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Density and Specific Gravity of Fifty-Four Lesser- Used Timber Species of Myanmar

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လက်ထောက်သုတေသနအရာရှိ
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စာတမ်းအကျဉ်းချုပ်

သစ်သား၏ အရည်အသွေးနှင့် ဂုဏ်သတ္တိများသည် သစ်မျိုးကိုလိုက်၍ များစွာ ကွာခြားမှုရှိသကဲ့သို့ အလွန်လည်း အရေးကြီးပါသည်။ မြန်မာ့လူသုံးနည်းသစ်မျိုး (၅၄) မျိုး၏ ရူပဆိုင်ရာ ဂုဏ်သတ္တိများကို ရေဆင်း၊ သစ်တောသုတေသနဌာနတွင် ဆောင်ရွက်ခဲ့သော 'မြန်မာ့လူသုံးနည်းသစ်မျိုးများ ကမ္ဘာ့ဈေးကွက်၌ တွင်ကျယ်လာစေရေးစီမံကိန်း'၏ အစီအစဉ်ဖြင့် စမ်းသပ်ခဲ့ပါသည်။ ၎င်းသစ်မျိုးများ၏ သိပ်သည်းခြင်းနှင့် ရေချိန်သိပ်သည်းဆတို့ကို ဤစာတမ်းတွင် တင်ပြထားပါသည်။ သစ်မျိုးတစ်မျိုးခြင်း၏ ရေချိန်သိပ်သည်းဆပေါ်တွင် မူတည်လျက် ပေါ့သော သစ်မျိုးများ၊ အတော်အတန်လေးသောသစ်မျိုးများ၊ လေးသောသစ်မျိုးများနှင့် အလွန်လေးသော သစ်မျိုးများဟူ၍ အတန်းအစား(၄)မျိုး ခွဲခြားထားပြီး သစ်မျိုးများ၏ အသုံးချနိုင်မှု အလားအလာကို ကိုးကားဆွေးနွေး တင်ပြထားပါသည်။ လူသုံးနည်းသစ်မျိုး (၅၄)မျိုးနှင့် ယခုအချိန်ထိ စမ်းသပ်ပြီးဖြစ်သည့် မြန်မာ့သစ်မျိုးများအနက် လက်ပံသည် အပေါ့ဆုံးသစ်မျိုးနှင့် ကြို့သည် အလေးဆုံးသစ်မျိုးဖြစ်ကြောင်း တွေ့ရှိရပါသည်။

Density and Specific Gravity of Fifty-Four Lesser- Used Timber Species of Myanmar

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Abstract

The properties and characteristics of timber species are widely varied, however, they are very important for timber utilization. In this study, density and specific gravity of fifty-four lesser-used timber species (LUS) were analysed based on the results obtained from the tests on physical properties. These tests were carried out at the Forest Research Institute (FRI), Yezin, under the title "Introducing Myanmar's Lesser- Used Timber Species to the World Market" project. Based on specific gravity, fifty-four LUS are categorised into four classes viz:- light, moderately heavy, heavy and very heavy. The utility of the tested species are also discussed according to their basic specific gravity. Letpan is found to be the lightest and Gyo is found to be the heaviest Myanmar timber among the tested fifty-four LUS as well as among the Myanmar timbers so far tested.

Contents

1. Introduction

As wood and wood-based products are recyclable, renewable, biodegradable and environmentally friendly with sustainable origin, global demand for forest products, especially those of tropical timber grows faster than sustainable supply. To meet the demand, indigenous tree species producing valuable timber, except commercial timbers have now come to be of considerable potential importance for local use and export. In view of the improved utilization of lesser-used timber species (LUS), their technological information, which remains to be developed, should be known.

In collaboration with International Tropical Timber Organization (ITTO), the Forest Department has undertaken a project on “Introducing Myanmar’s Lesser-Used Timber Species to the World Market”. Properties of some LUS have been investigated at the Forest Research Institute (FRI), Yezin under this project. The research on anatomical characteristics, physical properties, mechanical properties, drying behavior, durability, treatability and workability of fifty-four LUS were carried out during the project period (Kyi -1 , 2000).

Density and specific gravity are the important factors in determining the physical and mechanical properties which characterize different kinds of wood and often individual pieces of the same kind, even when these are from the identical tree.

The amount of wood substance in a given block of wood is a reliable indicator of its strength properties and, to a certain degree, of its working and finishing characteristics as well. The density of wood also controls the extent of the dimensional changes that take place in it with changes in the moisture content (MC) below the fiber saturation point (FSP). Thus influencing the basic properties of wood, density plays an important part in determining the utility of a given kind of wood, indeed even of a given piece, for a specific purpose (Brown et al , 1952). Density of homogenous material is defined as its mass per unit volume. Density is usually expressed as slugs per cubic foot, grams per cubic centimeter, or kilograms per cubic meter. Values for density are commonly cited in the metric system, but in the English system true density values are not given because the units are unfamiliar to people other than physicists. In English speaking countries, the term density is employed for weight per unit volume (Panshin & de Zeeuw, 1980).

