Government of the Union of Myanmar

Ministry of Forestry

Forest Department

Density, Specific Gravity and Dimensional Stability of Seventy- Five Timber Species in Myanmar

Cho Cho Win (Research Assistant -2)
Forest Research Institute

Prof: Win Kyi -1
University of Forestry

July 2008

မြန်မာနိုင်ငံမှ သစ်မျိုး (၇၅) မျိုး၏ သိပ်သည်းခြင်း၊ ရေချိန်သိပ်သည်းဆနှင့် ပုံသဏ္ဍာန် တည်မြဲမှု တို့ကို ဆန်းစစ်လေ့လာခြင်း

ဒေါ်ချိုချိုဝင်း B.Sc. (Chem.), M.Sc. (Wood Preservation)
သုတေသနလက်ထောက်-၂
သစ်တောသုတေသနဌာန

ပါမောက္ခဦးဝင်းကြည်-၁
B.Sc (Hons.), (D.S.), M.S. (Virginia Tech)
သစ်တောတက္ကသိုလ်

စာတမ်းအကျဉ်းချုပ်

သစ်မျိုးတစ်မျိုး၏ ဂုဏ်သတ္တိနှင့် စရိုက်လက္ခဏာများသည် ၎င်းကို အသုံးချရာတွင် အရေးကြီးသော အချက်များ ဖြစ်ပါသည်။ ရူပဂုဏ်သတ္တိများသည် သစ်အသုံးချမှုနှင့် ကျယ်ပြန့်စွာ ဆက်သွယ်မှုရှိသဖြင့် သစ်မျိုးရွေးချယ်ရာတွင် ၎င်းတို့အပေါ် အခြေခံစဉ်းစားနိုင်ပါသည်။ ဤစာတမ်းတွင် မြန်မာနိုင်ငံရှိ သစ်မျိုး (၇၅) မျိုး၏ သိပ်သည်းခြင်း၊ ရေချိန်သိပ်သည်းဆနှင့် ပုံသဏ္ဍာန် တည်မြဲမှု တို့ကို လေ့လာဆန်းစစ် ထားပါသည်။ သစ်မျိုးတစ်မျိုးခြင်း၏ ရေချိန် သိပ်သည်းဆပေါ်မူတည်၍ ပေါ့သော သစ်မျိုးများ၊ အတော်အတန်လေးသော သစ်မျိုးများ၊ လေးသောသစ်မျိုးများနှင့် အလွန်လေးသော သစ်မျိုးများ ဟူ၍ အတန်းအစား (၄) မျိုး ခွဲခြား ထားပါသည်။ နှစ်ကွင်းနှင့် ထောင့်မတ် ကျုံ့မှု၊ နှစ်ကွင်းနှင့် အပြိုင်ကျုံ့မှု များကို အစိုမှ အစိုခါတ် (၂၀%)၊ အစိုမှ အစိုခါတ် (၁၂%)၊ အစိုခါတ် (၂၀%) မှ (၁၂%) ရှိ ကျုံ့မှုအသီးသီးကို တွက်ချက်တင်ပြထားပါသည်။ သစ်မျိုးတစ်မျိုးချင်း၏ ပုံသဏ္ဍာန် တည်မြဲမှုကို ၎င်းသစ်မျိုး၏ နှစ်ကွင်းနှင့် ထောင့်မတ်ကျုံ့မှု၊ နှစ်ကွင်းနှင့် အပြိုင်ကျုံ့မှုများ အပေါ် အခြေခံ၍ တွက်ချက်တင်ပြထားပါသည်။ လေ့လာတွေ့ရှိချက်များအရ သစ်မျိုး (၇၅) မျိုး အနက် (၇) မျိုးမှာ ပေါ့သောသစ်၊ (၁၇) မျိုးမှာ အတော်အတန်လေးသောသစ်၊ (၄၆) မျိုးမှာ လေးသောသစ်နှင့် (၅) မျိုးမှာ အလွန်လေးသောသစ်မျိုးများ ဖြစ်ကြောင်းတွေ့ရှိရပါသည်။ ၎င်းတို့အနက် လက်ပံသည် အပေါ့ဆုံးဖြစ်ပြီး ကြို့သည် အလေးဆုံး သစ်မျိုးဖြစ်ကြောင်း တွေ့ရပါသည်။ စမ်းသပ်ပြီးသစ်မျိုးများအနက် (၂၃) မျိုးသည် အရည်အသွေးမြင့် သစ်သားထည် ပစ္စည်းများ ပြုလုပ်ရန်သင့်တော်ကြောင်း တွေ့ရပါသည်။

Density, Specific Gravity and Dimensional Stability of Seventy-Five Timber Species in Myanmar

Daw Cho Cho Win, B.Sc. (Chem.), M. Sc. (Wood Preservation)
Research Assistant-2
Forest Research Institute

Prof: Win Kyi-1
B.Sc (Hons.), (D.S.), M.S. (Virginia Tech)
University of Forestry

Abstracts

The properties and characteristics of wood species are very important keys for successful utilization of timber. Complete investigation of wood properties may take considerable time but most of physical properties of wood are immediately available for consideration in a broad sense in relation to use. In this study, density, specific gravity and dimensional stability of seventy-five timber species in Myanmar were analysed based on the results obtained from the previous tests. Based on the specific gravity, seventy-five species are categorized into four classes viz: light, moderately heavy, heavy and very heavy. The tangential and radial shrinkage from green to 20% MC, green to 12%MC and 20% MC to 12%MC were calculated based on the shrinkage values from green to oven dry. The dimensional stability were calculated based on tangential and radial shrinkage values. According to this study, out of the presented seventy-five species, seven species are light, seventeen species are moderately heavy, forty-six species are heavy and five species are very heavy. Letpan is the lightest and Gyo is the heaviest. Basic specific gravity of Chinyok, Hnaw, Leza, Seikchi, Tawthayet and Zaungbale are almost equal to that of Kyun. Basic specific gravity of Gyo, Thitya, Thinwin, Taukkyan, Thitmagyi, Pinlekanazo, Yindaik, Yinma, Panga and Tinyu are above or equal to that of Pyinkado. Twenty-three species could be suitable for making high quality wood products.

Contents

1. Introduction

Men have used timbers and found it suitable for their daily needs since his earliest days. Timber has been used extensively for structural and non-structural purposes throughout human history although its properties were not thoroughly understood. Timbers were then chosen which not only possessed the properties necessary for efficient service but also were available in the sizes and quantities required (Wallis, 1970). It was widely used as a construction material in the industrial era of the 19th century, in house framing and also in making furniture, water wheels, gear wheels, the rails of early pit railways sleepers, signal poles and boats (Dinwoodie, 1981).

