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The susceptibility of oriented structural straw board (OSSB) to damage by subterranean wood-destroying and grass-feeding termites in Australia

James Hague[1], Damian Scown[1], Jim Creffield[2] and Michael Neal[3]

[1]Australian Forest Research Company Pty Ltd., 12 Wilton Crescent, Wheelers Hill, VIC 3150 Australia

[2]Onwood Entomology Pty Ltd., 22 Davis Drive, Mt. Eliza, VIC 3930 Australia

[3]Northern Territory Government, Department of Resources, Makagon Road, Berrimah, NT 0828, Australia

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IRG SECRETARIAT
Box 5609
SE-114 86 Stockholm
Sweden
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The susceptibility of oriented structural straw board (OSSB) to damage by subterranean wood-destroying and grass-feeding termites in Australia

James Hague[1], Damian Scown[1], Jim Creffield[2] and Michael Neal[3]

[1]Australian Forest Research Company Pty Ltd., 12 Wilton Crescent, Wheelers Hill, VIC 3150 Australia

[2]Onwood Entomology Pty Ltd., 22 Davis Drive, Mt. Eliza, VIC 3930 Australia

[3]Northern Territory Government, Department of Resources, Makagon Road, Berrimah, NT 0828, Australia

ABSTRACT

The field performance of untreated oriented structural straw board (OSSB) made from wheat straw was evaluated against two economically important Australian species of wood destroying subterranean termite, *Coptotermes acinaciformis* and *Mastotermes darwiniensis*, and two Australian species of grass-feeding subterranean termite, *Amitermes meridionalis* and *Nasutitermes triodiae*. Oriented strand board (OSB) made from both hardwood and softwood, and solid radiata pine sapwood, were included as reference materials. All OSSB test specimens were totally destroyed by *N. triodiae*. OSSB test specimens were heavily damaged by *M. darwiniensis* (mean loss of 75%), with half of the test specimens being totally destroyed. Approximately a third of the OSSB test specimens were consumed by *C. acinaciformis*, supporting previously published data for the susceptibility of OSSB against the *Coptotermes* genus from laboratory studies against *C. formosanus*. *M. darwiniensis* largely consumed or totally destroyed test specimens from all three of the wood-based reference samples. *C. acinaciformis* displayed a distinct preference for the radiata pine sapwood, with five of the six test specimens being almost totally consumed; damage to the OSB test specimens was limited. Similar limited damage was also observed in the OSB test specimens when exposed to the grass-feeding *N. triodiae*, but one colony of *N. triodiae* almost totally consumed a single radiata pine sapwood test specimen, resulting in a mean mass loss of 20% for the radiata pine sapwood test specimens. The results of the study suggest that OSSB is potentially highly susceptible to damage by at least some grass-feeding and wood destroying subterranean termite species. Furthermore, the results suggest that softwood sapwood may also potentially be susceptible to damage by at least some grass-feeding subterranean termites.

Keywords: *Amitermes meridionalis*, *Coptotermes acinaciformis*, *Mastotermes darwiniensis*, *Nasutitermes triodiae*, OSSB, termites

1. INTRODUCTION

Oriented structural (split) straw board (OSSB) is a structural composite panel manufactured from the cut, split stems of cereal crops (e.g. wheat, barley etc.). It is manufactured by first applying a thermosetting adhesive (isocyanate) to the surfaces of the prepared straw particles. The particles are then formed into a mattress in three discrete layers, with the longitudinal axis of the particles oriented predominantly in one direction in each layer, with the orientation of particles in adjacent layers being perpendicular. In order to achieve the required minimum strength and stiffness properties of a structural panel, a key requirement of the product is to ensure that the average length of the split straw particles is of the order of 40 mm or greater. OSSB was originally developed by Alberta Research Council (now Alberta Innovates Technology Futures) in Canada in the 1990's, with the technology being patented in 1999. A full-scale production plant to manufacture the product was built and commissioned in China in 2009.

