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REPORT ON DURABILITY OF MAICA'S COMPACT LAMINATES AGAINST SUBTERRANEAN TERMITES COMPARED TO SOFTWOOD, HARDWOOD AND PARTICLEBOARD

For:

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By:

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1.0 INTRODUCTION

1.1 The **Forest Research Institute Malaysia (FRIM)** was requested by **Maica Laminates Sdn Bhd** to conduct termite resistance test of the product, Maica's Compact Laminates (MCL) and compared the result with softwood, hardwood and particleboard.

1.2 Two test were conducted based on the following standard:

1.2.1 Laboratory test following ASTM D3345-74 (reapproved 1999) "Laboratory Evaluation of Wood and Other Cellulosic Materials for Resistance to Termites".

1.2.2 Field test following FRIM Working Procedure (PK) A1 "Test Method for Determining The Relative Effectiveness of Wood Above Ground Contact"

1.3 This joint expert opinion is put forward by the following:

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2.0 OBJECTIVE

Objective of this project were;

(i) To determine the resistance of MCL against subterranean termite attack under local condition.

(ii) To analyze the degree of subterranean termite attack to MCL compared to other wood (softwood, hardwood and particleboard) under local condition.

3.0 SCOPE OF WORK

The scopes of work undertaken by each party for this project are as follow;

FRIM

i. FRIM experts will undertake the tests.
ii. FRIM experts will evaluate the documents and any samples provided.
iii. FRIM experts will provide their professional opinion on the possible degradation of quality that can happen under the problem situation and give scientific explaination and justification for their opinion.
iv. FRIM experts will provide a written report on the result from the study to Maica Compact Laminates Sdn Bhd.

Clients

i. Maica Compact Laminates Sdn Bhd agrees to provide the financial support for the project.
ii. Maica Compact Laminates Sdn Bhd agrees to provide the necessary information about the tested product.

iii. Maica Compact Laminates Sdn Bhd agrees that the test conducted were based on laboratory and field test for resistance against subterranean termites for Maica's Compact Laminate sample. In addition, a representative wood sample from hardwood (rubberwood), softwood (pinewood) and particleboard were used as comparison to Maica's product.

4.0 FINANCIAL CONTRIBUTIONS

Maica Compact Laminates Sdn Bhd agrees to contribute the amount of **RM9,000 (Malaysia Ringgit Nine Thousand only)** for the whole duration of the project to cover for project expanses. This includes cost of materials, test charges, fees for staffs, travelling and other miscellaneous purchases made by FRIM researchers.

5.0 MATERIALS AND METHODS

5.1 Laboratory Test

5.1.1 Preparation of test blocks

All the test wood was converted into cubic blocks of dimensions (19x19x19) mm. A total of ten (10) blocks for each tested woods were used as replicates. Softwood from **pinewood** (*Pinus* sp.), **rubberwood** (*Hevea brasiliensis*) as the hardwood and particleboard were used in this test as comparison with MCL. All test blocks were oven dried overnight at 105°C prior to the test and weighted to a constant weight.

5.1.2 Subterranean Termites

For this test, subterranean termite of the species *Coptotermes gestroi* was used. Termites were collected from around FRIM's premises by trapping at the identified termite colonies. Collected termites were fed with blotting papers for three days and those unhealthy and inactive individuals observed during the period were eliminated.

5.1.3 Test Blocks Arrangement

Two test blocks were placed inside a jar measuring 8 cm in diameter and 13 cm in height. A total of five jars were used in this test for each tested wood (MCL, softwood, hardwood and particleboard). Sterilized sands (200g) with 30ml of distilled water were added inside each test jars. Approximately 1g of termites, consisting of 360 workers and 40 soldiers were then added inside each test jars. All the jars were kept inside the incubation chamber room at 25 ±1°C and 65±2% relative humidity during the 4 weeks test duration.

5.1.4 Test Duration

The test was conducted for 4 weeks which commenced on 28 May 2009 and ended on 25 June 2009.

