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PRESERVATION OF RUBBERWOOD BY BORON-DOUBLE VACUUM PROCESS

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SALAMAH SELAMAT, HABIBAH MOHAMMAD & ZAITUN SAID. 1988. Preservation of rubberwood by boron-double vacuum process. Treatment of rubberwood with preservatives by dip-diffusion takes a long time. To shorten the time, the double vacuum pressure treatment was tried. Rubberwood samples in green and partially air-dried conditions were impregnated with a boron compound using double-vacuum pressure treatment. The chemical was found to diffuse naturally into the centre of the wood and achieved a specific loading of more than 0.2% boric acid equivalent at the sample core within one week following treatment. This treatment is preferable over the dip-diffusion process which normally takes two weeks for samples of similar size.

Key words: Rubberwood - boron compound - double vacuum treatment.

Introduction

Rubberwood is highly susceptible to biodeteriorating organisms such as insects and fungi (Hong 1982). The wood therefore needs to be treated, especially if the clear and light coloured finish desired by furniture makers is to be retained.

The dip-diffusion treatment process using boron compound presently used is adequate for protecting the fresh and partially air-dried sawn rubberwood against insects (Salamah *et al.* 1987). However, this process is not recommended for sawn timber with low moisture content since it takes a long time to achieve the specific chemical loading. An alternative treatment which is faster and protection is permanent is required.

In the double vacuum pressure treatment, both the chemical and the solvent are forced into the wood through application of artificial pressure prior to natural diffusion. Diffusion still operates when moist timber is placed in contact with a strong chemical solution. A dilution tendency is set up whereby the chemical moves in the solution from the zone of high concentration on the surface of the wood to the zone of zero concentration at the centre until equilibrium is reached (Anonymous 1979). In this study, we determined the effectiveness of the double-vacuum pressure treatment on rubberwood in green and partially air-dried conditions using borax-boric acid mixture.

Materials and methods

Test samples

Freshly felled logs of rubberwood (25 years old; obtained from Bukit Kiara, Peninsular Malaysia) were immediately converted into 300 battens with dimensions of 5 x 5 x 50 *cm* in the laboratory. These samples were free from any natural defects, fungal and insect attacks. Both ends of the wood samples were sealed with epoxy paint. The wood samples were then divided into three groups of 100 pieces each based on their drying period: freshly cut, one week and two weeks of air-drying (under shade).

For each drying condition, ten samples were taken for moisture content determination. The remaining 90 samples from each drying time were used for double-vacuum treatment. Each test sample was weighed before treatment.

Preservative solution

Treatment solutions at three concentration levels of six, eight and ten percent (weight/volume) of boron solution [borax: boric acid (1.54 : 1.00)] were used.

Method of treatment

Thirty test samples were loaded into the treatment cylinder for each concentration of test solution. The schedule for double-vacuum pressure treatment was as follows:

Initial vacuum:	711.2 *cm Hg*
Vacuum period:	3.75 *h*
Pressure:	200 *p.s.i.*
Pressure period:	2.50 *h*
Final vacuum:	711.2 *cm Hg*
Vacuum period:	10 *min*

Immediately after the treatment, six samples were weighed and air-dried. The rest of the samples were close-stacked in polythene bags and stored to allow diffusion to take place. At intervals of one, two, four and six weeks, six samples each were selected at random for preservative determination.

Each sample was cut into three sections as shown in Figure 1a. Two pieces of 1 *cm* thick samples (A & B) were cut from each section. One was used for penetration test and the other for chemical analysis.

The penetrated zone on the cross cut surface of each section visible by its darker colouration compared with the untreated core was measured. The boundary separating the penetrated and unpenetrated zones on each piece of wood was detected using curcumin reagent (Anonymous 1979).