The superiorities of timber as a structural material are as follows:

(1) It is light and easy to handle, cut, drill and nail
(2) It has a high resistance to shock loading and to loads of short duration.
(3) Thermal expansion and contraction are very small.
(4) Large size members do not quickly lose their structural rigidity in a fire.
(5) Properly treated, it requires little maintenance (Beckett, 1986).

In selecting individual timbers for particular uses under present day conditions it is most important to obtain if possible the answers to three questions for each timber considered:-

1) What is it correct identity in standard trade common and botanical names?
2) What sizes and quantities are available at economic cost?
3) What natural properties has the timber, good and bad, relative to the used proposed?

It is evident that for each particular use the essential requirements to be met by the woodwork were carefully considered. Some timbers have become so closely related to particular uses that timber craftsmen have tendency to believe that no other timber could be suitable for the work, or at least could not give the same degree of efficiency. In many places, timbers widely accepted and used in the past have become increasingly difficult and expensive to procure and it has been found necessary to reassess the position, both from the view point of continued availability and basic quality of timber for the woodwork to be carried out.

As only a few species of the wide variety available are used in both domestic consumption as well as export, scarcity of those species is expected eventually. The situation of diminishing supply and an increasing demand of such quality timbers will be met at an increased cost. To meet the demand, the utilization of new timber species is significant. In view of the improved utilization of lesser-used timber species (LUS), their technological information, which remains to be developed, shall be investigated.

Complete investigation of wood properties, particularly of lesser – used timbers, may take considerable time but most of wood properties are immediately available for consideration in a broad sense in relation to use. In fact, a point score, both and against, can be made for most timbers provided that users is able to agree upon the properties which are, and are not essential and the relative importance of each for the work in hand.

It is probably true that for most uses, the three most important keys to investigate the successful utilization of timber are a detailed knowledge of its **density, specific gravity** and **shrinkage.**

In this study, density, specific gravity and dimensional stability of seventy-five timber species in Myanmar are gathered and analysed.

The objectives of the present study are:

(1) To categorize seventy-five timbers so far tested into four classes viz: light, moderately heavy, heavy and very heavy based on their basic specific gravity.

(2) To propose some timber species which could be best suited among the mentioned species for manufacturing high quality wood products based on their dimensional stability and absolute transverse dimensional changes.

2. Literature Review

2.1. Density

Density is an important factor in determining the physical and mechanical properties, which characterize different kinds of wood and individual pieces of the same kind, even when these are from the identical tree. Wood density has a close affinity with a number of other properties, which have great significance in successful utilization. In the first place, it is a reliable general guide to the "workability" or ease of working of any timber.

There is a correlation between strength properties and density of wood. For Australia timbers, Pearson (1965) calculated the correlation between strength properties in small clear specimens. He calculated that density at 12% MC should be used as a parameter for classifying timber species into strength groups (Appendix I).

The density of wood also control the extent of the dimensional changes that can take place in it with changes in the moisture content (MC) below the fiber saturation point (FSP). Finally, air-dry density can be used as a general index to shrinkage, and to the durability of timber; those of higher density usually being subject to greater shrinkage and slower deterioration due to fungal attack.

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).

Wood is used in wide range of conditions and thus has a wide range of MC. 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 after being determined and reported on a MC – in use condition. The determination of density usually is sufficiently accurately 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 (Anon., 1974).

2.2. Specific Gravity

To standardize comparison of species or products and estimation of product's weights, specific gravity is used as a standard references basis, rather than density.

Specific gravity 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°C) has become practically the universal standard in determining the sp. gr. of all substance including wood. At this temperature, the density of water is 1g cm^{-3} or 62.4 lb ft^{-3} (Brown *et. al.,* 1952).

In determining the specific gravity of wood, the oven dry weight of wood is always used as the numerator. The value of denominator depends on the volume of the wood. It varies with MC of the test block. For this reason it is necessary to specify the MC of wood at which volume was determined, when stating the specific gravity of wood.

Specific gravity based on green volume, or basic sp. gr., is one of the most useful and commonly cited values. The term basic is applied since both green volume and oven dry weight are as nearly constant and reproducible measurement as can be obtained with wood (Panshin & de Zeeuw, 1980).

Specific gravity is a measure of the amount of wood substance per unit volume of wood. So it provides certain indications on some other properties such as weight, elastic and strength properties, thermal conductivity, hardness, abrasion resistance, nail-holding capacity etc (Reineke, 1965). The ease of working wood with hand-tools generally varies directly with the specific gravity of wood. The lower the specific gravity, the easier it is to cut the wood with a sharp tool (Anon., 1974).

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 strength and stiffness of wood vary with specific gravity. The relationship between specific gravity and their various strength properties can be expressed as by the parabolic equation of the n^{th} degree. The general form of this equation is $\mathbf{y = ax^{n} + b}$**.** Where**,** y = the strength property, x = specific gravity of wood tested and a and b are experimental constants (Brown, *et al.,* 1952). Equations for the different strength properties of wood, computed by this correlation, are listed in appendix (II).

It is also closely related to some technological characteristics like ease or difficult in drying, treatability with preservatives.

Specific gravity can guide to estimate the drying rates or overall drying time. Some light-weight hardwoods dry rapidly under favorable air drying condition. The heavier hardwoods require longer drying periods. The difference in sp.gr between species is due to differences in the size of the cells and the thickness of the cell walls. However, it is related to the permeability of the wood and the diffusivity of the water in it (John, 1978). Moreover, the difference in this case may be related to the greater amount of extractives such as tyloses present in it which tend to decrease in drying by their bulking action on the cell wall (de. Zeeuw, 1980). For example, the specific gravity of Chinyok (0.601), Nabe (0.672) and Hnaw (0.601) are nearly the same. But, Hnaw can be dried easily but Chinyok and Nabe is very difficult to dry because of the presence of tyloses in their vessels. That is why; the villagers are reluctant to Nabe and Chinyok for fuel-wood.

Similarly, it can effect on the treatability of this species. Hnaw can be treated with preservatives easily, however, Chinyok and Nabe are difficult to treat with preservatives.

Knowledge of Sp. Gr. of a certain species of wood could therefore, readily allow some conclusions with regards to its possible uses. For example, high specific gravity woods would be ideal for heavy construction, industrial flooring and railway ties, while medium sp. gr. woods could be suitably used for furniture – making, parquet flooring and for veneer and plywood manufacture (Bello, 2000).

Specific gravity can be used as one of the important criteria in selecting the suitable tree species for fuel wood. Because, if the average sp.gr. of the tree species and total outturn volume of that species are known, the total outturn in terms of weight can be calculated and then the total amount of heat energy which will be produced from that species can be calculated. In term of weight, species which has higher specific gravity will produce higher amount of heat energy (Win Kyi-1, 2000).