Han *et al* (2011, 2012) postulated that straw-based composite materials are likely to be more susceptible to degradation by biodeteriogens owing to the chemical composition of cereal straws, with such materials typically being comprised of markedly higher proportions of water-soluble carbohydrates (hemicelluloses) compared with wood (Staniforth 1980). In laboratory studies, Han *et al* (2011, 2012) demonstrated that untreated OSSB was indeed highly susceptible to mould growth, incurred up to 70% mass loss when exposed to certain fungi (e.g. *Trametes versicolor* (L.) Lloyd) and was moderately attacked by the Formosan termite (*Coptotermes formosanus* Shiraki). Addition of the biocide zinc borate to the product during its manufacture appeared to provide adequate protection against both the fungi and *C. formosanus* at biocide addition rates of around 1.5% m/m.

The laboratory testing of OSSB reported by Han *et al* (2011, 2012) against *C. formosanus* was conducted in accordance with AWPA E1-97 Standard Method for Laboratory Evaluation to Determine Resistance to Subterranean Termites (AWPA 1997). Test specimens were exposed to 400 individual insects in a 'no choice' test for a period of 28 days. Whilst the data are interesting, representing the only known published information on the performance of OSSB against an economically important species of subterranean termite, they do not however necessarily give an indication of the likely performance of the product when exposed against subterranean termites in the field for longer periods of time. Furthermore, there is no information available in the literature on the potential susceptibility of OSSB, manufactured from a form of 'grass' rather than wood, to damage by grass-feeding termite species.

The work reported here aimed to determine the field performance of untreated OSSB against two economically important Australian species of wood destroying subterranean termite, *Coptotermes acinaciformis* (Froggatt) and *Mastotermes darwiniensis* Froggatt, and two Australian species of grass-feeding subterranean termite, *Amitermes meridionalis* Froggatt and *Nasutitermes triodiae* (Froggatt).

2. MATERIALS AND METHODS

2.1 Materials

The OSSB sample was manufactured in the laboratories of Alberta Innovates Technology Futures from cut, split wheat straw and 5% diphenylmethane diisocyanate (pMDI) resin. Finished panels were 12 mm thick with a density of approximately 530 kg/m^3.

The performance of the OSSB was compared with that of two samples of commercially manufactured oriented strand board (OSB), one comprised of softwood flakes (7.5 mm thick, density approximately 500 kg/m^3) and the other of hardwood flakes (10 mm thick, density approximately 660 kg/m^3), and radiata pine (*Pinus radiata* D. Don) sapwood (density approximately 470 kg/m^3). All three of the wood-based reference samples were sourced from a building materials supplier in Melbourne, Australia.

Test specimens were prepared from the four samples such that their volumes were approximately 57 cm^3. The OSSB and radiata pine sapwood test specimens measured 100 x 48 x 12 mm. The softwood OSB test specimens measured 100 x 76 x 7.5 mm. The hardwood OSB test specimens measured 100 x 58 x 10 mm. All test specimens were labelled with stainless steel tags, attached with brass boat nails. Prior to exposure in the field, test specimens were artificially weathered in vacuum ovens for five days at 40°C and 0.05 mBar to remove any residual volatiles, as specified in the AWPC Protocols for Assessment of Wood Preservatives (2007) for Hazard Class H2 exposure conditions (inside, aboveground).

2.2 Test Termites

Half of the prepared test specimens were exposed to two of Australia's most economically important subterranean wood destroying termite species, *C. acinaciformis* and *M. darwiniensis* (the giant northern termite). *C. acinaciformis* is widely distributed throughout mainland Australia and is responsible for greater economic loss than all the other Australian species of termites combined (Gay and Calaby 1970). North of the Tropic of Capricorn, *C. acinaciformis* builds aboveground mounds. *M. darwiniensis* is a tropical species; the southern limit of its distribution approximates to the Tropic of Capricorn, both in coastal and inland localities. In this zone it is by far the most destructive termite (Gay and Calaby 1970). *M. darwiniensis* is a non-mound builder.