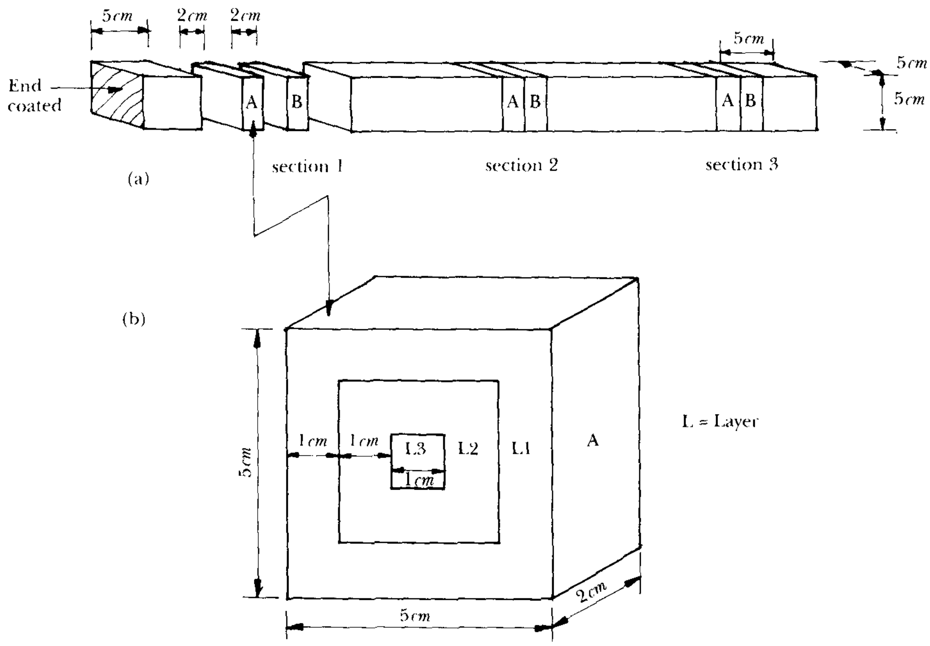

Figure 1. Sampling system from batten and sections for penetration test and boric acid equivalent determination

Determination of boric acid equivalent in the treated wood

Each wood block for chemical analysis was cut into three layers as shown in Figure 1b. Each layer was then separately grounded into fine sawdust (maximum 1 *mm* in size) and then dried at 60°*C*.

Next, 5 *g* of the dried sawdust and 15 *ml* of 7.5% barium hydroxide solution were placed in a silica crucible and mixed thoroughly. This sample was dried in an oven at 105°*C* for 2 *h*. Later the crucible was transferred into a furnace at 200°*C* and the temperature was raised to 600°*C* for 2 *h*. The crucible was cooled to room temperature, a few drops of distilled water was added to moist the ash and then hydrochloric acid (1:1) was added in excess.

The contents of the crucible were washed and filtered through a No. 4 filter paper into a 250 *ml* conical flask and rinsed with hydrochloric acid (1:1). The filtrate was neutralised with 10% sodium hydroxide (with methyl red as indicator). The solution was then acidified with hydrochloric acid (1:40), allowed to simmer for 2 *min* to expel CO_2, cooled to room temperature and neutralised with sodium hydroxide solution (0.1N, O_2-free).

Mannitol was added to the solution followed by ten drops of phenolpthalein indicator. The solution was titrated with the standard 0.1N sodium hydroxide until a permanent pink colour was reached. The percentage boric acid equivalent (B.A.E) is calculated as below:

$$\% \text{ B.A.E.} = \frac{T \times N \times 6.184}{W}$$

where
W = oven-dried weight of the sample,
N = normality of the sodium hydroxide, and
T = correction titre (titre for the sample -blank titre)

Results and discussion

The amount of boron compound retained by the rubberwood samples after double-vacuum pressure treatment is dependent on the moisture content of the wood: more boric acid was retained at lower moisture content. This may be because vacuum-pressure treatment removes the air, thereby creating empty spaces inside the wood cells (Wilkinson 1979). The empty space facilitates diffusion of chemical solution in the wood.

Water from the woods' surface and outermost layers evaporate faster than the inner layers. Once these surface layers of partially air-dried wood (one and two weeks) were penetrated with solution under the double-vacuum pressure treatment, a diffusion pressure is set up due to the difference in concentration gradient of salt solution at the outer and inner section of the wood and diffusion was achieved.

After double-vacuum pressure treatment, in all partially air-dried rubberwood samples full penetration (more than 0.2% of B.A.E.) was observed, but only 64% penetration was achieved in freshly-cut samples. The latter samples, however, showed 10% penetration with boron after five days air-drying (Figure 2). The average B.A.E. values in the different layers of treated freshly-cut samples had the following specific gradients from the outside to the core: at 0 to 1 *cm* layer the B.A.E. values were about 1.604 and 2.336 for 6 and 8% of solution strengths, respectively. These were reduced to 1.325 and 1.701 (6 and 8% of solution strengths, respectively) after the samples were left for six weeks in the polythene bags. At the core the amount of B.A.E. increased instead from 0.109 and 0.159 to 0.764 and 0.969 for 6 and 8% solution strengths, respectively (Figure 2).