Global warming and climate change have become a serious threat to the survival of biological organisms and the well being of people around the world. The most likely cause of warmer temperature is the increased concentrations of greenhouse gases (GHGs) in the atmosphere. Among the GHGs carbon dioxide is the biggest contributor to global warming. Establishing forest plantations provides an energy conscious world with a clean, efficient means of absorbing some of excess in atmospheric carbon dioxide. Win Kyi-1 (2003) calculated the total amount of carbon storage and carbon dioxide absorption of Myanmar forest Plantations by using two methods based on the total tree volume of the forest plantations of each of the tree species and specific gravity and carbon content of each of the planted wood species. Therefore, specific gravity can also be used to estimate the total amount of CO_2 absorbed and carbon stored by the forests.

2.3. Dimensional Stability

Moisture content in timber is directly related to its stability in dimensions and shape, and minimum of change is most desirable in all furniture, other finished products, joinery, tool handles and timber used in precision instruments.

Wood is hygroscopic. So, wood responds to change in atmospheric humidity and loses bound water as the relative humidity (RH) drops, regaining bound water as the RH increases. For a given RH, a balance is eventually reached at which the wood is no longer gaining or losing moisture. Moisture gaining and losing in wood, below fiber saturation point (25 - 30% MC) is always accompanied by dimensional changes. It shrinks when losing moisture from the cell walls and swells when gaining moisture in the cell walls. These dimensional changes are called shrinking and swelling. Normally it is expressed as a percentage of the initial dimension.

The reduction in size parallel to growth ring is called tangential shrinkage. The reduction in size parallel to wood rays (or perpendicular to growth rings) is called radial shrinkage. As wood is anisotropic material, the dimensional changes in wood are unequal along the three dimensional directions Tangential shrinkage is about twice as great as radial shrinkage in most species, and only slightly along the grain (longitudinally).

The combined effects of radial and tangential shrinkage can distort the shape of wood pieces because of the differences in shrinkage and curvature of growth rings. It is, therefore most important that these phenomena should be understood and carefully considered before utilization.

Dimensional stability is the ratio of tangential shrinkage to radial shrinkage. The ratio of tangential shrinkage to radial shrinkage (T/R) along with the shrinkage percent itself, constitute a means of assessing the dimensional stability of any given wood. The wood best suited for use involving critical dimensional stability is one with a low T/R ratio and with low transverse dimensional changes (Panshin & de Zeeuw, 1980).

The dimensional stability of wood has an important effect on the distortion of flat-sawn lumber, squares and rounds as they are dried. The cross sections, which have faces in the radial and tangential planes obviously shrink more tangentially than radially in drying but retain right angle corners.

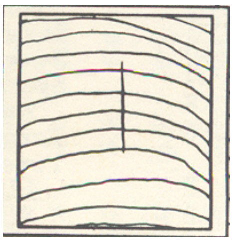

Fig. 1. a

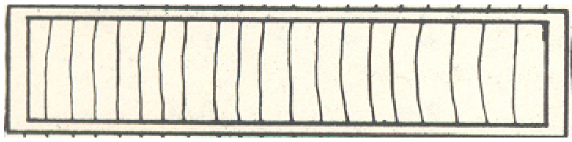

Fig. 1. b

Fig. 1. Distortion in flat boards in drying as the result of anisotropic shrinkage in the transverse directions.

Squares with diagonal growth ring orientation (Fig. 2.a) and rounds (Fig. 2. b) dry to a diamond cross-section or an oval shape respectively, because of the differential transverse shrinkage.

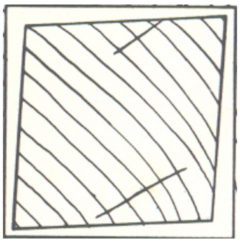

Fig. 2.a

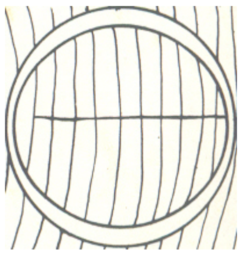

Fig.2.b

Fig. 2. Distortion in square and round cross sections in drying as the result of anisotropic shrinkage in the transverse directions.

Therefore, the total dimensional changes that may occur in a piece of wood, in drying from green condition are an important consideration in finished products manufacture. It is useful index to the employment of wood under the range of atmospheric conditions that affect wood in service.

The differential shrinkage or ratio of tangential to radial shrinkage, which causes distortion of wood in drying, particularly in thicker pieces sawn between the back and quarter positions.

3. Material and Methods

In this study, some physical properties such as, density, specific gravity, shrinkage and dimensional stability of seventy-five timber species in Myanmar were studied.

Data information of the thirty-four timber species is obtained from Timber Digest Volume I, No.3. FRI, Yezin (Win Kyi-1, 1993**).** In that paper, physical and mechanical properties of fifty-one Myanmar timbers and Indian timbers were described. The results given in that paper are reported to be obtained from the tests conducted at FRI, Dehra Dun, India, Forest Research and Training Circle, Yangon and FRI, Yezin. Among the described data, the species which were collected from different parts of Myanmar were used to study.

Data information of fifty-four LUS is obtained from the following research papers:

(1) "Density and Specific Gravity of Fifty-Four Lesser-Used Timber Species of Myanmar" accomplished by U Win Kyi-1, U Win Oo Naing and Daw Cho Cho Myint and

(2) "Dimensional Stability of Fifty - Four LUS of Myanmar" accomplished by U Win Kyi -1.

According to the above-mentioned papers, it was noted that those studies were conducted under the project of "Introducing Myanmar's Lesser Used Timber Species to the World Market". This project was carried out by the collaboration with International Tropical Timber Organization (ITTO) and Forest Department. The project was carried out during 1997 to 2000.

The wood samples are reported to be collected from the Kabaung Reserved Forest and Phyukwin Reserved Forest of Taungoo District, Bago Division and identified and authenticated at the Harbium Section and Wood Anatomy Section of Forest Research Institute, Yezin.

It was noted that, the physical properties which were given in those papers were determined by using the test procedure described in ASTM designation: D 143-52 (R 1965) developed by the American Society for Testing and Materials (ASTM).

4. Results and Discussions

Density and specific gravity at green and air-dry states of seventy-five timber species is given in Table (1).