For wood, density is customarily calculated on the basis of both the mass (or weight) and the volume of the piece taken at the same MC.

Specific gravity (Sp.Gr) in comparison with density, is the ratio of the density of a material to the density of a standard substance taken at a specified temperature. Water at its greatest density (4 $^{\circ}$C) has become practically the universal standard substance in determining the specific gravity of all substances including wood. The term specific gravity is very misleading since it has nothing to do with gravity. A more suitable name for this concept is density index or relative density.

In determining the specific gravity of wood, the ovendry weight of the wood is always used as the numerator. The value of the denominator, which depends on the volume of the wood, varies with the MC of the test block, because of the dimensional changes that occur in wood below the FSP. For this reason it is necessary to specify the MC of the wood at which the volume was determined, when stating the specific gravity. Specific gravity of wood based on green volume, or basic specific gravity, is one of the most useful and commonly cited values. The term basic is applied since both green volume and ovendry weight are as nearly constant and reproducible measurement as can be obtained with wood (Panshin & de Zeeuw, 1980).

Wood is used in a wide range of conditions and thus has a wide range of moisture contents in use. Since moisture makes up part of the weight of each product in use, the density must reflect this fact. This has resulted in the density of wood often being determined and reported on a moisture content-in-use condition. This determination of density usually is sufficiently accurate to permit proper utilization of wood products where weight is important. Such applications range from estimation of structural loads to the calculating of approximate shipping weights. To standardize comparisons of species or products and estimation of product weights, specific gravity is used as a standard reference basis, rather than density (Wood handbook, 1974).

The present study is intended to categorise the fifty-four LUS into four classes viz; light, moderately heavy, heavy and very heavy based on their basic specific gravity and to propose the utility of the tested-LUS.

2. Materials and Methods

Wood samples tested in this study were collected from the Kaboung Reserved Forest and Phyu Kwin Reserved Forest of Taungngu District, Bago Division. These samples were identified and authenticated by Wood Anatomy Section, FRI.

Some physical properties such as, specific gravity, density, radial shrinkage, tangential shrinkage and volumetric shrinkage of each of the fifty-four LUS were tested. These properties were determined using the test procedure described in ASTM designation; D 143-52 (1965) developed by the American Society for Testing and Materials (ASTM).

3. Results and Discussion

Density and specific gravity at green and air dry states and radial shrinkage and tangential shrinkage from green to ovendry conditions of the tested fifty-four LUS are given in Table (1).

In this study, fifty-four LUS are categorized into four classes according to their basic specific gravity (based on ovendry weight and green volume) and are given in Table (2). Here, woods with basic specific gravity of 0.360 and less are considered to be light, 0.361 to 0.500 moderately heavy, 0.501 to 0.800 heavy and above 0.800, very heavy. Bar chart of basic specific gravity of 54 LUS is given in Fig.(1). This bar chart is drawn in the ascending order and also categorized into four classes so as to have a clear observation.

It is found that, **Letpan** which has the basic specific gravity 0.260 is the lightest whereas **Gyo** which has the basic specific gravity 0.938 is the heaviest among the fifty-four LUS. The lightest timber in the world is reported to be *Alstonia spatulata* which basic specific gravity being 0.0394 to 0.0580 and letter wood of Dutch Guiana (*Piratinera guianesis*) ,which basic specific gravity being 1.363 is recorded to be the heaviest timber in the world (Tiemann, 1951). In fact, the density of the dry cell-wall is noted to be 1.451 to 1.525 g/cc (Skaar,1972).

According to table (2), Gyo, Taukkyan and Thitmagyi are found to be very heavy timbers whereas Letpan, Gwe, Bonmeza, Hmyaseik, Myaukthwegyi, Thapan and Shaw are found to be light timbers. It can be seen that, more than half of the tested LUS lie in the heavy group.