5.1.5 Monitoring Testing Progress

Three criteria, which were done at the end of the 4 weeks test duration, were used for efficacy evaluation against subterranean attack of the test blocks:

1. Visual rating

   These qualitative criteria will be evaluated based on the visual inspection as stated in ASTM D3345-74 (Reapproved 1999) below:

Rating	Description
10	Sound, surface nibbles permitted
9	Light attack
7	Moderate attack, penetration
4	Heavy
0	Failure

2. Weight loss (g)

3. Percentage (%) of weight loss

4. Termite mortality **(%)**

Rating	Description
100%	Complete
67-99%	Heavy
34-66%	Moderate
0-33%	Slight

5.2 Field Test

5.2.1 Test Plot

The test site was located inside FRIM's premises where there was obvious presence of the subterranean termite's colony and high humidity area (RH 70-90%). The site must be undisturbed, level natural area with fertile soil of uniform important soil properties (i.e. pH, texture, organic matter content, moisture holding capacity).

5.2.2 Test Blocks

Test blocks will be converted to (40x100) mm wood stake. It shall be free of defects and shall show no evidence of mold, stain, decay or insect attack. Twenty samples of each tested wood (MCL, softwood and hardwood) will be used at the test plot. Softwood from pine wood (*Pinus* sp.) and rubber wood (*Hevea brasiliensis*) as the hardwood and particleboard made of oil palm fibers were used in this test as comparison with MCL.

5.2.3 Test Blocks Arrangement

Each of the wood test blocks (MCL, softwood and hardwood) will be randomly arranged inside a 20L steel drum at the high humidity field test site. At the bottom of the drum, a layer of highly susceptible timber substrate (e.g. rubber wood, *Hevea brasilliensis*) with dimension of (12x120x140) mm, which has been dipped in the water overnight, shall be tightly packed on their ends.

The test blocks will be place on top of a galvanized weld mesh (25 mm square opening) with another susceptible timber substrate place in between of the test block.

5.2.4 Test Duration

The test was conducted for 16 weeks which commenced on 5 June 2009 and ended on 25 September 2009.

5.2.5 Inspection of Test Blocks

All test block was inspected on biweekly basis during the 16 weeks test duration. At the end of the test, the drums were dissembled and the blocks removed and cleaned, using small brush and rinsed with distilled water (if necessary) to remove sand. Test blocks were evaluated as follow:

1. Each test blocks were examined according to the visual rating:

Rating	Description
0	Sound
1	Trace attack
2	Slight attack
3	Moderate attack, penetration
4	Severe attack
5	Failure by termite attack

2. Actual (mg) change in dry mass of the block at end of test.

3. Percentage (%) change in dry mass of block at end of test.

5.3 Data analysis

Mean changes in block masses for each tested variable were statistically analyzed using analysis of variance (ANOVA).

6.0 RESULTS AND OBSERVATION

Result for accelerated laboratory test against subterranean termites (*Coptotermes gestroi*) and field test for Maica's Compact Laminates (MCL), rubberwood (hardwood), pinewood (softwood) and particleboard was shown below in Table 6.1 and 6.2 respectively.

Table 6.1 Evaluation on resistance of subterranean termites against Maica's Compact Laminates (MCL), rubberwood, pinewood and particleboard during laboratory test[1].

Test type	Sample	Termite bioassay				
		Weight loss (g)	Percentage of weight loss (%)	Density (g/cm^3)	Average visual rating[2]	Termite mortality[3]
Lab test	Maica's Compact Laminate (MCL)	0.01 (0.001)	0.104a (0.013)	1.381 (0.032)	10	Complete
	Rubberwood	0.257 (0.060)	6.476c (1.650)	0.673 (0.036)	7	Slight
	Pinewood	0.081 (0.082)	2.330b (1.783)	0.548 (0.140)	7	Slight
	Particleboard	0.426 (0.107)	12.975d (3.707)	0.670 (0.009)	7	Moderate

[1]Each value represents the means of 10 replications. Values in parentheses are standard deviations.

[2]Termite attack rating scale: 0, failure; 4, heavy; 7, moderate; 9, light; and 10, sound.

[3]Termite mortality rating: 100%, complete; 67-99%, heavy; 34-66%, moderate; and 0-33%, slight.