Table (1) Specific Gravity and Density of Seventy–Five Myanmar Timbers

Sr. No.	Species	Locality	Seasoning	Moisture Content (%)	Specific Gravity	Density (kg/m3)
1	Baing (*Tetrameles nudiflora*)	Taungoo	Green Air-Dry	113.2 12.0	0.376 0.400	800 449
2 (a)	Binga (*Mitragyna rotundifolia*)	Myammar	Green Air-Dry	58.4 12.8	0.553 0.586	881 657
(b)	Binga (*Mitragyna rotundifolia*)	Taungoo	Green Air-Dry	67.0 12.0	0.554 0.595	925 665
3	Bonmeza (*Albizzia chinensis*)	Taungoo	Green Air-Dry	171.1 12.0	0.291 0.304	790 340
4	Chinyoke (*Garuga pinnata*)	Taungoo	Green Air-Dry	101.1 12.0	0.601 0.640	1209 716
5	Didu (*Salalia inmsignis*)	Taungoo	Green Air-Dry	143.9 12.0	0.363 0.385	886 429

Table(1) Continued

Sr. No.	Species	Locality	Seasoning	Moisture Content (%)	Specific Gravity	Density (kg/m3)
6	Dwabok *(Kydia calycina)*	Taungoo	Green Air-Dry	96.9 12.0	0.429 0.453	843 508
7	Dwani (*Eriolaena candollei*)	Taungoo	Green Air-Dry	66.2 13.0	0.719 0.766	1194 857
8	Eucalypt (*Eucalyptus camaldulensis*)	Kyauk- padaung	Green Air-Dr	76.7 -	0.713 -	1138 -
9	Gwe (*Spondias pinnata*)	Taungoo	Green Air-Dry	196.4 12.0	0.280 0.295	826 330
10	Gyo (*Schleichera oleosa*)	Taungoo	Green Air-Dry	34.0 12.0	0.938 1.034	1258 1157
11	Hmyaseik (*Antiaris toxicaria*)	Taungoo	Green Air-Dry	123.2 12.0	0.335 0.353	747 394
12	Hnaw (*Adina cordifolia*)	Taungoo	Green Air-Dry	60.2 12.0	0.601 0.637	975 713
13	In (*Dipterocarpus tuberculatus*)	Myanmar	Green Air-Dry	50.3 19.4	0.726 0.755	1090 897
14	Ingyin (*Shorea siamensis*)	Myanmar	Green Air-Dry	54.3 13.4	0.779 0.819	1202 929
15	Kanyaung (*Shorea argentea*)		Green Air-Dry	56.9 12.7	0.706 0.731	1090 817
16	Kanyin-byu (*Dipterocarpus alatus*)	Myanmar	Green Air-Dry	73.4 17.2	0.574 0.604	994 705
17	Kanyin-ni (*Diptero-carpus turbinatus)*	Myanmar	Green Air-Dry	65.7 14.3	0.655 0.689	1090 785
18	Kaunghmu (*Anisoptera scaphula*)	Myanmar	Green Air-Dry	117.8 -	0.475 -	1042 -
19	Kokko (*Albizzia lebbek*)	Taungoo	Green Air-Dry	68.6 12.0	0.538 0.565	907 633
20 (a)	Kuthan *(Hymenodictyon excelsum)*	Pyinmana	Green Air-Dry	126.5 12.3	0.376 0.441	1029 442
20 (b)	Kuthan (*Hymenodictyon excelsum*)	Taungoo	Green Air-Dr	131.4 12.0	0.404 0.427	941 479
21	Kyana (*Xylocarpus moluccensis)*	Myanmar	Green Air-Dry	45.0 11.9	0.670 0.702	978 785
22	Kyetyo (*Vitex peduncularis*)	Taungoo	Green Air-Dry	50.1 12.0	0.761 0.820	1141 918
23 (a)	Kyun (*Tectona grandis*)	Myanmar	Green Air-Dry	51.8 13.9	0.596 0.598	913 673
24 (a)	Lein (*Terminalia pyrifolia*)	Pyinmana	Green Air-Dry	85.2 15.6	0.625 0.658	1106 801
(b)	Lein (*Terminalia pyrifolia*)	Taungoo	Green Air-Dry	72.2 12.0	0.644 0.709	1109 793
25	Letpan (*Salmalia malabarica*)	Taungoo	Green Air-Dry	119.0 1.0	0.260 0.272	571 304
26 (a)	Leza (*Lagerstroemia tomentosa*)	Pyinmana	Green Air-Dry	98.2 12.4	0.522 0.545	1026 673
(b)	Leaz (*Lagerstroemia tomentosa)*	Taungoo	Green Air-Dry	59.8 12.0	0.583 0.627	931 702
(c)	Leza (*Lagerstroemia tomentosa)*	Tatkone	Green Air-Dry	94.0 12.0	0.550 0.630	1075 679
27	Ma-u-lettan-she (*Anthocephalus cadamba*)	Taungoo	Green Air-Dry	94.3 12.0	0.436 0.467	848 524