Table (1) Density, Specific Gravity and Shrinkage of Fifty-Four LUS of Myanmar

Sr. No.	Species	Seasoning	Moisture Content (%)	Density (Kgm^{-3})	Specific Gravity	Shrinkage (Green to Oven-Dry)	
						Radial (%)	Tangential (%)
1.	Baing (*Tetrameles nudiflora*)	Green Air-Dry	113.2 12.0	800 449	0.376 0.400	3.5 -	8.5 -
2.	Binga (*Mitragyna rotundifolia*)	Green Air-Dry	67.0 12.0	925 665	0.554 0.595	4.0 -	8.2 -
3.	Bonmeza(*Albizzia chinensis*)	Green Air-Dry	171.1 12.0	790 340	0.291 0.304	2.2 -	6.2 -
4.	Chinyok(*Garuga pinnata*)	Green Air-Dry	101.1 12.0	1209 716	0.601 0.640	3.3 -	6.1 -
5.	Didu (*Salmalia insignis*)	Green Air-Dry	143.9 12.0	886 429	0.363 0.385	2.8 -	5.9 -
6.	Dwabok (*Kydia calycina*)	Green Air-Dry	96.9 12.0	843 508	0.429 0.453	3.0 -	6.6 -
7.	Dwani (*Eriolaena candollei*)	Green Air- Dry	66.2 13.0	1194 857	0.719 0.766	4.2 -	6.9 -
8.	Gwe (*Spondias pinnata*)	Green Air-Dry	196.4 12.0	826 330	0.280 0.295	2.1 -	5.6 -
9.	Gyo (*Schleichera oleosa*)	Green Air-Dry	34.0 12.0	1258 1157	0.938 1.034	5.0 -	10.8 -
10.	Hmyaseik (*Antiaris toxicaria*)	Green Air-Dry	123.2 12.0	747 394	0.335 0.353	2.7 -	5.3 -
11.	Hnaw (*Adina cordifolia*)	Green Air-Dry	60.2 12.0	975 713	0.601 0.637	3.6 -	6.5 -
12.	Kokko (*Albizzia lebbek*)	Green Air-Dry	68.6 12.0	907 633	0.538 0.565	3.0 -	6.0 -
13.	Kuthan (*Hymenodictyon excelsum*)	Green Air-Dry	131.4 12.0	941 479	0.404 0.427	3.2 -	6.1 -
14.	Kyetyo (*Vitex peduncularis*)	Green Air-Dry	50.1 12.o	1141 918	0.761 0.820	4.9 -	9.2 -
15.	Lein (*Terminalia pyrifolia*)	Green Air-Dry	72.2 12.0	1109 793	0.644 0.709	5.9 -	9.2 -
16.	Letpan (*Salmalia malabarica*)	Green Air-Dry	119.0 12.0	571 304	0.260 0.272	2.1 -	4.9 -
17.	Leza (*Lagerstroemia tomentosa*)	Green Air-Dry	59.8 12.0	931 702	0.583 0.627	4.9 -	7.6 -
18.	Ma-U-lettan-she (*Anthocephalus cadamba*)	Green Air-Dry	94.3 12.0	848 524	0.436 0.467	3.8 -	8.0 -
19.	Myaukchaw (*Homalium tomentosum*)	Green Air-Dry	30.5 12.0	1013 950	0.776 0.848	5.6 -	10.7 -
20.	Myaukngo (*Duabanga grandiflora*)	Green Air-Dry	114..5 12.0	979 546	0.464 0.488	3.2 -	5.1 -
21.	Myaukthwegyi (*Myristica spp.*)	Green Air-Dry	129.1 12.0	777 407	0.339 0.363	4.0 -	7.0 -
22,	Myaukthwethe (*Myristica angustifolia*)	Green Air-Dry	56.3 12.0	856 655	0.549 0.585	4.3 -	8.4 -
23.	Nabe (*Lannea coromandelica*)	Green Air-Dry	78.7 12.0	1199 787	0.672 0.704	3.5 -	6.0 -
24.	Panga (*Terminalia chebula*)	Green Air-Dry	62.2 12.0	1263 960	0.779 0.856	5.4 -	11.0 -
25.	Petthan (*Haplophragma adenophyllum)*	Green Air-Dry	41.5 12.0	1055 897	0.745 0.801	4.4 -	7.5 -
26.	Pyaukseik (*Holoptelea integrifolia*)	Green Air-Dry	64.9 12.0	915 686	0.567 0.612	3.8 -	8.5 -

Table (1) (Concluded)