The decrease of B.A.E. at the outermost layer and the increase towards the core suggests the movement of chemical is from higher to lower concentrations during the diffusion (Figure 2). This phenomenon was not found in partially air-dried samples.

Although the one week air-dried samples absorbed less treatment solution than the two weeks air-dried samples (Table 1), the actual amounts of B.A.E. in both samples were not significantly different (Appendix 1). However, the amount of B.A.E. retained from the outer layer to the core after the pressure treatment was more than sufficient (more than minimum loading of 0.2% B.A.E.) (McQuire 1962) to protect the wood from *Lyctus* and *Anobium* species.

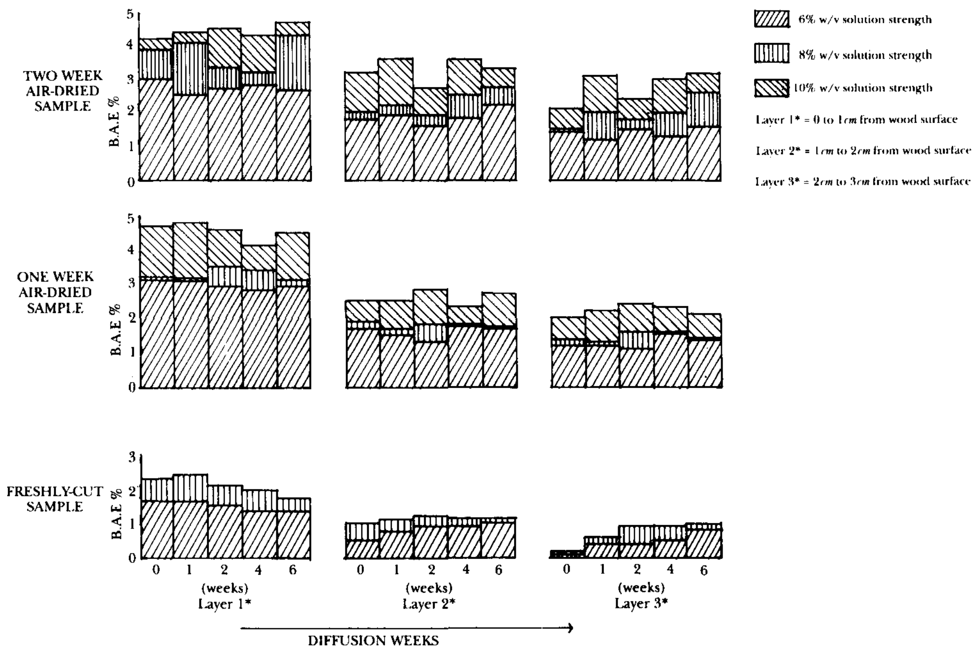

Figure 2. The amount of boric acid equivalent (%) at three layers of freshly-cut, one week air-dried and two weeks air-dried samples after double-vacuum pressure treatment

Table 1. Chemical absorption of boron compounds by rubberwood after vacuum pressure treatment at different drying time and solution strength

Drying time (weeks) (% w/w of sample)	Average moisture content (% w/v)	Treatment solution	Average retention of treatment (*kg m⁻³*)	
			x*	SD**
0 (Freshly cut samples)	68 SD 4.679	6 8	205.26 211.00	10.70 11.78
1	42 SD 2.577	6 8 10	360.91 324.62 377.60	15.67 15.67 13.22
2	29 SD 2.387	6 8 10	423.86 417.53 394.00	10.28 11.35 12.67

x* = Mean of 6 samples; SD** = Standard Deviation

Conclusion

The double-vacuum pressure treatment alone was sufficient to protect partially air-dried rubberwood samples. However, for fresh samples, a combination of diffusion-vacuum pressure process was necessary to achieve the required chemical loading. This chemical loading could be achieved in less than one week after the pressure treatment for the given sample size.

This treatment could be used to overcome the time consuming process of treating rubberwood with boron by dip-diffusion which normally takes nearly two weeks for the same sample size. The double-vacuum treatment could also be used for samples with low moisture content.