Table(1) Continued

Sr. No.	Species	Locality	Seasoning	Moisture Content (%)	Specific Gravity	Density (kg/m3)
28 (a)	Myaukchaw (*Homalium tomentosa*)	Myanmar	Green Air-Dry	40.4 8.6	0.755 0.825	1058 897
(b)	Myaukchaw (*Homalium tomentosa*)	Taungoo	Green Air-Dr	30.5 1.0	0.776 0.848	1013 950
29 (a)	Myaukngo (*Duabanga grandiflora*)	Pyinmana	Green Air-Dry	110.0 12.0	0.429 0.433	721 433
(b)	Myaukngo (*Duabanga grandiflora*)	Taungoo	Green Air-Dry	114.5 12.0	0.464 0.488	979 546
30	Myaukthwegyi (*Myristica spp*)	Taungoo	Green Air-Dry	129.1 12.0	0.339 0.363	777 407
31	Myaukthwethe (*Myristica angustifolia*)	Taungoo	Green Air-Dry	56.3 12.0	0.549 0.585	856 655
32	Nabe (*Lennea grandis*)	Taungoo	Green Air-Dry	78.7 12.0	0.672 0.704	1199 787
33 (a)	Nyan (*Quercus serrata*)	Southern Shan State	Green Air-Dry	74.7 -	0.650 -	1026 -
(b)	Nyan (*Quercus serrata*)	Pyin Oo Lwin	Green Air-Dry	53.5 -	0.690 -	1106 -
34 (a)	Padauk (*Pterocarpus macrocarpus)*	Myanmar	Green Air-Dry	43.8 12.5	0.752 0.769	1074 865
(b)	Padauk (Plantation) (*P. macrocarpus*)	Pyinmana	Green Air-Dry	58.6 12.0	0.706 0.796	1106 892
35	Panga (*Terminalia chebula*)	Tungoo	Green Air-Dry	62.2 12.0	0.779 0.856	1263 960
36 (a)	Petthan (*Heplophrogma aderophyllum)*	Myanmar	Green Air-Dry	50.5 11.7	0.726 0.755	924 849
(b)	Petthan (*Heplophrogma aderophyllum)*	Tungoo	Green Air-Dry	41.5 12.0	0.745 0.801	1055 897
37	Pinlekanazo (*Heritiera fomes*)	Myanmar	Green Air-Dr	56.3 11.4	0.792 0.927	1234 1026
38 (a)	Pyaukseik (*Holoptelea integrifolia)*	Taungoo	Green Air-Dry	64.9 12.0	0.567 0.612	915 686
(b)	Pyaukseik (*Holoptelea integrifolia)*	Tatkone	Green Air-Dry	67.5 12.0	0.580 0.640	964 715
39	Pyinkado (*Xylia xylocapus*)	Myanmar	Green Air-Dry	48.6 10.3	0.779 0.816	1154 897
40	Pyinma (*Lagerstroemia speciosa)*	Tungngu	Green Air-Dry	71.6 12.0	0.529 0.563	906 630
41	Sagawa (*Michelia champace*)	Myanmar	Green Air-Dry	112.9 8.8	0.426 0.441	913 481
42	Seikche (*Bridelia retusa*)	Taungoo	Green Air-Dry	98.2 12.0	0.583 0.606	1156 678
43	Shaw (*Sterculia versicolor*)	Taungoo	Green Air-Dry	86.5 12.0	0.352 0.366	654 412
44	Sit (*Albizzia procera*)	Taungoo	Green Air-Dry	69.4 12.0	0.720 0.754	1220 845
45	Taukkyan (*Terminalia tomentosa)*	Taungoo	Green Air-Dry	44.8 12.0	0.815 0.885	1221 992
46	Taung meok (*Alstonia scholaris*)	Taungoo	Green Air-Dry	96.9 1.0	0.388 0.412	761 462
47	Taungokshit (*Elaeocarpus spp*)	Taungoo	Green Air-Dr	46.5 12.0	0.691 0.739	1011 829

Table(1) Continued

Sr. No.	Species	Locality	Seasoning	Moisture Content (%)	Specific Gravity	Density (kg/m3)
48	Taungpeinne (*Artocarpus chaplasha*)	Taungoo	Green Air-Dry	106.3 12.0	0.435 0.453	899 506
49	Taungpetwun (*Pterospermum cerifolium*)	Taungoo	Green Air-Dry	79.9 12.0	0.483 0.515	870 577
50 (a)	Taungthayet (*Swintonia floribunda*)	Myanmar	Green Air-Dry	58.5 13.7	0.551 0.375	865 657
(b)	Taungthayet (*Swintonia floribunda*)	Taungoo	Green Air-Dry	84.2 12.0	0.558 0.585	1029 655
51	Tawthayet (*Mangifera spp*)	Taungoo	Green Air-Dry	75.6 12.0	0.582 0.611	1021 780
52	Thabye (*Eugenia spp*)	Taungoo	Green Air-Dry	51.4 12.0	0.674 0.732	1021 819
53 (a)	Thadi (*Protium serratum*)	Pyinmana	Green Air-Dry	43.7 17.9	0.710 0.820	1072 821
(b)	Thadi (*Protium serratum*)	Taungoo	Green Air-Dry	73.2 12.0	0.697 0.764	1205 856
54	Thande (*Stereospermum personatum)*	Taungoo	Green Air-Dry	53.0 12.0	0.725 0.781	1109 875
55	Thaphan (*Ficus spp*)	Taungoo	Green Air-Dry	121.5 12.0	0.344 0.362	763 405
56 (a)	Thingadu (*Parashorea stellata*)	Myanmar	Green Air-Dry	70.7 11.0	0.589 0.642	1010 705
(b)	Thingadu (*Parashorea stellata*)	Taungoo	Green Air-Dry	59.2 12.0	0.561 0.599	883 671
57	Thingan (*Hopea odorata*)	Myanmar	Green Air-Dr	73.9 12.1	0.637 0.675	1106 753
58	Thinwin (*Millettia pendula*)	Pyinmana	Green Air-Dry	44.3 -	0.850 0.970	1199 937
59	Thitkha (*Pentace burmanica*)	Myanmar	Green Air-Dry	37.0 13.9	0.558 0.573	769 657
60 (a)	Thitkado (*Cedrela toona*)	Myanmar	Green Air-Dry	65.1 14.8	0.473 0.498	785 576
(b)	Thitkado (*Cedrela toona*)	Taungoo	Green Air-Dry	75.8 12.0	0.410 0.428	723 479
61	Thitmagyi (*Albizzia odoratissima*)	Taungoo	Green Air-Dry	43.2 12.0	0.803 0.847	1149 949
62	Thitmin (*Podocar puswallichianus*)	Myinmar	Green Air-Dry	45.5 13.2	0.462 0.480	673 545
63	Thitpagan (*Millettia brandisiana*)	Pyinmana	Green Air-Dry	137.8 12.0	0.440 0.513	1029 574
64	Thitpayaung (*Nauclea sessilifilia*)	Taungoo	Green Air-Dry	61.6 12.0	0.720 0.810	1164 907
65	Thitsein (*Terminalia bellerica*)	Taungoo	Green Air-Dry	53.5 12.0	0.717 0.788	1101 883
66	Thitswele (*Schrebera swietenioides*)	Taungoo	Green Air-Dry	48.7 12.0	0.710 0.751	1048 840
67	Thitya (*Shorea oblongifolia*)	Myanmar	Green Air-Dry	46.3 10.6	0.858 0.933	1250 1026
68	Tinyu (*hna-khwa*) *(Pinusmercusii*)	Taungyi	Green Air-Dry	65.7 12.7	0.470 0.560	913 561
69	Tinyu (*thone-khwa*) (*Pinus insularis*)	Kalaw	Green Air-Dr	61.9 12.8	0.460 0.490	913 572

Table(1) Concluded

Sr. No.	Species	Locality	Seasoning	Moisture Content (%)	Specific Gravity	Density (kg/m3)
70 (a)	Yemane (*Gmelina arborea*)	Myanmar	Green Air-Dry	151.2 12.1	0.419 0.432	1058 481
(b)	Yemane (*Gmelina arborea*)	Taungoo	Green Air-Dry	125.6 12.0	0.469 0.492	1056 551
71	Yindaik (*Dalbergia cultrate*)	Taungoo	Green Air-Dry	39.6 12.0	0.792 0.878	1108 982
72	Yinma (*Chukrasia tabularis*)	Taungoo	Green Air-Dry	59.2 12.0	0.781 0.885	1239 946
73	Yinzat (*Dalbergia fusca*)	Taungoo	Green Air-Dry	45.9 12.0	0.704 0.762	1026 853
74 (a)	Yon (*Anogeissus acuminata*)	Myanmar	Green Air-Dry	34.8 13.4	0.739 0.784	994 881
(b)	Yon (*Anogeissus acuminata*)	Taungoo	Green Air-Dry	40.6 12.0	0.762 0.827	1071 926
75 (a)	Zaungbale (*Lagerstroemia villo)*	Myanmar	Green Air-Dry	39.1 15.8	0.610 0.690	974 728
(b)	Zaungbale (*Lagerstroemia villo*)	Taungoo	Green Air-Dry	66.0 12.0	0.597 0.644	991 721

In this study, seventy-five timber species in Myanmar are categorized into four classes according to their basic specific gravity and these are given in Table (2). Here, 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'.