Sr. No.	Species	Seasoning	Moisture Content (%)	Density (Kgm^{-3})	Specific Gravity	Shrinkage (Green to Oven-Dry)	
						Radial (%)	Tangential (%)
27.	Pyinma (*Lagerstroemia speciosa*)	Green Air-Dry	71.6 12.0	906 630	0.529 0.563	3.1 -	7.4 -
28.	Seikchi (*Bridelia retusa*)	Green Air-Dry	98.2 12.0	1156 678	0.583 0.606	2.2 -	5.9 -
29.	Shaw (*Sterculia versicolor*)	Green Air-Dry	86.5 12.0	654 412	0.352 0.366	1.9 -	5.9 -
30.	Sit (*Albizzia procera*)	Green Air-Dry	69.4 12.0	1220 845	0.720 0.754	2.8 -	5.5 -
31.	Taukkyan (*Terminalia tomentosa*)	Green Air-Dry	44.8 12.0	1221 992	0.815 0.885	5.7 -	8.4 -
32.	Taungmeok (*Alstonia scholaris*)	Green Air-Dry	96.9 12.0	761 462	0.388 0.412	3.5 -	5.5 -
33.	Taungokshit (*Elaeocarpus spp.*)	Green Air-Dry	46.5 12.0	1011 829	0.691 0.739	3.0 -	8.1 -
34.	Taungpeinne (*Artocarpus chaplasha*)	Green Air-Dry	106.3 12.0	899 506	0.435 0.453	1.8 -	4.3 -
35.	Taungpetwum (*Pterospermum acerifolium*)	Green Air-Dry	79.9 12.0	870 577	0.483 0.515	3.8 -	6.7 -
36.	Taungthayet (*Swintonia floribunda*)	Green Air-Dry	84.2 12.0	1029 655	0.558 0.585	2.7 -	5.9 -
37.	Tawthayet (*Mangifera spp.*)	Green Air-Dry	75.6 12.0	1021 780	0.582 0.611	3.6 -	5.6 -
38.	Thabye (*Eugenia spp.*)	Green Air-Dry	51.4 12.0	1021 819	0.674 0.732	4.3 -	9.3 -
39.	Thadi (*Protium serratum*)	Green Air-Dry	73.2 12.0	1205 856	0.697 0.764	5.8 -	10.2 -
40.	Thande (*Stereospermum personatum*)	Green Air-Dry	53.0 12.0	1109 875	0.725 0.781	4.8 -	8.4 -
41.	Thapan (*Ficus spp.*)	Green Air-Dry	121.5 12.0	763 405	0.344 0.362	2.7 -	6.7 -
42.	Thingadu (*Parashorea stellata*)	Green Air-Dry	59.2 12.0	883 671	0.561 0.599	3.8 -	7.4 -
43.	Thitkado (*Cedrela toona*)	Green Air-Dry	75.8 12.0	723 479	0.410 0.428	3.1 -	6.4 -
44.	Thitmagyi (*Albizzia odoratissima*)	Green Air-Dry	43.2 12.0	1149 949	0.803 0.847	2.9 -	6.3 -
45.	Thitpagan (*Millettia brandisiana*)	Green Air-Dry	133.8 12.0	1029 574	0.440 0.513	6.7 -	14.5 -
46.	Thitpayaung (*Nauclea sessilifolia*)	Green Air-Dry	61.6 12.0	1164 907	0.720 0.810	6.6 -	15.3 -
47.	Thitsein (*Terminalia belerica*)	Green Air-Dry	53.5 12.0	1101 883	0.717 0.788	6.4 -	9.7 -
48.	Thitswele (*Schrebera swietenioides*)	Green Air-Dry	48.7 12.0	1048 840	0.705 0.751	4.5 -	7.1 -
49.	Yemane (*Gmelina arborea*)	Green Air-Dry	125.6 12.0	1056 551	0.469 0.492	3.0 -	5.5 -
50.	Yindaik (*Dalbergia cultrata*)	Green Air-Dry	39.6 12.0	1108 982	0.792 0.878	6.2 -	10.1 -
51.	Yinma (*Chukrasia tabularis*)	Green Air-Dry	59.2 12.0	1239 946	0.781 0.885	5.2 -	9.7 -
52.	Yinzat (*Dalbergia fusca*)	Green Air-Dry	45.9 12.0	1026 853	0.704 0.762	4.2 -	9.7 -

Table (1) (Concluded)

Sr. No.	Species	Seasoning	Moisture Content (%)	Density (Kgm^{-3})	Specific Gravity	Shrinkage (Green to Oven-Dry)	
						Radial (%)	Tangential (%)
53.	Yon (*Anogeissus acuminata*)	Green Air-Dry	40.6 12.0	1071 926	0.762 0.827	5.4 -	9.4 -
54.	Zaungbale (*Lagerstroemia villosa*)	Green Air-Dry	66.0 12.0	991 721	o.597 0.644	4.7 -	7.1 -