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Appendix 1

Amounts of boron compound retained as percentage of boric acid equivalent in rubberwood after double vacuum pressure and diffusion treatment

Average moisture content (%w/w) of sample	Diffusion time (*week*)	Distance from wood surface (*cm*)	Average boron acid equivalent retained after treatment with three different solution strength: 6% w/v		8% w/v		10% w/v	
			Mean	SD	Mean	SD	Mean	SD
Freshly cut samples	0	0 to 1	1.60	0.081	2.34	0.114		
		1 to 2	0.50	0.011	1.00	0.099		
		2 to 3	0.11	0.020	0.16	0.013		
	1	0 to 1	1.60	0.102	2.38	0.135		
		1 to 2	0.76	0.022	1.08	0.096		
		2 to 3	0.38	0.062	0.56	0.023		
Mean = 67.81	2	0 to 1	1.47	0.122	2.14	0.113		
		1 to 2	0.88	0.032	1.18	0.101		
		2 to 3	0.44	0.046	0.87	0.088		
	4	0 to 1	1.33	0.132	1.95	0.132		
		1 to 2	0.98	0.098	1.09	0.116		
		2 to 3	0.49	0.022	0.90	0.093		
		0 to 1	1.33	0.112	1.70	0.114		
		1 to 2	1.00	0.096	1.14	0.112		
		2 to 3	0.76	0.024	0.97	0.016		
One week air dried	0	0 to 1	3.06	0.110	3.17	0.211	4.68	0.248
		1 to 2	1.73	0.104	1.85	0.113	2.57	0.204
		2 to 3	1.20	0.101	1.37	0.109	1.99	0.198
	1	0 to 1	3.12	0.221	3.12	0.237	4.80	0.223
		1 to 2	1.52	0.121	1.66	0.117	2.58	0.214
		2 to 3	1.21	0.143	1.32	0.120	2.20	0.204
Mean = 41.96	2	0 to 1	2.87	0.213	3.48	0.233	4.58	0.319
		1 to 2	1.26	0.176	1.76	0.121	2.74	0.206
		2 to 3	1.11	0.183	1.56	0.132	2.44	0.299
	4	0 to 1	2.97	0.127	3.41	0.211	4.10	0.309
		1 to 2	1.75	0.114	1.75	0.210	2.33	2.202
		2 to 3	1.57	0.098	1.57	0.198	2.29	0.219
	6	0 to 1	2.91	0.177	3.09	0.263	4.46	0.326
		1 to 2	1.74	0.102	1.72	0.125	2.68	0.214
		2 to 3	1.37	0.097	1.34	0.139	2.10	0.207
Two weeks air dried	0	0 to 1	3.00	0.233	3.79	0.211	4.07	0.328
		1 to 2	1.75	0.162	1.95	0.174	3.22	0.247
		2 to 3	1.53	0.134	1.53	0.204	3.09	0.255
	1	0 to 1	2.48	0.182	4.01	0.304	4.25	0.367
		1 to 2	1.86	0.177	2.20	0.198	3.59	0.299
		2 to 3	1.32	0.134	1.99	0.180	3.06	0.227
Mean = 28.75 SD = 2.387	2	0 to 1	2.73	0.182	3.32	0.263	4.37	0.377
		1 to 2	1.55	0.136	1.93	0.113	2.69	0.293
		2 to 3	1.51	0.127	1,82	0.120	2.35	0.261
	4	0 to 1	2.80	0.169	3.17	0.244	4.22	0.382
		1 to 2	1.78	0.143	2.48	0.198	3.54	0.293
		2 to 3	1.32	0.122	2.00	0.169	3.00	0.299
	6	0 to 1	2.64	0.210	4.19	0.250	4.56	0.316
		1 to 2	2.22	0.180	2.74	0.168	3.27	0.285
		2 to 3	1.62	0.177	2.57	0.178	3.23	0.299

SD = Standard Deviation

THE ABRASIVE RESISTANCE OF SEVEN-YEAR OLD *ACACIA MANGIUM* TIMBER FROM KEPONG PLANTATION

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AHMAD SHAKRI MAT SEMAN. 1988. The abrasive resistance of seven-year old *Acacia mangium* timber from Kepong plantation. The abrasive resistance of *Acacia mangium* was assessed and compared with that of kempas (*Koompassia malaccensis*), a common flooring timber. The results showed that *A. mangium* is much inferior to kempas and is not suitable for use as a flooring material.

Key words: *Acacia mangium* - abrasion testing machine - abrasive resistance -abrasive medium - cutting pattern - weight losses - flooring.

