Durability of Tropical Woods

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Since 1964, the Forestry and Forest Products Research Institute has conducted a series of comprehensive studies on the wood properties and processing suitabilities of timbers from Southeast Asia and the Pacific regions.

The authors have taken over a portion of the study on wood properties of the timbers and have evaluated the durability of the timbers.

Woods of about one hundred species from Southeast Asia and the Pacific regions were selected for the test. Most species among them were sampled from markets in Japan, and had been unknown or less-known in Japanese wood industries at the time they were chosen for the tests. Several additional species which had already utilized in Japan were also included to compare the results with those of other species.

The two methods were adopted to evaluate the durability of tropical woods in our test. The one was the sawdust block method in laboratory authorized in Japanese Industrial Standard (JIS), and by this method an average weight loss of each species by fungal attack was measured. The other was the stake test method in field known by research groups of wood preservation, and by the method an average life of each species stake as affected by the damage due to fungal and termite attacks in field was determined.

Samples used for both methods were taken from two positions: one is at 2—3 cm from bark and the other at 60% in relative distance from pith to bark on radial direction of log. The former is called as sapwood, and the latter as heartwood in our test.

Grading of the durability of tropical woods depended upon the durability of heartwood, because the sapwood of most species of them had low durability.

Natural resistance of tropical woods to fungal attack in laboratory

The natural resistance of each species to fungal attack is determined by exposing them in the form of small blocks of $20 \times 20 \times 20$ mm to the action of pure cultures of wood destroying fungi during two months. In this method, the sawdust medium to culture the wood destroying fungi is composed of some beech sawdust, distilled water as twice as the sawdust weight, and 1% glucose and 0.2% peptone to the sawdust in weight. The test fungi were three species, *Tyromyces palustris* (brown rot), *Coriolus versicolor* (white rot), and *Pyconoporus coccineus* (white rot). In every bottle, three blocks are placed on the sawdust medium in which each test fungus is grown, as shown in Plate 1. After the blocks have been introduced, the bottles are closed by means of a screw lid. The bottles are mostly allowed to stand for two months at 26 to 28°C. The blocks in the bottle are attacked by the test fungi during two months. A weight loss of each block was used as a measure of rate of decay.