Table(2) Four Classes of Fifty-four LUS Based on Basic Specific Gravity

Light Species	Moderately Heavy Species	Heavy Species	Very Heavy Species
1.Letpan (0.260)	1.Didu (0.363)	1.Pyinma (0.529)	1.Thitmagyi (0.803)
2.Gwe (0.280)	2.Baing (0.376)	2.Kokko(0.538)	2.Taukkyan (0.815)
3.Bonmeza(0.291)	3.Taungmeok(0.388)	3.Myaukthwethe (0.549)	3.Gyo (0.938)
4.Hmyaseik (0.335)	4.Kuthan (0.404)	4.Binga (0.554)	
5.Myaukthwegyi (0.339)	5.Thitkado (0.410)	5.Taungthayet (0.558)	
6.Thapan (0.344)	6.Dwabok (0.429)	6.Thingadu (0.561)	
7.Shaw (0.352)	7.Taungpeinne (0.435)	7.Pyaukseik (0.567)	
	8.Ma-U-lettan-she (0.436)	8.Tawthayet (0.582)	
	9.Thitpagan (0.440)	9.Seikchi (0.583)	
	10.Myaukngo (0.464)	10.Leza (0.583)	
	11.Yemane (0.469)	11.Zaungbale (0.597)	
	12.Taungpetwun (0.483)	12.Hnaw (0.601)	
		13.Chinyok (0.601)	
		14.Lein (0.644)	
		15.Nabe (0.672)	
		16.Thabye (0.674)	
		17.Taungokshit (0.691)	
		18.Thadi (0.697)	
		19.Yinzat (0.704)	
		20.Thitswele (0.705)	
		21.Thitsein (0.717)	
		22.Dwani (0.719)	
		23.Thitpayaung (0.720)	
		24.Sit (0.720)	
		25.Thande (0.725)	
		26.Petthan (0.745)	
		27.Kyetyo (0.761)	
		28.Yon (0.762)	
		29.Myaukchaw (0.776)	
		30.Panga (0.779)	
		31.Yinma (0.781)	
		32. Yindaik (0.792)	

