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IN-GROUND PERFORMANCE OF AMMONIACAL COPPER QUATERNARY (ACQ) AND COPPER CHROME ARSENATE (CCA) TREATED BAMBOO *Gigantochloa scortechinii*

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ABSTRACT. *This work presents the field test performance of two-and four-year old tropical bamboo species of G. scortechinii after a twenty four months of ground contact tests. Prior to the tests, samples were taken from the bottom, middle and top portion of each culm. Each portion was treated separately with ammoniacal copper-quaternary (ACQ) and copper-chrome-arsenate (CCA) at 1%, 2%, 4% and 8% concentration of the preservatives. Three methods of treatment: soaking, high pressure sap-displacement and vacuum pressure were used in is study. The overall field trial results indicated that the untreated bamboo stakes lasted less than 24-months in ground contact tests. Most of the stakes treated with ACQ and CCA generally appeared to be fresh and were still in good condition after the tests period. Stakes treated through vacuum pressure performed slightly better than those treated by soaking and high pressure sap-displacement methods. Stakes treated through soaking performed better than the high pressure sap-displacement treated. The four-year old stakes were found to be more durable than the two-year old stakes. The CCA treated stakes performed slightly better than the ACQ treated stakes. Stakes treated at high solution strength performed better than stakes treated at the lower solution strength. Stakes taken from top portion of G. scortechinii were also found to be more durable than the stakes taken at middle and bottom portion of the culm.*

KEYWORDS. Treated bamboo, *Gigantochloa scortechinii*

INTRODUCTION

Bamboo, a plant with multiple utilities has long been associated with temporary and short life span service products. They are used intensively for making a wide range of products such as house-hold items, handicrafts, paper, joss-sticks, barbecue sticks and chopsticks. It is one of the oldest light building materials used in the rural areas and villages due to its availability, low cost, strength, and high yield and renewable nature.

Bamboos considered to have a very low natural durability, when placed in contact with soil (Liese, 1985, Kumar *et al.*, 1994, Jayanetti & Follett, 1998), the young bamboo culms in particular or that has been insufficiently treated with preservatives usually deteriorate rapidly by the action of a mixed population of soil microorganisms and termites. Fungi and termites may still colonize even to those bamboo regarded as adequately treated with preservative. The decay and the attack rates on these bamboo may be slower, and the patterns of fungal colonization may also differ from untreated or less adequately treated bamboo.

This study present results of in-ground performance of bamboo treated with preservatives. The aims of the study was to determine and assess the durability between untreated and chemically treated bamboo against fungal and termites attacked in short term ground contact tests. Information generated from the study will help to promote and increase the utilization of bamboo for construction and exterior uses.

MATERIALS AND METHODS

The bamboo samples for this study were taken from the Forest Research Institute of Malaysia's (FRIM) research trial plot in Nami, Kedah in Malaysia. Bamboo culms were cut at about 30 cm above the ground level. These culms of known age were taken from randomly selected clumps all had diameters between 8 to 10 cm. They were harvested immediately after the rainy season. Investigations indicated that bamboo harvested during this period contained a very minimum amount of starch (Sulthoni, 1983; Liese, 1985; Abd. Razak *et al.*, 1995). The top parts of the culms with branches were removed leaving bamboo poles of about 12 metres in length. All together 400 bamboo poles consisting of 200 of the two-year and another 200 of four-year old were harvested. These poles were later subdivided into 3 equal lengths consisting of bottom, middle and top portions of 4 meters each. These were later treated with ACQ Type B (CuO 60.7%, DDAC 33.3%) and CCA Type C (CuO 18.5%, CrO_3 47.5%, As_2O_5) through soaking, vacuum impregnating and high pressure sap-displacement (HSPD) processes. These blocks were converted into 300 mm x 20 mm x culm wall thickness and were chosen from the bottom, middle and top portion of the culms. This test were conducted based on ASTM: D 1758-74 (Anon, 1974) and procedure developed by Jackson (1957), but with some modification. The total numbers of test stakes investigated were 900 consisting of 2 age-group, 3 culm-height, 3 type of treatments, 3 type of preservatives, 4 level of preservatives and 4 replication.