The remaining half of the prepared test specimens were exposed to two of Australia's 'iconic' subterranean grass-feeding termite species, *A. meridionalis* (the magnetic termite) and *N. triodiae* (the Spinifex termite). Both are mound builders and are tropical species. *A. meridionalis* is confined to a region within a radius of approximately 50 km from Darwin in the Northern Territory, Australia. *N. triodiae* is more widely distributed across the northern half of Australia, with a similar distribution to that of *M. darwiniensis* (Gay and Calaby 1970, Watson and Abbey 1993).

2.3 Installation of Field Trials

Six replicate test specimens of each sample were exposed in the field trials against six different colonies of each target termite species. The exposure period was six months.

The test methodology used to install the field trials against *C. acinaciformis* and *M. darwiniensis* was in accordance with that specified in the AWPC Protocols for Assessment of Wood Preservatives (2007). Test specimens were contained within stainless steel exposure containers with equal volumes of susceptible bait-wood, the latter present in order to attract and maintain the presence of the target termite species. Exposure containers were connected to active galleries of *C. acinaciformis* and *M. darwiniensis*, and removed from the field once all susceptible material had been consumed and termites had vacated the chambers.

A modified form of the 'lunch-box' method, as specified in the AWPC Protocols for Assessment of Wood Preservatives (2007), was used to install the field trials against *A. meridionalis* and *N. triodiae*. Termite galleries were exposed close to the bases of mounds by 'spading' i.e. skimming the surface of the soil with a spade to remove successive thin layers of soil until active galleries were revealed. Sections of perforated rubber mat (approximately 20 mm thick) were then placed over the exposed galleries, and one test specimen of each sample placed on each mat section's upper surface. The assembly was then enclosed with an upturned plastic container; the latter was in turn covered with a piece of durable plastic sheeting, and the whole assembly covered with soil. The adopted approach varied from that specified in the AWPC Protocols (2007) in that it did not incorporate any susceptible bait materials in order to attract and maintain the presence of foraging termites of the target species.

The test site for exposure of samples to *C. acinaciformis* and *A. meridionalis* was located at Humpty Doo, Northern Territory, Australia. Exposure of samples to *M. darwiniensis* was at both the Humpty Doo test site and at a test site located at Kowandi, Northern Territory, Australia. Exposure of samples to *N. triodiae* was at a test site located at Palmerston, Northern Territory, Australia.

2.4 Evaluation of Results

Mean percentage mass loss of test specimens of each sample was used as the criterion for determining the relative susceptibility of each sample to damage by each of the target termite species.

3. RESULTS AND DISCUSSION

All exposure containers were checked approximately four weeks after their installation. It was evident that all of those exposed to *C. acinaciformis*, *M. darwiniensis* and *N. triodiae* had 'struck' i.e. the sample / bait-wood assemblies were heavily mudded and termites were observed to be actively foraging within the exposure containers. In contrast, there was no evidence of mudding or foraging termites in the exposure containers targeting *A. meridionalis*; termites of the target species had clearly declined to forage over the offered timber- and straw-based substrates and had sealed off the exposed galleries. Accordingly, active galleries were re-exposed using the 'spading' method, and the mat / test specimen / exposure container assemblies were re-set as described in section 2.3.

At the conclusion of the field trials, all test specimens within the exposure containers exposed to *C. acinaciformis, M. darwiniensis* and *N. triodiae* had evidence of contact by the target species of termite. All untreated bait-wood in the exposure containers targeting *C. acinaciformis* and *M. darwiniensis* had been destroyed; there was also heavy mudding and faecal spotting on all remaining test specimens exposed to all three termite species. In contrast, there was only evidence that termites had contacted one of the six sets of test specimens exposed to *A. meridionalis*; mudding on the single set of test specimens was moderate, and termites had vacated the exposure container.

A summary of the mean mass loss data for test materials exposed for six months against *C. acinaciformis*, *M. darwiniensis* and *N. triodiae* in the Hazard Class H2 field trials is given in Table 1.