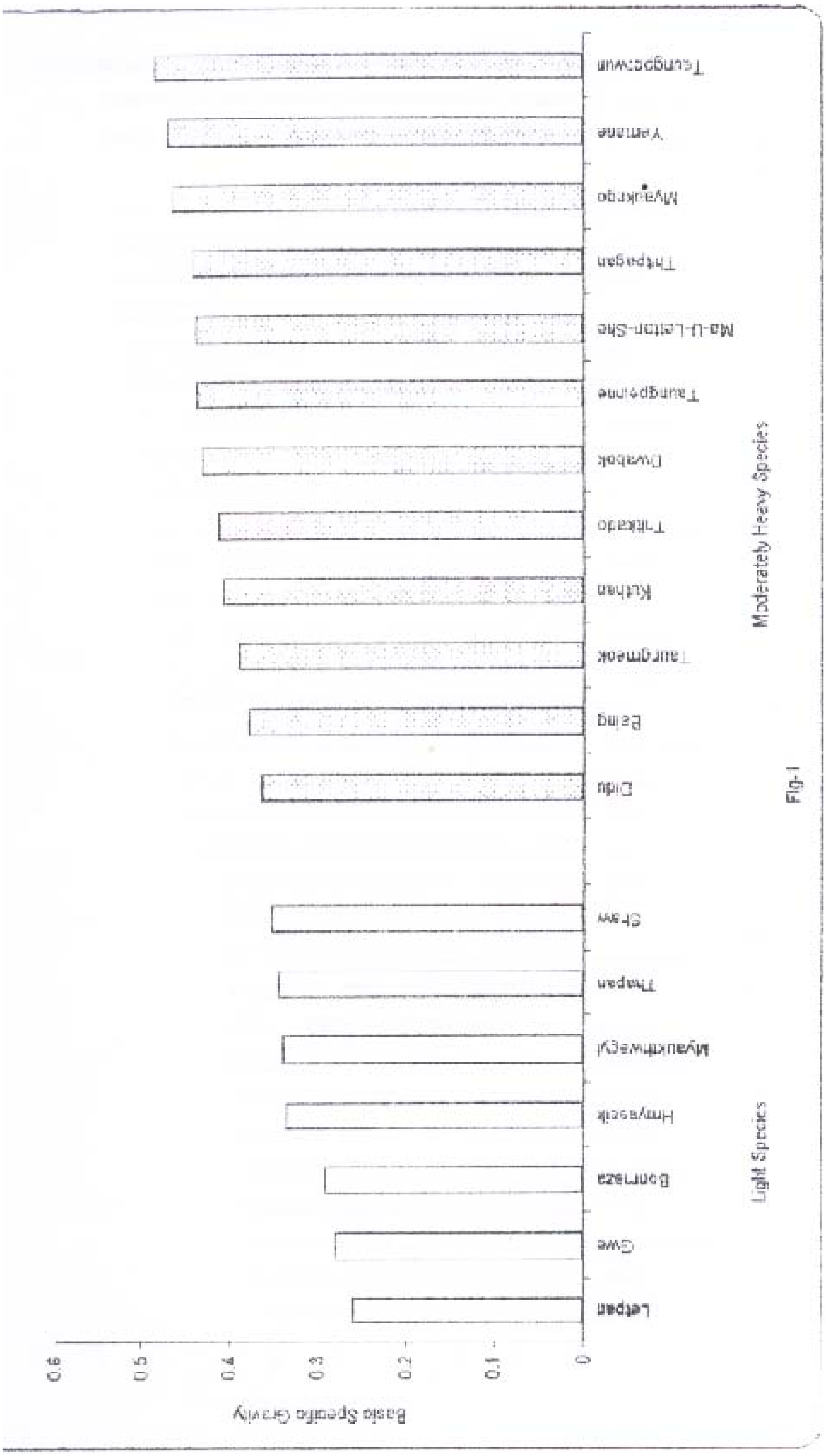
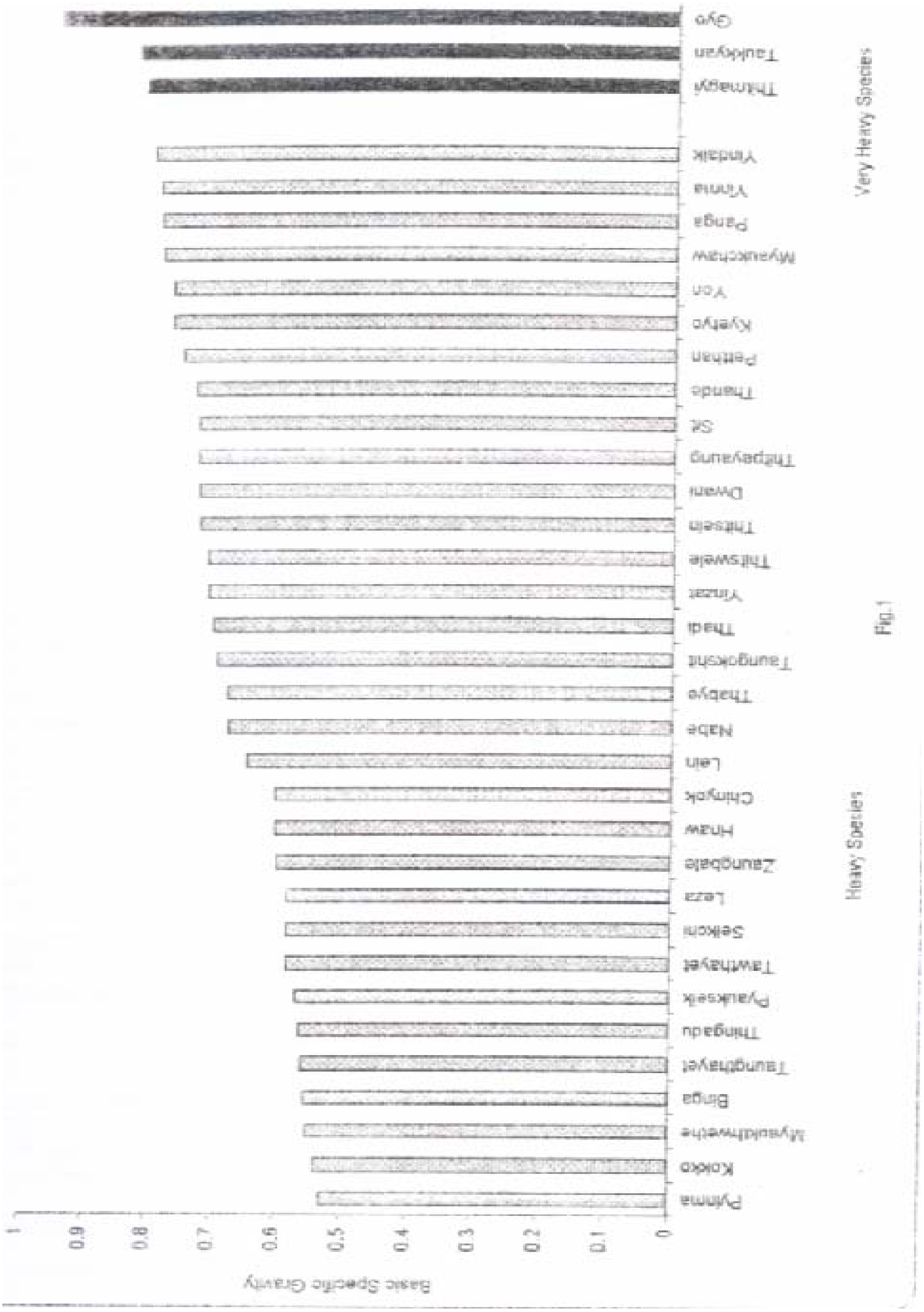