The test stakes were buried upright with 4/5 of their length in the ground. They were installed 200 mm apart within and between rows and were distributed randomly based on randomized complete-block design. The test stakes were exposed to the decay hazard as well as termites. The tests were monitored for a period of 24 months. The stakes were installed during the dry season. The testing site for the field/grave-yard study was located in Melaka, Malaysia. The site is located in a lowland area. The site is in an agriculture land having hot and humid climate throughout the year with an average daily temperature vary from 21° to 32°C and average annual rainfall of about 2540 mm.

The procedures and the assignment of ranking to each test stakes were as outlined in Table 1 (Thornton *et al.*,1983). The stakes were inspected every 3 months. The exposed upper parts of each stake were given a light blow before being removed from the ground and surface examined with a blunt probe (a 9 inch screwdriver). A stake that has a rating of 4 or less, were highly degraded and considered no longer in a serviceable condition.

Table 1. Ranking system used in the assessment of the bamboo test stakes (Modified from Thornton *et al.*, 1983)

Ranking	*Description*
8	Sound
7	0 – 2 mm decay/termites attack
6	Less than one-quarter of cross-section decayed/termites attack
5	One-quarter of cross-section decayed/termites attack
4	Less than half cross-section decayed/termites attack
3	Half of cross-section decayed/termites attack
2	More than half of cross-section decayed/termites attack
1	Three-quarter of cross-section decayed/termites attack
0	Full of cross-section decayed, stake easily broken

RESULTS AND DISCUSSION

The results and assessments of the control and treated stakes are tabulated in Table 2, 3, 4 and 5.

Table 2. Assesment of bamboo control stakes after 24 month soil exposure

Control specimen result from grave yard test			
Age	Portion	Type of evaluation	
		Decay	Termites
2	B	0.0	4
	M	1.0	3
	T	2.0	7
4	B	1.0	3
	M	2.0	4
	T	3.0	7

B = Butt M = Middle T = Top

Table 3. Assesment of bamboo stakes degraded after 24 month soil exposure.

Age	Preservative		Portion	Method of Treatment					
				Soaking		Vacuum		HPSD	
	Chemical	%		Decay	Termites	Decay	Termites	Decay	Termites
2	ACQ	1	B	6.3	6	6.3	7	5.5	6
			M	6.3	6	6.5	8	6.0	6
			T	6.3	7	6.8	8	6.3	7
		2	B	6.8	6	7.0	7	6.0	6
			M	6.8	7	7.3	8	6.0	7
			T	7.3	8	7.5	8	6.3	7
		4	B	7.0	6	7.0	8	7.0	6
			M	7.3	8	7.5	8	7.0	7
			T	7.3	8	7.5	8	7.3	8
		8	B	7.0	7	7.8	8	7.0	7
			M	7.3	8	7.8	8	7.3	8
			T	8.0	8	8.0	8	8.0	8
	CCA	1	B	7.5	7	7.8	8	7.3	6
			M	7.5	7	7.8	8	7.5	7
			T	7.8	8	8.0	8	7.5	8
		2	B	7.5	6	7.8	8	7.3	6
			M	8.0	7	8.0	8	7.8	7
			T	8.0	8	8.0	8	8.0	8
		4	B	8.0	7	8.0	8	8.0	7
			M	8.0	8	8.0	8	8.0	8
			T	8.0	8	8.0	8	8.0	8
		8	B	8.0	8	8.0	8	8.0	8
			M	8.0	8	8.0	8	8.0	8
			T	8.0	8	8.0	8	8.0	8
4	ACQ	1	B	6.3	6	6.5	7	6.3	6
			M	6.5	6	6.5	8	6.3	6
			T	6.8	8	7.0	8	6.5	7
		2	B	7.0	6	7.3	8	6.8	6
			M	7.0	8	7.5	8	7.0	8
			T	7.3	8	7.5	8	7.3	8
		4	B	7.3	7	7.5	8	7.0	7
			M	7.5	7	7.8	8	7.3	7
			T	7.5	8	8	8	7.3	8
		8	B	8.0	8	8.0	8	7.5	8
			M	8.0	8	8.0	8	8.0	8
			T	8.0	8	8.0	8	8.0	8
	CCA	1	B	7.8	7	7.8	8	7.8	7
			M	7.8	7	7.8	8	7.8	7
			T	7.8	8	8.0	8	7.8	8
		2	B	8.0	8	8.0	8	7.8	7
			M	8.0	8	8.0	8	8.0	8
			T	8.0	8	8.0	8	8.0	8
		4	B	8.0	8	8.0	8	8.0	8
			M	8.0	8	8.0	8	8.0	8
			T	8.0	8	8.0	8	8.0	8
		8	B	8.0	8	8.0	8	8.0	8
			M	8.0	8	8.0	8	8.0	8
			T	8.0	8	8.0	8	8.0	8