Introduction

Acacia mangium is one popular species selected for tree plantations by the Malaysian Forestry Department. The texture of the wood is fairly coarse without growth rings. The density of nine year old wood ranges from 420 to 483 kg/m^3 (Logan & Baloids 1982, Peh *et al.* 1982). The tangential and radial hardness at 15% moisture content are 4300 and 3981 *Newton*, respectively (Tan 1979). In general, the timber has been found to kiln dry well without any serious defects, easy to saw, and gives a smooth and lustrous surface when planed (Tan 1979). Sanding is easy with no torn fibres on the finished face (Peh & Khoo 1985), and it could be nailed very well even at the ends of one-inch boards. The species has already been used on a limited scale, and has been shown to be suitable for products such as particleboard, plywood, panels, and decking for houses and boats (Peh & Khoo 1985). It may also be suitable for parquet and strip flooring. The abrasive resistance against wear test for the suitability of this timber as a flooring material was ascertained in the laboratory. The abrasive resistance of *A. mangium* was compared to that of a common flooring timber, kempas (*Koompassia malaccensis*).

Materials and methods

Preparation of test materials

Test boards of *A. mangium* were obtained from two seven-year old trees from a plantation in Kepong, Peninsular Malaysia. The boards were air dried for eight months and dimensions 50 x 50 x 150 *mm* were cut from heartwood regions. Test samples of 50 x 12 x 75 *mm* were obtained from these boards. The cutting pattern shown in Figure 1 was used to obtain radial, tangential, and end face samples for attaching to the sample holder (Figure 2) for testing. Five samples were tested for each cutting pattern. The test samples were then conditioned at 22° *C* and 70% relative humidity in a conditioning chamber to a moisture content of about 12% before testing.

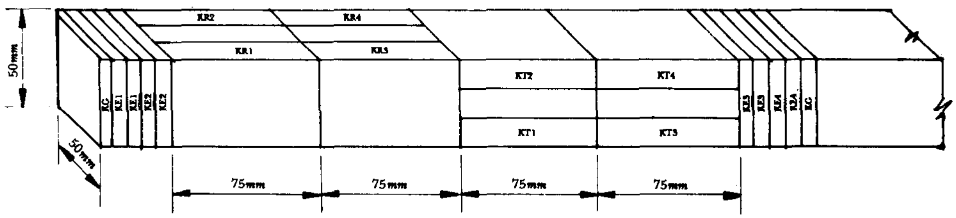

Figure 1. Cutting pattern of wood blocks (KR = radial ; KT = tangential ; KE = end grain ; KG = specific gravity of sample)

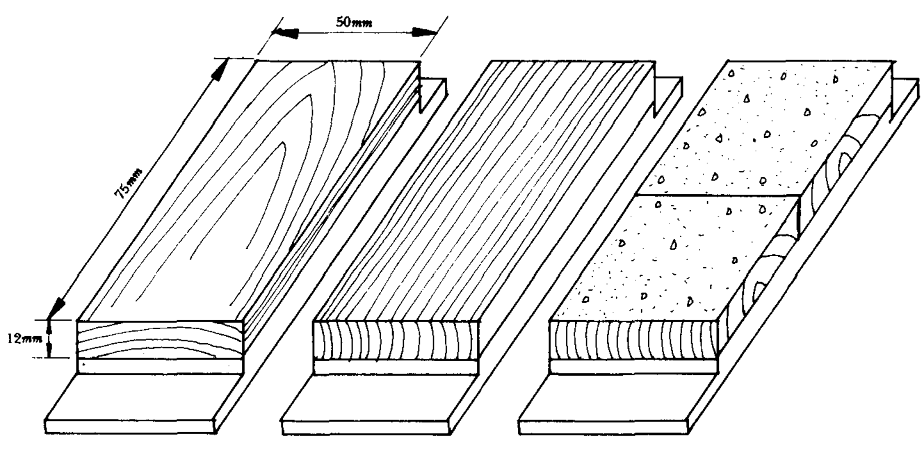

Figure 2. Sample holder with wood blocks attached

Testing procedure

The test procedure adopted in this study follows the American Standard D 1037

-72a (Anonymous 1977). The abrasive medium used was number 80 grit aluminium oxide.

The test samples were mounted onto the holder using epoxy adhesive. The holder which carried a dead weight of 4.5 *kg* on top was used to apply a fixed pressure on the sample during each revolution. The abrasive wear on the sample was obtained by grinding against a revolving steel disk covered with the abrasive medium. The sample holder revolved clockwise at a constant speed of 32.5 *rpm* while the steel disk revolved at a speed of 23.5 *rpm* in the same direction. The sample was lifted a distance of 1.6 *mm* and dropped back into contact with the revolving disk twice during each revolution of the sample holder. The abrasive medium was introduced to the revolving disk via a mechanically agitated hopper at a rate of about 46 $g\ min^{-1}$. The abrasive medium was changed after 2000 revolutions.