Table (2) Four Classes of Seventy-Five Timber Species Based on Basic Sp. Gr.

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 (.388)	3. Myaukthwethe (0.549)	3. Thinwin (0.850)
4. Hmyaseik (0.335)	4. Kuthan (0.404)	4. Binga (0.554)	4. Thitya (0.858)
5. Myaukthwegyi (0.339)	5. Thitkado (0.410)	5. Taungthayet (0.558)	5. Gyo (0.938)
	6. Sagawa (0.426)	6. Thitka (0.558)	
6. Thapan (0.344)	7. Dwabok (0.429)	7. Thingadu (0.561)	
7. Shaw (0.352)	8.Taungpeinne(0.435)	8. Pyaukseik (0.567)	
	9. Ma-u- she (0.436)	9. Kanyin-byu (0.574)	
	10.Thitpagan (0.440)	10. Tawthayet (0.582)	
	11. Tinyu (thone khwa) (0.460)	11 .Leza (0.583)	
	12.Thitmin (0.462)	12 Seikchi (0.583)	
	13.Myaukngo (0.464)	13. Zaungbale (0.597)	
	14. Yemane (0.469)	14. Kyun (0.598)	

Table (2) concluded

Light Species	**Moderately Heavy Species**	**Heavy Species**	**Very Heavy Species**
	15. Tinyu -nha khwa (0.470)	15. Chinyoke (0.601)	
		16. Hnaw (0.601)	
	16. Kaunghmu (0.475)	17. Thingan (0.637)	
	17. Taungpetwun (0.483)	18. Lein (0.644)	
		19. Nyan (0.650)	
		20. Kanyin-ni (0.655)	
		21. Kyana (0.670)	
		22. Nabe (0.672)	
		23. Thabye (0.674)	
		24. Taungoakshit (0.691)	
		25. Thadi (0.697)	
		26. Yinzat (0.704)	
		27. Thitswele (0.705)	
		28. Ka-nyaung (0.706)	
		29. Eucalypt (0.713)	
		30. Thitsein (0.717)	
		31. Dwani (0.719)	
		32 .Sit (0.720)	
		33.Thitpayaung(0.720)	
		34. Thande (0.725)	
		35. In (0.726)	
		36. Petthan (0.745)	
		37. Padauk (0.752)	
		38. Kyetyo (0.761)	
		39. Yon (0.762)	
		40. Myaukshaw (0.776)	
		41. Ingyin (0.779)	
		42. Panga (0.779)	
		43. Pyinkado 0.779)	
		44. Yinma (0.781)	
		45. Yindaik (0.792)	
		46. Pinlekanazo (0.792)	

According to this classification, five species, Gyo, Thitya, Thinwin, Taukkyan and Thitmagyi are found to be very heavy timbers. Therefore, these species can be expected to use for heavy construction, industrial flooring and rail way ties. Where as, seven species namely Letpan, Gwe, Bonmeza, Hmyaseik, Myaukthwegyi, Thapan and Shaw are found to be Light timbers. It can be seen that more than half of the timbers lie in the heavy group and sixteen species are found to be moderately heavy.

It is found that Letpan, which has the basic specific gravity 0.260, is the lightest where as Gyo, which has the basic specific 0.938 is the heaviest among all the timber species mentioned in this paper. The lightest timber in the world is reported to be '*Alstonia spatulata*', which basic specific gravity being 0.0394 to0.0580 and Letter wood of Dutch Guriana (*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 this table, it can be seen that Sp. Gr. of Chinyoke, 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, feature, grain pattern, dimensional changes, workability, drying behavior and durability have to be taken into consideration. Among these six species, Seikche and Taw thayet which have the lower tangential shrinkage (5.9% and 5.6%) could be suitable for making furniture and other quality wood products.

It can also be seen that, basic specific gravity of Pyinkado (known as Myanmar Ironwood) which is accepted as the best structural timber in Myanmar is 0.779. The basic specific gravity of Gyo, Thitya, Thinwin, Taukkyan, Thitmagyi, Pinlekanazo, Yindaik, Yinma and Panga are above or equal to 0.779. Thus, these species could be expected as suitable for structural timber. However, for structural timber durability is the secondary factor to be taken into account.

For carbon credit, the total amount of carbon stored by the forests can be estimated based on Mean Annual Incresement (MAI), basic specific gravity and carbon content. Average basic specific gravity of timber species is usually taken as 0.500. According to table (2), average basic specific gravity of 75 timbers is found to be 0.568. Thus, for estimating the total carbon credit of Myanmar forests, it will not be over-estimated if we assume the basic specific gravity of Myanmar timber as 0.500.

The tangential and radial shrinkage values are given in tables (3) and (4). The values from the reference papers are shrinkage from green to oven dry. However, in real practice, the MC of the wood finished products normally fluctuates between 12% and 20%. Therefore, the shrinkage from green to 12% MC and green to 20%MC were calculated by using the following formula.

$$S_m = S_o [(30 - m) / 30]$$

Where, S_m is shrinkage (%) from the green condition to moisture content m (below 30%) and S_o is shrinkage (%) from green to oven dry and m is moisture content (%). Based on these values, tangential shrinkage from 20% MC to 12% MC and radial shrinkage from 20%MC to 12%MC are calculated and also given in table (3) and (4).