Table 4. Analysis of variance on the assessment of treatment by various methods

Treatment	S.V	Sum of square	d.f.	Mean square	F-ratio
Soaking	Age	1.8802	1	1.8802	4.716 *
	Preservatives	30.8802	1	30.8802	77.459 **
	Concentration	16.3073	3	5.4358	13.635 **
	Height	1.5729	2	0.7865	1.9730 ns
Vacuum	Age	0.4364	1	0.4364	2.586 ns
	Chemicals	15.8409	2	15.8409	93.895 **
	Concentration	17.2347	3	5.7449	34.052 **
	Height	2.1346	2	1.0673	6.326 **
HPSD	Age	3.2552	1	3.2552	11.880 **
	Chemicals	43.1302	2	43.1302	157.407 **
	Concentration	30.0573	3	10.0191	36.566 **
	Height	3.4688	2	1.7344	6.330 **

** : significant at P<0.01; * : significant at P<0.05; ns : not significant

Table 5. Analysis of variance on the assessment of various treatment

S.V.	Sum of square	d.f.	Mean square	F-ratio
Age	4.9027	1	4.9027	17.209 **
Treatments	8.8873	2	4.4436	15.598 **
Chemicals	86.4428	2	86.4428	303.433 **
Concentration	61.5436	3	20.5145	72.010 **
Height	6.9263	2	3.4632	12.156 **

** : significant at P<0.01; * : significant at P<0.05; ns : not significant

Greater exposure effect after 24 months period of the field stakes trial was seen in the decay ratings. The stakes site used was found to have a relatively low level of termite activity (this is clearly seen in Table 3). The assessment of the untreated control stakes shows that these stakes lasted less than 2 years. A similar observations were also made by Purushotham *et al.* (1953) and Kumar *et al.* (1994).

Comparison between the three methods used in the study clearly shows that vacuum treated stakes performed better than soaking and high pressure sap-displacement treated stakes in area such as age of stakes, types of preservatives used, concentration of preservatives and height of the culms from where the stakes were taken. This can be seen in Table 4 where means for the decay and termites rating in the 4 year-old bamboo treated stakes were found to be slightly higher compared with those of the 2 year-old stakes. This might be due to the fact that the 2 year-old stakes possess higher preservatives retentions compared to the 4 year-old stakes as comparable to the observation by Razak (1998).

Treatment technique

The treatment technique proved not to be the critical factor in influencing the good performance of the bamboo tests stakes (Table 2). The rating of decay and termites attack does not depends on the treatment methods employed. The rating assessment also shows relatively some treatment consistency between the soaking, vacuum pressure and high-pressure sap-displacement process. However, some variations do occur depending on the net dry salt retention (NDSR) uptakes between the various treatment techniques applied to the tested stakes (Razak, 1998).

However, when the factor of costing is taken into consideration the soaking treatment may have an advantage. Vacuum pressure treatment is quite expensive to be employed commercially in the bamboo industry. High pressure sap-displacement treatment proved to be time consuming as relatively few bamboo culms can be treated at one particular time. And only round bamboo can be treated by this method. This technique proved to be uneconomic for commercial usage in treating bamboo.

Preservatives

The type of preservatives used influenced greatly the outcome of the study. CCA treated stakes apparently and consistently gives better performance than the ACQ treated stakes (Table 3). The rating for ACQ treated stakes were close next to CCA. It is also clear that on an average, the CCA preservatives proved to be more effective against fungal attack compared with ACQ.