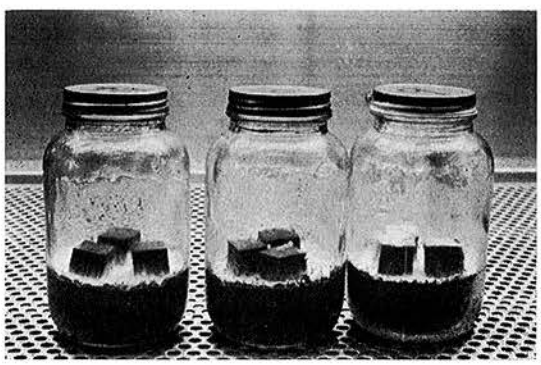

Plate 1. Sawdust block method

Table 1. Percentage of weight loss caused by decay

	Common name	Position*	Specific gravity in air dry	*T. palustris*	*C. versicolor*	*P. coccineus*
1.	Agathis	S	0.41	23.0	2.1	8.1
		H	0.43	2.2	0.7	0
2.	Alstonia	S	0.44	0.8	12.7	14.6
		H	0.44	17.8	10.2	15.8
3.	Apitong	S	0.63	4.1	14.5	14.4
		H	0.69	7.4	8.3	7.6
4.	Balau	S	0.85	2.8	4.8	2.8
		H	0.99	0	0	1.4
5.	Bangkirai	S	0.84	1.2	0.7	1.4
		H	0.90	1.0	1.2	1.1
6.	Borneo oak	S	0.95	0	1.4	3.3
		H	1.01	0	0.7	1.6
7.	Calophyllum	S	0.69	—	10.2	8.3
		H	0.64	0	3.2	1.4
8.	Campnosperma	S	0.58	7.0	14.7	18.0
		H	0.50	15.8	22.6	28.3
9.	Canarium	S	0.55	17.5	25.7	29.4
		H	0.53	17.7	24.5	22.6
10.	Celtis	S	0.64	27.6	16.1	31.9
		H	0.63	25.6	19.5	34.6
11.	Champaka	S	0.47	7.8	9.5	13.8
		H	0.50	0	0.3	0
12.	Chhoeuteal bangkuoi	S	0.65	2.8	14.9	—
		H	0.75	1.4	4.3	—
13.	Chhoeuteal sar	S	0.60	1.3	17.0	—
		H	0.75	3.2	7.4	—
14.	Erima	S	0.41	—	15.6	19.6
		H	0.36	4.9	6.6	9.7
15.	Giam	S	0.82	0.4	2.7	0
		H	0.98	0	0.5	0
16.	Jelutong	S	0.40	3.5	12.6	19.9
		H	0.41	5.0	18.6	29.5
17.	Jongkong	S	—	—	—	—
		H	0.52	0	16.2	16.8
18.	Kapur	S	—	—	—	—
		H	0.60	0	3.3	—
19.	Karas	S	0.43	19.4	14.9	31.0
		H	0.41	25.0	18.1	38.8
20.	Kelat	S	0.68	0	8.3	12.4
		H	0.76	0	1.3	2.0
21.	Keledang	S	0.58	11.9	13.9	20.9
		H	0.53	6.5	16.2	25.8
22.	Keruing	S	0.71	0.6	11.6	—
		H	0.77	2.0	7.3	—
23.	Koki khsach	S	0.75	0.9	4.8	—
		H	0.85	1.5	1.6	—
24.	Komnhan	S	0.60	3.4	5.0	—
		H	0.77	1.6	2.1	—
25.	Labura	S	0.47	14.6	14.5	22.9
		H	0.49	21.9	15.4	13.0
26.	Light red meranti	S	0.53	4.2	1.4	0
		H	0.46	0	0.2	0
27.	Nato	S	0.69	—	10.8	9.6
		H	0.68	0	0.5	1.1

	Common name	Position*	Specific gravity in air dry	*T. palustris*	*C. versicolor*	*P. coccineus*
28.	New Guinea basswood	S	0.40	8.1	16.5	18.8
		H	0.34	11.8	16.5	21.9
29.	Phdiek	S	0.65	8.3	11.7	—
		H	0.72	1.6	2.1	—
30.	Ramin	S	—	—	—	—
		H	0.66	25.5	19.0	26.8
31.	Red lauan	S	0.62	2.4	10.8	10.9
		H	0.50	2.6	2.2	0
32.	Resak	S	0.64	3.2	0	1.7
		H	0.79	0	0.5	0
33.	Rong leang	S	1.04	2.0	5.0	—
		H	1.15	3.4	2.7	—
34.	Ro yong	S	—	—	—	—
		H	0.35	11.5	13.9	—
35.	Srol kraham	S	0.43	14.7	7.5	—
		H	0.49	0.6	7.3	—
36.	Taun	S	0.65	6.5	12.2	9.5
		H	0.59	2.3	4.2	2.7
37.	Teraling	S	—	—	—	—
		H	0.65	0	4.0	3.8
38.	Terminalia	S	—	—	—	—
		H	0.53	2.9	12.2	14.3
39.	White meranti	S	0.62	5.2	10.6	6.0
		H	0.60	1.1	2.1	1.2
40.	White siris	S	—	—	—	—
		H	0.43	7.0	15.5	16.8

* S: Samples taken from a position of 2—3 cm from bark on radial direction.
H: Samples taken from a position of 60% in relative distance from pith on radial direction.

The average weight losses of main species caused by three fungi in this method are shown in Table 1.

The weight losses in sapwoods of most species among them were higher than those in heartwoods. The weight loss in heartwoods caused by brown rot was approximately similar to that caused by white rot in case of Alstonia, Apitong and Bangkirai, but the former is lower than the latter in Campnosperma Jelutong, Jongkong, Red lauan and White siris, while the former was higher than the latter in Labura.

Average life of tropical wood stakes as affected by fungal and termite attacks in field

The stakes used in this stake test were 3 by 3 by 60 cm in size. Number of stakes for each species was at least ten for sapwood and heartwood, respectively. The stakes were set in an upright position with about half of their length in ground. The inspection of all stakes in the field has been carried out once a year. In this inspection, the stakes were individually removed from the test field, inspected and then returned to their original place unless their condition indicated removal. A view of the stake test

Plate 2. Stake test field

Plate 3. Appearance of damage

and the condition of damage on a tropical wood stake are shown in Plate 2 and 3, respectively.

