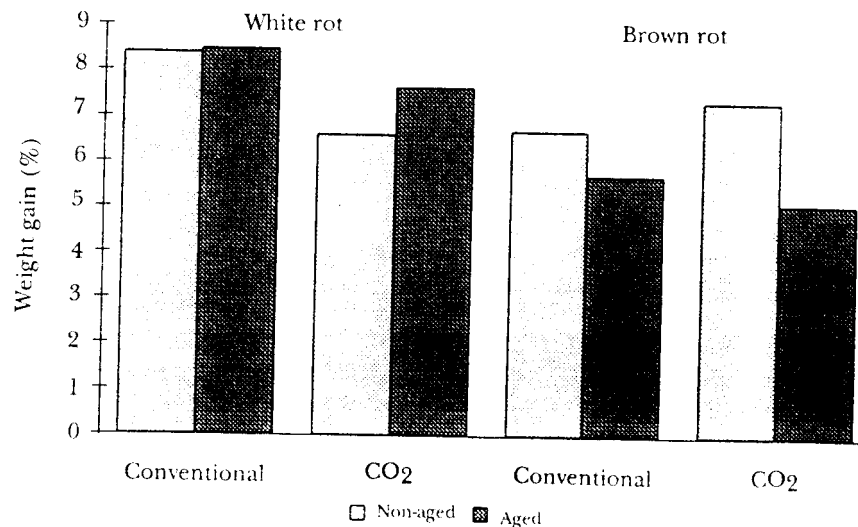


Figure 3. Results of a soil-block test of high density CBP

The termite test

By the end of the test all termites had died. Since termites could not feed on the cement boards, they were most likely to have died due to starvation, not toxicity of the board. In all replicates, termites could tunnel within and transport soil substrates into the composite test blocks. Samples of pure aspen wood placed with the board samples showed an average of 73% termite survival.

Conclusion

No measurable wood degradation (weight loss) occurs in CBPs when exposed to two wood-destroying Basidiomycetes in a soil-block test. The fungi are able to grow on the surface and interstitial spaces of the boards despite the high alkalinity.

Boards produced with the two fabrication processes (conventional and CO₂-injection), the two test conditions (aged and non-aged), and tested with brown and white rot fungi, show substantial weight gain instead of weight loss. The white rot fungus is associated with greater weight gain than the brown rot fungus.

Three hypotheses have arisen to explain these weight gains, i.e. (a) incorporation of CO₂ by the fungi, (b) incorporation of minerals by the fungi or (c) final curing of the cement.

In the termite test, the boards are found to be very resistant because there is no survival in all the treatments. Cement is not toxic to the termites, which evidently died of starvation.

The results suggest that CPB is suitable for use in tropical countries where moisture associated with fungi and termites is wood's greatest enemy.

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