Strength /Concentration of preservatives solution

The higher retention of preservatives solution in the bamboo stakes when treated at higher concentration of preservatives such at 4% and 8% level were still performing well after 24 months in the field trial. Even 2% solution strength with CCA and ACQ were giving good performance, as was CCA at a 1% treating solution concentration.

Age of bamboo culm

The results from Table 3 shows differences in durability between the 2 and 4 year-old stakes. The culm age of bamboo to a certain extent has an important role in determining their durability in field environment. This element is not considered to be a major factor compared with, for example, preservative type or concentration. However, a small and statistically significant increase in durability of untreated or treated 4 year-old stakes was found. Comparation on bamboo age (ANOVA Table 4) between the treatment methods applied shows an insignificant results.

Portion of bamboo

The results (seen from Table 3) shows that there are some differences in term of the bamboo durability between the bamboo portion used in the study. The top portion are more durable than the middle and butt, both in term of the the fungal and termites attacked. These are clearly seen in the stakes with 1% and 2% chemicals concentration. The chemicals uptake are higher at the top portion compare to the middle and butt. These are supported by the comparison (ANOVA Table 4) between treatment applied to the bamboo portion shows significant value at $p>0.01$ for both vacuum and HPSD treatments. No different was observed for the soaking method.

The application of high pressure in the vacuum and HPSD method might have improved the amount of the chemicals uptake in the bamboo portions; treatment with both methods gave better performance as compared to soaking.

CONCLUSIONS

i) The treated *G. scortechinii* stakes were much more durable compared to that the untreated stakes.

ii) *G. scortechinii* stakes of 4 year-old were more durable than the 2 year-old stakes.

iii) CCA treated stakes performed relatively better than the ACQ treated stakes.

iv) Stakes treated at high solution strength performed better than stakes treated at the lower solution strength. Stakes treated with CCA at all levels of solution strength performed extremely well having little decay. Stakes treated with 2%, 4% and 8% ACQ performed well in the field test.

v) Stakes taken from top portion of *G. scortechinii* were more durable than the stakes taken at middle and bottom portion of the culms. Stakes taken from middle portion perform better than the bottom portion.

vi) The stakes treated by vacuum pressure process were found to be more durable than those treated by soaking and high pressure sap-displacement based on their rating performances.

REFERENCES

Anon, 1974. *Annual book of ASTM standard: D 1758-74.*

Jackson, W. K. 1957. Durability of Malaysian timbers. *Malayan Forester*. **20**: 38-46.

Jaysnetti, D. J. and Follett, P. R. 1998. Bamboo in construction an introduction. Trada technology and International Network for Bamboo and Rattan (INBAR).

Kumar, S., Shukla, K.S., Dev, I. and Dobriyal, P. B. 1994. Bamboo preservation techniques: A review. International Network for Bamboo and Rattan, and Indian Council of Forestry Education.

Levy, J. F. 1965. The soft rot fungi: their mode of action and significance in the degradation of wood. *Advances in Botanical Research*, **2** :323-357.

Liese, W. 1985. Bamboo: Biology, silvics, properties, utilization. Schriftenreihe der GTZ, no. 180.

Nilsson, T. and Daniel, G. 1990. *Decay types observed in small stakes of pine and Alstonia scholaris inserted in different types of unsterilize soil*. International Research Group Wood Preservation. Document No. IRG/WP/1357.

Purushotam, A., Sudan, S.K. and Sagar, V. 1953. Preservative treatment of green bamboo under low pneumatic pressure. *Indian Forest Bulletin*, **178**: 1-21.

Thornton, J.D., Walters, N. E. M. and Sounders, I. W. 1983. An in-ground natural durability test of Australia timbers and exotic reference species I. Progress report after more than 10 years exposure. *Mater. Org*. **18**: 27-49.

Razak, W. 1998. Effect of selected preservatives on the durability of *Gigantochloa scortechinii*. A Ph.D. Dissertation, University of London (Unpublished).