Table (3) Tangential Shrinkage of Seventy-Five Timbers

Sr. No.	Species	Locality	Tangential Shrinkage (%)			
			Green to Oven Dry	Green to 12% MC	Green to 20%MC	20%MC to 12% MC
1	Baing (*Tetrameles nudiflora)*	Taungoo	8.5	5.1	2.83	2.27
2(a)	Binga (*Mitragyna rotundifolia*	Myanmar	7.3	4.38	2.43	1.95
(b)	Binga (*Mitragyna rotundifolia*	Taungoo	8.2	4.92	2.73	2.19
3	Bonmeza (*Albizzia chinensis*)	Taungoo	6.2	3.72	2.07	1.65
4	Chinyoke (*Garuga pinnata*)	Taungoo	6.1	3.66	2.03	1.63
5	Didu (*Salmalia insignis*)	Taungoo	5.9	3.54	1.97	1.57
6	Dwabok (*Kydia calycina*)	Taungoo	6.6	3.96	2.20	1.76
7	Dwani (*Eriolaena candollei*)	Taungoo	6.9	4.14	2.30	1.84
8	Eucalypt (*Eucalyptus camaldulensis*)	Kyauk-padaung	7.3	4.38	2.43	1.95
9	Gwe (*Spondias pinnata*)	Taungoo	5.6	3.36	1.87	1.49
10	Gyo (*Schleichera oleosa*)	Taungoo	10.8	6.48	3.60	2.88
11	Hmyaseik (*Antiaris toxicaria*)	Taungoo	5.3	3.18	1.77	1.41
12	Hnaw (*Adina cordifolia*)	Taungoo	6.5	3.9	2.17	1.73
13	In (*Dipterocarpus tuberculatus*)	Myanmar	9.1	5.46	3.03	2.43
14	Ingyin (*Shorea siamensis*)	Myanmar	8.9	5.34	2.97	2.37
15	Kanyaung (*Shorea argentea*)		10.9	6.54	3.63	2.91
16	Kanyin-byu (*Dipterocarpus alatus*)	Myanmar	8.6	5.16	2.87	2.29
17	Kanyin-ni (*Dipterocarpus turbinatus)*	Myanmar	8.9	5.34	2.97	2.37
18	Kaunghmu (*Anisoptera scaphula*)	Myanmar	n.a	-	-	-
19	Kokko (*Albizzia lebbek)*	Taungoo	6.0	3.6	2.00	1.60
20 (a)	Kuthan (*Hymenodictyon excelsum)*	Pyinmana	6.9	4.14	2.30	1.84
20 (b)	Kuthan (*Hymenodictyon excelsum)*	Taungoo	6.1	3.66	2.03	1.63
21	Kyana (*Xylocarpus moluccensis)*	Myanmar	5.5	3.3	1.83	1.47
22	Kyetyo (*Vitex peduncularis*)	Taungoo	9.2	5.52	3.07	2.45
23 (a)	Kyun (*Tectona grandis*)	Myanmar	4.2	2.52	1.40	1.12

Table (3) Continued

Sr. No.	Species	Locality	Tangential Shrinkage (%)			
			Green to Oven Dry	Green to 12% MC	Green to 20%MC	20%MC to 12% MC
24 (a)	Lein (*Terminalia pyrifolia)*	Pyinmana	9.1	5.46	3.03	2.43
(b)	Lein (*Terminalia pyrifolia*)	Taungoo	9.2	5.52	3.07	2.45
25	Letpan (*Salmalia malabarica*)	Taungoo	4.9	2.94	1.63	1.31
26 (a)	Leza (*Lagerstroemia tomentosa*)	Pyinmana	6.4	3.84	2.13	1.71
(b)	Leza (*Lagerstroemia tomentosa*)	Taungoo	7.6	4.56	2.53	2.03
(c)	Leza (*Lagerstroemia tomentosa*)	Tatkone	6.9	4.14	2.30	1.84
27	Ma-u-lettan-she (*Anthocephalus cadamba*)	Taungoo	8.0	4.8	2.67	2.13
28 (a)	Myaukchaw (*Homalium tomentosa*)	Myanmar	10.1	6.06	3.37	2.69
(b)	Myaukchaw (*Homalium tomentosa*)	Taungoo	10.7	6.42	3.57	2.85
29 (a)	Myaukngo (*Duabanga grandiflora*)	Pyinmana	6.6	3.96	2.20	1.76
(b)	Myaukngo (*Duabanga grandiflora*)	Taungoo	5.1	3.06	1.70	1.36
30	Myaukthwegyi (*Myristica spp*)	Taungoo	7.0	4.2	2.33	1.87
31	Myaukthwethe (*Myristica angustifolia*)	Taungoo	8.4	5.04	2.80	2.24
32	Nabe (*Lennea grandis*)	Taungoo	6.0	3.6	2.00	1.60
33 (a)	Nyan (*Quercus serrata*)	Southern Shan State	10.1	6.06	3.37	2.69
(b)	Nyan (*Quercus serrata*)	Pyin Oo Lwin	12.9	7.74	4.30	3.44
34 (a)	Padauk (*Pterocarpus macrocarpus*)	Myanmar	5.1	3.06	1.70	1.36
(b)	Padauk (Plantation) (*P. macrocarpus*)	Pyinmana	5.6	3.36	1.87	1.49
35	Panga (*Terminalia chebula*)	Taungoo	11.0	6.6	3.67	2.93
36 (a)	Petthan (*Heplophrogma aderophyllum*)	Myanmar	7.8	4.68	2.6	2.08
(b)	Petthan **(***Heplophrogma aderophyllum*)	Tungoo	7.5	4.5	2.5	2.00
37	Pinlekanazo (*Heritiera fomes*)	Myanmar	11.6	6.96	3.87	3.09
38 (a)	Pyaukseik (*Holoptelea integrifolia*)	Tungoo	8.5	5.1	2.83	2.27
(b)	Pyaukseik (*Holoptelea integrifolia*)	Tatkone	7.6	4.56	2.53	2.03
39	Pyinkado (*Xylia xylocarpus*)	Myanmar	6.7	4.02	2.23	1.79
40	Pyinma (*Lagerstroemia speciosa*)	Taungoo	7.4	4.44	2.47	1.97