Basic Specific Gravity
0
0.1
0.2
0.3
0.4
0.5
0.6
Light Species
Moderately Heavy Species

Fig-1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Basic Specific Gravity
Very Heavy Species
Heavy Species

Fig.1

Table (3) Density, Specific Gravity and Shrinkage of Some Important Commercial Timbers and Some Other Timbers of Myanmar

Sr. No.	Species	Seasoning	Moisture Content (%)	Density (Kgm^{-3})	Specific Gravity	Shrinkage (Green to Oven-Dry)	
						Radial (%)	Tangential (%)
1.	Kyun (*Tectona grandis*)	Green Air-Dry	51.8 13.9	913 673	0.598 0.596	2.3 -	.4.2 -
2.	Pyinkado (*Xylia dolabriformis*)	Green Air-Dry	48.6 10.3	1154 897	0.779 0.816	3.3 -	6.7 -
3.	Padauk (*Pterocarpus macrocarpus*)	Green Air-Dry	43.8 12.5	1074 865	0.752 0.769	3.4 -	5.1 -
4.	Thitya (*Shorea oblongifolia*)	Green Air-Dry	46.3 10.6	1250 1026	0.858 0.933	5.4 -	9.7 -
5.	Ingyin (*Pentacme siamensis*)	Green Air-Dry	54.3 13.4	1202 929	0.779 0.819	4.8 -	8.9 -
6.	In (*Dipterocarpus tuberculatus*)	Green Air-Dry	50.3 19.4	1090 897	0.726 0.755	4.4 -	9.1 -
7.	Kanyin – byu (*Dipterocarpus alatus*)	Green Air-Dry	73.4 17.2	994 705	0.574 o.6o4	3.6 -	8.6 -
8.	Kanyin –ni (*Dipterocarpus turbinatus*)	Green Air-Dry	65.7 14.3	1090 785	0.655 0.689	4.2 -	8.9 -
9.	Binga (*Mitragyna rotundifolia*)	Green Air-Dry	58.4 12.8	881 657	0.553 0.586	3.8 -	7.3 -
10.	Eucalypt (*Eucalyptus camaldulensis*) 18 years old	Green Air-Dry	76.7 12.0	1138 833	0.713 0.827	3.9 -	7.3 -
11.	Kanyaung (*Shorea argentea*)	Green Air-Dry	56.9 12.7	1090 817	0.706 0.731	5.5 -	10.9 -
12.	Kaunghmu (*Anisoptera scaphula*)	Green Air-Dry	117.8 -	1042 -	0.475 -	- -	- -
13.	Kyana (*Xylocarpus moluccensis*)	Green Air-Dry	45.0 11.9	975 785	0.670 0.702	3.0 -	5.5 -
14.	Nyan (*Quercus serrata*)	Green Air-Dry	74.7	1026	0.650	4.4 -	10.1 -
15.	Pinle-kanazo (*Heritiera fomes*)	Green Air-Dry	56.3 11.4	1234 1026	0.792 0.927	5.9 -	11.6 -
16.	Shanthabye (*Eucalyptus grandis*)	Green Air-Dry	- 12.0	1202 753	- -	3.1-4.0 -	5.1-6.5 -
17.	Thingan (*Hopea odorato*)	Green Air-Dry	73.9 12.1	1106 753	0.637 0.675	3.4 -	6.5 -
18.	Thinwin (*Millettia pendula*)	Green Air-Dry	44.3 -	1199 937	0.850 0.970	4.3 -	7.7 -
19.	Thitka (*Pentace burmanica*)	Green Air-Dry	37.0 13.9	769 657	0.558 0.573	3.1 -	6.5 -
20.	Thitmin (*Podocarpus wallichianus*)	Green Air-Dry	45.5 13.2	673 545	0.462 0.480	3.7 -	6.6 -
21.	Tinyu (*Pinus kaysia*)	Green Air-Dry	65.7 12.7	913 561	0.470 0.560	6.5 -	9.6 -
22.	Tinyu (*Pinus insularis*)	Green Air-Dry	61.9 12.8	913 572	0.460 0.490	4.7 -	8.0 -

Source: Physical and Mechanical Properties of Some Myanmar Timbers (Kyi-1,1993)

For comparison, density, specific gravity, radial shrinkage and tangential shrinkage of some important commercial timbers and other timbers of Myanmar are also given in Table (3) (Kyi-1,1993). From this table, it can be seen that, basic specific gravity of Thitya being 0.858 is the highest among the given species. Thus, Gyo which specific gravity being 0.938 can be recorded as the heaviest Myanmar timber so far tested. Similarly, Tinyu (*Pinus insularis*) which has a basic specific gravity of 0.460 is the lightest timber among those species mentioned in Table (3). Therefore, Letpan which specific gravity being 0.260 can be recorded as the lightest Myanmar timber so far tested.