Mean value for percentage of weight loss (%) by the same letter are not significantly ($P<0.05$) different according to Bonferroni-Holm posthoc test following ANOVA.

Table 6.2 Evaluation on resistance of subterranean termites against Maica's Compact Laminates (MCL), rubberwood, pinewood and particleboard during field test[1].

Test type	Sample	Termite bioassay			
		Weight loss (g)	Percentage of weight loss (%)	Density (g/cm^3)	Average visual rating[2]
Field test	Maica's Compact Laminate (MCL)	0.883 (0.072)	0.843a (0.070)	1.409 (0.005)	0
	Rubberwood	8.373 (6.288)	24.161b (22.420)	0.657 (0.009)	2
	Pinewood	0.501 (0.419)	1.125a (0.902)	0.580 (0.094)	0
	Particleboard	7.722 (2.356)	25.8b (9.951)	0.678 (0.008)	2

[1]Each value represents the means of 10 replications. Values in parentheses are standard deviations.

[2]Termite attack rating scale: 0, sound; 1, trace attack; 2, slight attack; 3, moderate attack, penetration; 4, severe attack and 5, failure by termite attack.

Mean value for percentage of weight loss (%) by the same letter are not significantly ($P<0.05$) different according to Bonferroni-Holm posthoc test following ANOVA.

6.1 Weight Loss

Mean weight loss percentage for Maica's Compact Laminates (MCL) was the lowest among the four tested woods for both lab test and field test with only 0.104% and 0.843% weight loss respectively. Particleboard had the highest weight loss for both lab test (12.98%) and field test (25.8%) (Figure 6.1). Statistical analysis on the mean weight loss (%) showed significant differences between all four tested woods [F= 65.85 (3, 36), p= 1.09E-14] for lab test as a result of termite feeding. Significant differences were also detected for field test [F= 12.78 (3, 36), p= 7.70E-06] except between MCL and pinewood, and between rubberwood and particleboard.

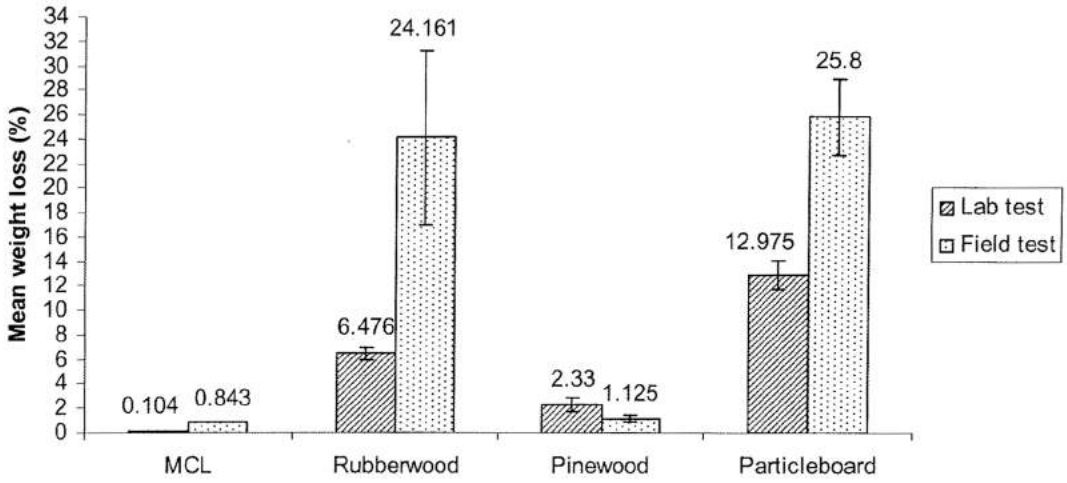

Figure 6.1 Weight loss percentages (%) for MCL, rubberwood, pinewood and particleboard for lab test and field test.

The result showed that MCL was the most resistant to termites among the four tested woods with the lowest weight loss in both lab and field test (Figure 6.1). Various factors may affect termites feeding behavior. Among them are wood species and hardness, presence of toxic substances, feeding inhibitors or deterrents, presence or absence of fungi, degree of fungal attack, and moisture content of wood and soil (Symthe et al. 1971, Carter & Smythe 1974, Nagnan & Clement 1990).