Table 1: Mean mass loss of test specimens after exposure to *C. acinaciformis*, *M. darwiniensis* and *N. triodiae* in Hazard Class H2 field trials.

Termite Species	Material Type	Mean mass loss [g]	Mean mass loss [%]
C. acinaciformis	OSSB	10.03	33.9
	Softwood OSB	1.53	5.9
	Hardwood OSB	2.01	5.1
	Radiata pine sapwood	20.82	81.5
M. darwiniensis	OSSB	23.40	74.9
	Softwood OSB	26.09	97.4
	Hardwood OSB	33.01	91.2
	Radiata pine sapwood	26.75	93.5
N. triodiae	OSSB	28.54	100.0
	Softwood OSB	2.23	8.2
	Hardwood OSB	2.86	7.4
	Radiata pine sapwood	5.59	20.5

The OSSB sample was clearly highly susceptible to attack by the grass-feeding *N. triodiae*, with all six test specimens being completely consumed, leaving only the stainless steel labels and brass boat nails. The OSSB sample was also heavily damaged by *M. darwiniensis*, incurring a mean loss of 75%, with three test specimens being destroyed. Around a third of the OSSB sample was consumed by *C. acinaciformis*, which is similar to the level attack reported by Han *et al* (2011, 2012) in laboratory studies against *C. formosanus*.

M. darwiniensis demonstrated its well known and documented (Gay and Calaby 1970) voracious nature in largely consuming or totally destroying all three of the wood-based samples. In contrast, *C. acinaciformis* displayed a distinct preference for the radiata pine sapwood, with five of the six test specimens being almost totally consumed. Damage to the OSB samples was generally limited to minor nibbling or surface grazing. Interestingly, the OSB samples were similarly damaged by the grass-feeding *N. triodiae*, whilst one colony of *N. triodiae* almost totally consumed a radiata pine sapwood test specimen (98% mass loss).

It is believed that the difficulty in establishing reliable contact with colonies of *A. meridionalis* compared with *N. triodiae* may be linked in part to two factors. Firstly the relative activity of the two species was noticeably different. When galleries of *N. triodiae* were exposed by the 'spading' method, numerous workers and soldiers poured out of the exposed galleries, and many insects were observed to be foraging over the test specimens immediately after they were placed on the mat sections. In contrast, when galleries of *A. meridionalis* were exposed, relatively few slow moving workers were revealed, and no soldiers were observed, which is in agreement with observations reported by Hill (1942). Secondly, whilst *A. meridionalis* is often considered to be a 'grass-feeder' (rather than a wood-feeder), a number of researchers have noted that although grass does form part of the diet of *A. meridionalis*, its diet also comprises 'small pieces of herbage and finely ground vegetable debris' (Gay and Calaby 1970, Hill 1942, Peters *et al* 1996). Accordingly, the straw- and wood-based substrates offered to *A. meridionalis* may well have been less attractive as potential food sources compared with the other three termite species targeted in this study.

Whilst only one of the six sets of test specimens were contacted by *A. meridionalis*, it is worth noting that the single colony consumed approximately 40% of the OSSB test specimen and 50% of the radiata pine sapwood test specimen. Damage to the OSB test specimens was similar to that observed for *C. acinaciformis* and *N. triodiae*.

4. CONCLUSIONS

The work reported here has demonstrated that untreated OSSB manufactured from wheat straw is potentially highly susceptible to damage by at least one species of grass-feeding subterranean termite. In addition, untreated OSSB has been shown to be markedly susceptible to damage by one of Australia's principle species of wood destroying subterranean termite, *M. darwiniensis*. The results of the study also appear to support those of previous workers (Han *et al* 2011, 2012), namely that untreated OSSB is moderately susceptible to damage by termites of the *Coptotermes* genus. An interesting observation from the study was that untreated softwood sapwood was also potentially susceptible to damage by grass-feeding subterranean termites.

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