Locally, Gyo gets a bad reputation among the sawmill owners. They are very much reluctant to saw this timber at their sawmills. Gyo is locally used as cartwheels, axles, ploughs, tool-handles, oil and sugar mills, ricepounders, etc. (Rodger, 1963).

Comparing table (1) and table (3), it can be seen that basic specific gravity of Chinyok, Hnaw, Leza, Seikchi, Tawthayet and Zaungbale are almost equal to that of Kyun. Thus, it can be assumed that these timbers could be as useful as Kyun. However, other characteristics, such as colour, grain pattern, dimensional changes, workability, drying behavior and durability have to be taken into consideration. Among these six species, Seikchi and Tawthayet which have the lower tangential shrinkage (5.9 % & 5.6%) could be suitable for making furniture and other quality wood products.

According to table (3), basic specific gravity of Pyinkado (known as Myanmar Ironwood) which is accepted as the best structural timber in Myanmar is 0.779.Thus Gyo, Panga, Taukkyan, Thitmagyi, Yindaik and Yinma which have the basic specific gravity above or equal to 0.779 could be assumed as suitable for structural timber. However, for structural timber durability is the secondary factor to be taken into account.

It is to be expected that the degree of shrinkage across the grain would be more or less, proportional to the specific gravity of the wood since both are functions of cell-wall thickness (Brown et al, 1952). Correlation between basic specific gravity and tangential shrinkage of the 54 LUS had been studied (Kyi-1, 2000). According to that study, it was reported that the tangential shrinkage of the tested 54 LUS are significantly correlated to the basic specific gravity at 0.05 α-level by the equation $Y = 6.8392 X + 3.73$ where X = basic specific gravity and Y = tangential shrinkage.

The ignition temperature of wood is usually given as about 275ºC and is actually the temperature at which wood begins to decompose exothermically, i.e. with liberation of heat. Fuel value of wood is primarily determined by the density or specific gravity of the wood. The heat of combustion (H) i.e., the heat in Btu produced by burning 1 pound of ovendry wood, averages about 8500 Btu for hardwoods and 9000 Btu for conifers. Actual heat produced by burning wood containing some moisture is lower than the value H quoted above, because part of the heat is lost in removing the water and vaporizing it (Panshin & de Zeeuw, 1980). Therefore, basic specific gravity based on ovendry weight and green volume can be used as one of the important criteria in selecting the suitable tree species for fuelwood plantations. If the growth rates of the two species selected for establishing fuelwood plantation are the same, the outturn (i.e. green volume) of fuelwood will be the same. However, in term of weight, species which has higher specific gravity will produce higher amount of heat energy.

From tables (1) and (3), basic specific gravity of Letpan and Eucalypt which are known to be fast growing tree species are 0.260 and 0.713. Wood samples tested for Eucalypt species was obtained from a 18 years-old tree which girth at breast height being 5 feet- 1 inch (Sum & Win Kyi-1, 1975). Assuming that the growth rate of Letpan and Eucalypt are the same and the outturn of 10 year-old fuelwood plantation of both species are 50 ton (2500 cubic feet) per acre, the ovendry weight produced by 1 acre of Letpan plantation will be 40,560 lb, whereas that of Eucalypt plantation will be 111,238 lb. Similarly, since the basic specific gravity of Eucalypt and Myaukchaw are nearly equal, 0.713 and 0.776, it will be better to select Eucalypt which has faster growth than Myaukchaw if the environment conditions are the same. Thus, basic specific gravity of tree species should be taken into account as one of the prime factors for selecting suitable tree species in the establishment of fuelwood plantations. In fact, according to the preliminary tests conducted at the Timber Physics Section, FRI, specific gravity of Bawzagaing (*Leucaena leucocephala*) and *Acacia auriculiformis* are found to be 0.490 to 0.619 and 0.600 to 0.710, respectively.

4. Conclusions

As a result of this study, the following conclusions can be drawn,

(1) Out of the tested fifty-four LUS, seven species are light, twelve species are moderately heavy, thirty-two species are heavy and three species are found to be very heavy.

(2) Letpan is the lightest and Gyo is the heaviest among the tested fifty-four LUS as well as among the Myanmar timbers so far tested.

(3) Basic specific gravity of Chinyok, Hnaw, Leza, Seikchi, Tawthayet and Zaungbale are almost equal to that of Kyun.

(4) Basic specific gravity of Gyo, Panga. Taukkyan, Thitmagyi, Yindaik and Yinma are above or equal to that of Pyinkado.

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