Following the inspection by observation, the stakes were graded according to decay and termite attacks, as follows;

Grade	Observed condition
0	sound
1	partial slight damage
2	whole slight damage
3	condition of 2 with partial severe damage
4	whole severe damage
5	destroyed

In evaluating a service life prior to 100% removal of stakes, it has been noted that an average life can approximately be estimated by knowing the time when an average grade of the stakes as a group has reached 2.5. The average lives of main species stakes in the field are shown in Table 2.

Sapwood stakes of Sugi and Hinoki in Japanese species have shown an average life of 4.5 and 5.5 years, while their heartwood stakes have shown an average life of 6.0 and 7.0 years. In tropical species, the heartwood stakes of Bankirai, Giam, Koki khsach, Resak and White meranti, etc. showed the longest average life of 8 years or over 8 years, while heartwood stakes of Agathis, Jelutong, Karas and Labura showed the shortest average life of 1 to 2 years. Other species showed an average life of 3 to 7 years.

Table 2. Service life on the stake test

	Common name	Service life (years)	
		S	H
1.	Agathis	1.5	1.5
2.	Alstonia	2.0	2.0
3.	Apitong	3.5	4.5
4.	Balau	—	9.0*
5.	Bangkirai	—	9.0*
6.	Borneo oak	—	9.0*
7.	Calophyllum	—	5.0
8.	Campnosperma	—	2.0
9.	Canarium	—	2.0
10.	Celtis	2.0	2.0
11.	Champaka	—	2.0
12.	Chhoeuteal bangkuoi	4.0	7.0
13.	Chhoeuteal sar	2.5	5.0
14.	Erima	—	3.5
15.	Giam	—	9.0*
16.	Jelutong	—	1.5
17.	Jongkong	—	4.0
18.	Kapur	—	7.0
19.	Karas	—	1.0
20.	Kelat	—	7.5
21.	Keledang	—	3.0
22.	Keruing	3.5	5.0
23.	Koki khsach	—	11.0*
24.	Komnhan	5.0	11.0*
25.	Labura	—	1.5
26.	Light red meranti	—	6.0
27.	Nato	—	4.0
28.	New guinea basswood	—	2.5
29.	Phdiek	—	7.0
30.	Ramin	—	2.5
31.	Red lauan	—	4.0
32.	Resak	—	8.0
33.	Rong leang	8.0	11.0*
34.	Ro yong	—	2.0
35.	Srol kraham	—	5.5
36.	Taun	—	4.0
37.	Teraling	—	7.0
38.	Terminalia	—	3.0
39.	White meranti	4.0	8.0
40.	White siris	—	2.5

* The species have continued to perform well after service years in the Table.

Relation between the average weight loss by fungal attack in laboratory and the average life in field

In order to know whether is it possible or

not to estimate the average life in the field in a short time from the results obtained in the laboratory, the relation between the average weight loss of small blocks by fungal attacks in the laboratory and the average life of stakes in the field was studied using the results obtained in this work.

It is supposed that the durability of the small blocks and that of the stakes are same with the same species, because they were sampled from the same timber in each species.

The relation between the average weight loss (in percentage) of the small blocks caused by *Coriolus versicolor* and the average life (in years) of stakes is shown in Fig. 1. The relation was recognized at a high level of significance as shown by the following formula:

$$y=5.72-0.19x \quad r=0.639 \quad s=\pm 1.54$$

where x: weight loss (%),
y: average life (years)
r: coefficient of correlation
s: standard deviation

This relation shows that an averaged life for all species before any weight loss occurred was about 6 years. However, the actual length of life differed with different species.

Therefore, it is difficult to grade the durability of individual species based on the results in the laboratory test alone. In order to grade the durability, it is unavoidable to depend upon the results of stake tests, service records or references.

Grading the durability of tropical woods

The durability of tropical woods was graded into five classes according to the results of heartwoods obtained by the sawdust block method in the laboratory and the stake test in the field.

The result is shown in Table 3.