During the lab test and field test, some of the test blocks, especially those of rubberwood and particleboard (Figure 6.1), were found to be infested by fungi which caused the wood to decay and discoloration. During the decay process, fungi released enzymes that change the chemical composition of the wood resulting in reduction of strength and weight loss. Presence of fungi might also increase termites feeding on the wood.

A study on the eastern subterranean termites, *Reticulitermes flavipes*, showed its preferences to decayed wood with 1.4 to 2.0 times of feeding rate than those of nondecayed wood from the same species (Smythe et al. 1971).

Another important factor that might affect termite attack on the wood is the density or specific gravity (SG) of the wood. SG is an index of the amount of wood substance in a piece of wood, and the changes in SG of the samples were measured on the basis of oven-dry weight in order to estimate percentage of weight loss due to exposure. According to Arongo et al. (2004), natural resistance of wood to termite attack correlates with wood species that have higher SG than others. In this study, MCL have the highest density than the other tested woods (Table 6.1 & Table 6.2) which might decrease the ability of termites to feed on the wood. However, pinewood which has the lowest density was ranked second lowest in term of weight loss. This might be due to the presence of various components known to exist in pinewood that act as insecticides and are toxic to insects such as termites (Lemaire 1991, Nagnan & Clement 1990).

It is also interesting to note that unlike other wood tested in this study, the weight loss for pinewood during lab test was found to be more than those during field test (Figure 6.1). More weight loss was usually expected during field test compared to field test due to the longer time span for field test and exposure to more biodegradation agents. This might be caused by variation on the repellent effect that the pinewood might have on different termite species found on field test compared to only one species of termite (i.e. *C. gestroi*) used in the lab test.

6.2 Visual Rating

Average visual rating for MCL was rated as 10 (sound attack by termites) while the other three tested wood were rated as 7 (moderate attack) for laboratory test (Figure 6.1). Wood tunnels and holes due to termite feeding were visibly seen on the surface of the pinewood, rubberwood and particleboard test blocks. Particleboard test blocks were severely attacked by fungi within two to three weeks of the lab test which increases weight loss of the test blocks.