The losses in weight of the samples were measured after every 100 revolutions of the revolving disk until a total of 1000 revolutions was achieved.

Results and discussion

Quantitative results of the present abrasive test on *A. mangium* timber, and kempas (Mohd. Shukari 1983) are shown in Figure 3. Average values for the specific gravity, loss in weight after each 100 revolutions and percentage loss in weight after 1000 revolutions of the abrasive disk are given for the three faces tested.

The wearing resistance at different faces for both timbers were different (Figure 3). However for both timbers, the radial face showed the least resistance followed by tangential and end faces. The losses in weight after 1000 revolutions for the radial, tangential and end faces of *A. mangium* were 5.38, 4.25 and 2.05% respectively. The corresponding values for kempas were 0.93, 0.82 and 0.22%, respectively. Thus, kempas performed better than *A. mangium.*

Figure 3 also shows the relationship between the number of revolutions and the weight loss for the two species. A linear relationship was also obtained by other workers for other timbers (Youngquist & Munthe 1948, Mohd. Shukari Midon 1983).

The percentage losses of weight after 1000 revolutions for different faces of *A. mangium* and kempas are illustrated in Figure 3. The losses in weight for *A. mangium* for the radial, tangential, and end faces were about six, five, and nine times as much as for kempas, respectively. These large differences are perhaps due to the obvious difference in densities and other anatomical properties. The factors related to anatomical structures of the wood such as size, arrangement and distribution of the pores and the structure of the fibres have been proven to play important roles in influencing the resistance to wear (Youngquist & Munthe 1948).

Based on the resistance to abrasion, density, strength group and texture of wood, kempas is considered suitable for heavy traffic flooring but preferable for

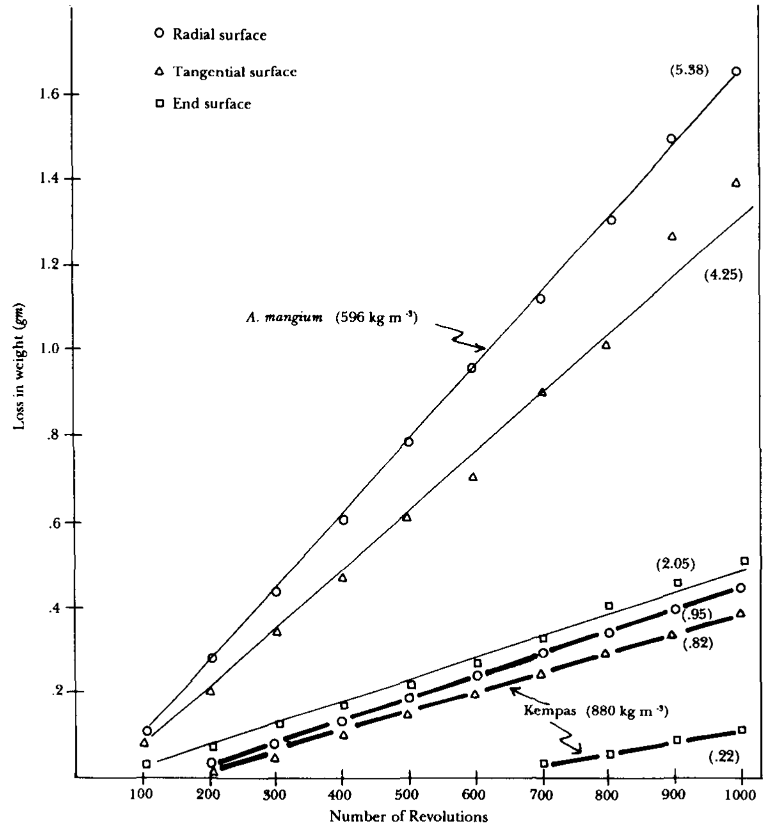

Figure 3. Amount of wear in terms of weight loss from three different surfaces of *A. mangium* after every 100 revolutions of the revolving dish. Percentage loss in weight after 1000 revolutions is shown in parenthesis (Data on Kempas: Mohd. Shukari 1983)

use under medium traffic conditions (Lim 1983). Hence, compared to kempas, *A. mangium* is inferior in its wearing properties, and is deemed not suitable for use as a heavy, medium or light traffic flooring material.

Conclusion

The results obtained from this study show that seven-year old *A. mangium* has inferior wearing properties than kempas in the radial, tangential and end faces. They were below the requirements for light traffic conditions. Hence seven-year old *A. mangium* timber is not suitable for use as a flooring material.

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