Standards used for grading durability into 5 classes are as follows:

Class	Designation	Weight loss (%)	Life (year)
I	very durable	0—3	more than 8
II	durable	0—5	6—7
III	moderately durable	less than 15	4—5
IV	non-durable	more than 15	2—3
V	perishable	more than 20	less than 2

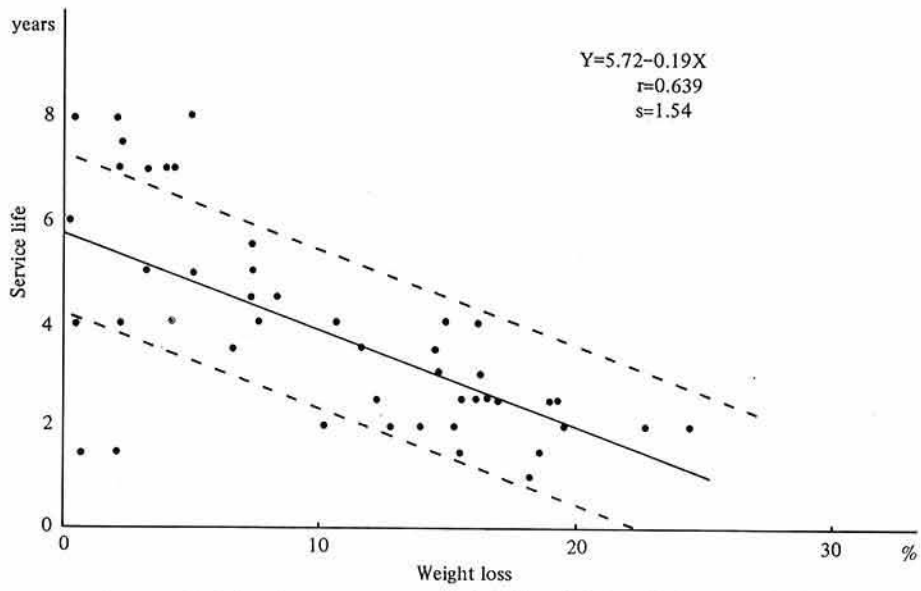

Fig. 1. Relation between average weight loss (%) by *Coriolus versicolor* and average life (years)

The wood species in class I can be used without preserving treatment in field, but the wood species except class I should be used with preserving treatment in field. The wood species in class IV and V should be used with preliminary preserving treatment in green log and timber, because of their susceptibility to blue stain.

Table 3. Classification of decay durability

Class V	1.	Agathis (*Agathis* sp.)
	16.	Jelutong (*Dyera* sp.)
	19.	Karas (*Aquilaria malaccensis*)
	25.	Labura (*Anthocephalus cadamba*)
Class IV	2.	Alstonia (*Alstonia* sp.)
	8.	Campnosperma (*Campnosperma brevipetiolata*)
	9.	Canarium (*Canarium* sp.)
	10.	Celtis (*Celtis* sp.)
	11.	Champaka (*Michelia* sp.)
	14.	Erima (*Octomeles sumatrana*)
	21.	Keledang (*Artocarpus* sp.)
	28.	New Guinea basswood (*Endospermum medullosum*)
	30.	Ramin (*Gonystylus bancanus*)
	34.	Ro yong (*Parkia streptocarpa*)
	38.	Terminalia (*Terminaria* sp.)
	40.	White siris (*Ailanthus* sp.)
Class III	3.	Apitong (*Dipterocarpus* sp.)
	7.	Calophyllum (*Calophyllum* sp.)
	13.	Chhoeuteal sar (*Dipterocarpus alatus*)
	17.	Jongkong (*Dactylocladus stenostachys*)
	22.	Keruing (*Dipterocarpus* sp.)
	27.	Nato (*Palaruim* sp.)
	31.	Red lauan (*Shorea negrosensis*)
	35.	Srol kraham (*Dacrydium elatum*)
	36.	Taun (*Pometia pinnata*)
Class II	12.	Chhoeuteal bangkuoi (*Dipterocarpus insularis*)
	18.	Kapur (*Dryobalanops* sp.)
	20.	Kelat (*Eugenia* sp.)
	26.	Light red meranti (*Shorea* (*Rubroshorea*) sp.)
	29.	Phdiek (*Anisoptera glabra*)
	37.	Teraling (*Tarrietia* sp.)
	39.	White meranti (*Shored* (*Anphoshorea*) sp.)
Class I	4.	Balau (*Shorea* (*Shorea*) sp.)
	5.	Bangkirai (*Shorea* (*Shorea*) sp.)
	6.	Borneo oak (*Quercus* sp.)
	15.	Giam (*Cotylelobium* sp.)
	23.	Koki khsach (*Hopea pierrei*)
	24.	Komnhan (*Shorea hypochra*)
	32.	Resak (*Vatica* sp.)
	33.	Rong leang (*Tristania* sp.)

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