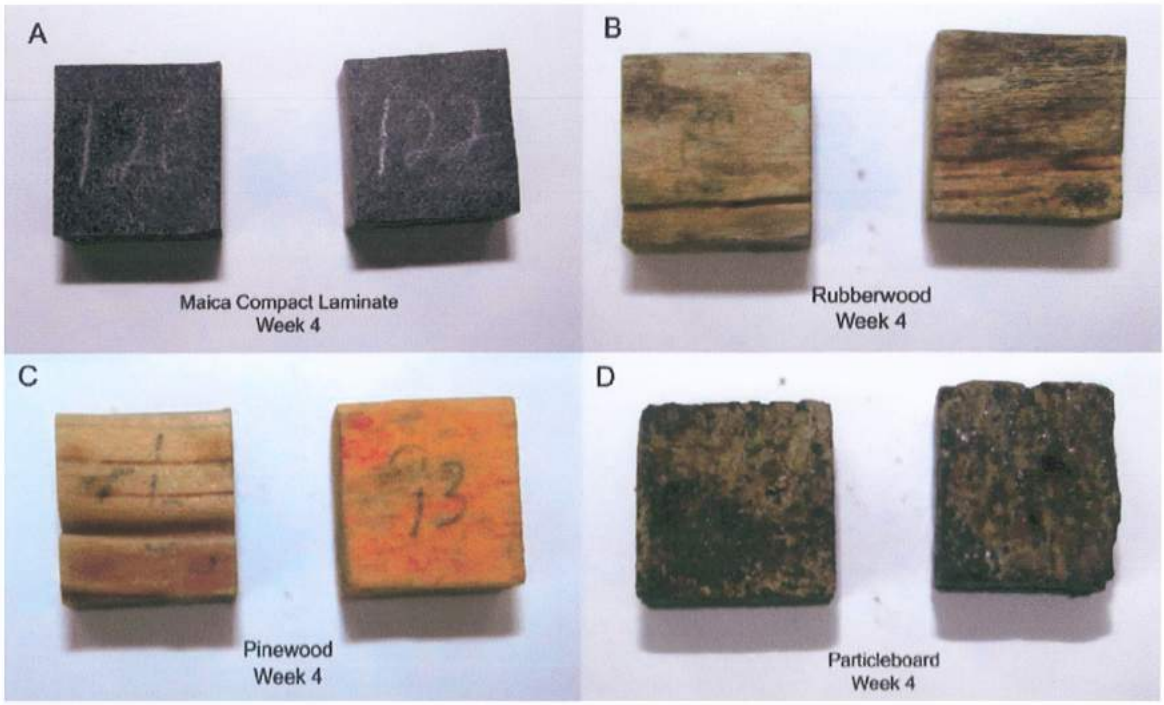

Figure 6.1 Test blocks after four (4) weeks of accelerated laboratory efficacy termite resistance test. (A) Maica's Compact Laminate (Average visual rating=10). (B) Rubberwood (Average visual rating=7). (C) Pinewood (Average visual rating=7). (D) Particleboard (Average visual rating=7).

For field test, the average visual rating is 0 (sound attack) for MCL and pinewood, and 2 (slight attack) for rubberwood and particleboard. Some of the rubberwood and particleboard test blocks were heavily attacked by termites with visual rating of 4 (severe attack) and 3 (moderate attack, penetration) respectively as seen in Figure 5.3. Variation on the degree of termite attack on each test blocks of the same species might be due to differences of origin of the woods used either based on different trees and ages or different sites (Arongo 2004). Younger trees normally have a much lower SG and thus lower durability than older trees. Trees of same species on different sites also have different degree of durability based on the character of it surrounding area such as soil, density of surrounding forest and climate.

During the field test period, termite mud tubes were built around most of the test blocks including on MCL (Figure 6.3) although no sign of termite feeding was detected on the MCL's test blocks. Particleboard and rubberwood test blocks were heavily covered with almost 70-80% of the surfaces by mud tubes indicating active activity of termites. Rubberwood is classified as light hardwoods and highly susceptible to insects attack in the tropics (Edwin & Muhammad Ashraf 2006). It requires treatment such as boron to enhance durability of the rubberwood. In this test, the rubberwood use was untreated and high termite activity was expected on the wood (Figure 6.3). Termite progress on the pinewood slowed after week 8 of field test with only slight changes on the mud tubes. This might be due to the repellant effect that the pinewood has on the termites.

Figure 6.2 Test blocks after 16 weeks of field test. (A) Maica's Compact Laminates (Average visual rating=0). (B) Rubberwood (Average visual rating=2). (C) Pinewood (Average visual rating=0). (D) Particleboard (Average visual rating=2).

Figure 6.3 The four tested woods at the end of the 16 weeks of field test. (A) Maica's Compact Laminates. (B) Rubberwood. (C) Pinewood. (D) Particleboard.

6.3 Termite Mortality

Termite mortality or percentage of termite died at the end of the four weeks of lab test was 100% or complete death for MCL. Particleboard has moderate termite mortality (60%) followed by rubberwood (slight, 30%) and pinewood (slight, 20%) respectively (Table 6.2).

Termite mortality is used as indicator for the effectiveness of chemical to repel termites feeding and natural resistance of the wood to termite attack. Complete termite mortality might be caused by termites starvation due to failure to feed on the wood material during the 4 weeks test duration or because of toxicity of chemical used to treat the wood. In this study, only MCL recorded complete mortality which might be due to starvation as termite failed to feed on the wood. Moderate termite mortality recorded on particleboard might be due to the presence of fungi on the test blocks that might changes wood composition of the particleboard making it unsuitable for *C. gestroi* termites.

7.0 Conclusions

1. MCL was highly resistant to both termite and fungi attack based on both laboratory and field test and may be used for exterior application and at high humidity area.

2. In this test, MCL was found to be the most durable against termite attack, followed by pinewood (softwood), rubberwood and particleboard under the local condition.

Report prepared by,

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