Table (3) Continued

Sr. No.	Species	Locality	Tangential Shrinkage (%)			
			Green to Oven Dry	Green to 12% MC	Green to 20% MC	20%MC to 12% MC
41	Sagawa (*Michelia champace*)	Myanmar	5.2	3.12	1.73	1.39
42	Seikche (*Bridelia retusa*)	Taungoo	5.9	3.54	1.97	1.57
43	Shaw (*Sterculia versicolor*)	Taungoo	5.9	3.54	1.97	1.57
44	Sit (*Albizzia procera*)	Taungoo	5.5	3.3	1.83	1.47
45	Taukkyan (*Terminalia tomentosa*)	Taungoo	8.4	5.04	2.8	2.24
46	Taung meok (*Alstonia scholaris*)	Taungoo	5.5	3.3	1.83	1.47
47	Taungokshit (*Elaeocarpus spp*)	Taungoo	8.1	4.86	2.70	2.16
48	Taungpeinne (*Artocarpus chaplasha*)	Taungoo	4.3	2.58	1.43	1.15
49	Taungpetwun (*Pterospermum cerifolium*)	Taungoo	6.7	4.02	2.23	1.79
50 (a)	Taungthayet (*Swintonia floribunda*)	Myanmar	6.0	3.6	2.00	1.60
(b)	Taungthayet (*Swintonia floribunda*)	Taungoo	5.9	3.54	1.97	1.57
51	Tawthayet (*Mangifera spp*)	Taungoo	5.6	3.36	1.87	1.49
52	Thabye (*Eugenia spp*)	Taungoo	9.3	5.58	3.10	2.48
53 (a)	Thadi (*Protium serratum*)	Pyinmana	8.9	5.34	2.97	2.37
(b)	Thadi (*Protium serratum*)	Taungoo	10.2	6.12	3.40	2.72
54	Thande (*Stereospremum personatum*)	Taungoo	8.4	5.04	2.80	2.24
55	Thaphan (*Ficus spp*)	Taungoo	6.7	4.02	2.23	1.79
56 (a)	Thingadu (*Parashorea stellata*)	Myanmar	9.8	5.88	3.27	2.61
(b)	Thingadu (*Parashorea stellata*)	Taungoo	7.4	4.44	2.47	1.97
57	Thingan (*Hopea odorata*)	Myanmar	6.5	3.9	2.17	1.73
58	Thinwin (*Millettia pendula*)	Pyinmana	7.7	4.62	2.57	2.05
59	Thitkha (*Pentace burmanica*)	Myanmar	6.5	3.9	2.17	1.73
60 (a)	Thitkado (*Cedrela toona*)	Myanmar	6.3	3.78	2.10	1.68
(b)	Thitkado (*Cedrela toona*)	Taungoo	6.4	3.84	2.13	1.71
61	Thitmagyi (*Albizzia odoratissima*)	Taungoo	6.3	3.78	2.10	1.68

Table (3) Concluded

Sr. No.	Species	Locality	Tangential Shrinkage (%)			
			Green to Oven Dry	Green to 12% MC	Green to 20% MC	20%MC to 12% MC
62	Thitmin (*Podocar puswallichianus*)	Myanmar	6.6	3.96	2.20	1.76
63	Thitpagan (*Millettia brandisiana*)	Pyinmana	14.5	8.7	4.83	3.87
64	Thitpayaung (*Nauclea sessilifilia*)	Taungoo	15.3	9.18	5.10	4.08
65	Thitsein (*Terminalia bellerica*)	Taungoo	9.7	5.82	3.23	2.59
66	Thitswele (*Schrebera swietenioides*)	Taungoo	7.1	4.26	2.37	1.89
67	Thitya (*Shorea oblongifolia*)	Myanmar	9.7	5.82	3.23	2.59
68	Tinyu (hna-khwa) (*Pinus mercusii*)	Taungyi	9.7	5.82	3.23	2.59
69	Tinyu (thone-khwa) (*Pinus insularis*)	Kalaw	8.0	7.02	3.90	3.12
70 (a)	Yemane (*Gmelina arborea*)	Myanmar	-	-	-	-
(b)	Yemane (*Gmelina arborea*)	Taungoo	5.5	3.3	1.83	1.47
71	Yindaik (*Dalbergia cultrate*)	Taungoo	10.1	6.06	3.37	2.69
72	Yinma (*Chukrasia tabularis*)	Taungoo	9.7	5.82	3.23	2.59
73	Yinzat (*Dalbergia fusca*)	Taungoo	9.7	5.82	3.23	2.59
74 (a)	Yon (*Anogeissus acuminata)*	Myanmar Kalaw	8.1	4.86	2.70	2.16
(b)	Yon (*Anogeissus acuminata)*	Taungoo	9.4	5.64	3.13	2.51
75 (a)	Zaungbale (*Lagerstroemia villo*)	Myanmar	7.6	4.56	2.53	2.03
(b)	Zaungbale (*Lagerstroemia villo)*	Taungoo	7.1	4.26	2.37	1.89

Table (4) Radial Shrinkage of Seventy-Five Timbers

Sr. No.	Species	Locality	Radial Shrinkage (%)			
			Green to Oven Dry	Green to 12% MC	Green to 20%MC	20%MC to 12% MC
1	Baing (*Tetrameles nudiflora)*	Taungoo	3.5	2.10	1.17	0.93
2(a)	Binga (Mitragyna rotundifolia	Myanmar	3.8	2.28	1.27	1.01
(b)	Binga *(Mitragyna rotundifolia*	Taungoo	4.0	2.40	1.33	1.07
3	Bonmeza *(Albizzia chinensis)*	Taungoo	2.2	1.32	0.73	0.59
4	Chinyoke (*Garuga pinnata)*	Taungoo	3.3	1.98	1.10	0.88
5	Didu (*Salmalia insignis)*	Taungoo	2.8	1.68	0.93	0.75

Table (4) continued

Sr. No.	Species	Locality	Radial Shrinkage (%)			
			Green to Oven Dry	Green to 12% MC	Green to 20%MC	20%MC to 12% MC
6	Dwabok (*Kydia calycina)*	Taungoo	3.0	1.80	1.00	0.80
7	Dwani (*Eriolaena candollei*)	Taungoo	4.2	2.52	1.40	1.12
8	Eucalypt (*Eucalyptus camaldulensis*)	Kyauk-padaung	3.9	2.34	1.30	1.04
9	Gwe (*Spondias pinnata*)	Taungoo	2.1	1.26	0.70	0.56
10	Gyo (*Schleichera oleosa*)	Taungoo	5.0	3.00	1.67	1.33
11	Hmyaseik (*Antiaris toxicaria*)	Taungoo	2.7	1.62	0.90	0.72
12	Hnaw (*Adina cordifolia*)	Taungoo	3.6	2.16	1.20	0.96
13	In (*Dipterocarpus tuberculatus*)	Myanmar	4.4	2.64	1.47	1.17
14	Ingyin (*Shorea siamensis*)	Myanmar	4.8	2.88	1.60	1.28
15	Kanyaung (*Shorea argentea*)		5.5	3.30	1.83	1.47
16	Kanyin-byu (*Dipterocarpus alatus)*	Myanmar	3.6	2.16	1.20	0.96
17	Kanyin-ni (*Dipterocarpus turbinatus)*	Myanmar	4.2	2.52	1.40	1.12
18	Kaunghmu (*Anisoptera scaphula*)	Myanmar	-	-	-	-
19	Kokko (*Albizzia lebbek)*	Taungoo	3.0	1.8	1.00	0.80
20 (a)	Kuthan (*Hymenodictyon excelsum)*	Pyinmana	3.9	2.34	1.30	1.04
20 (b)	Kuthan (*Hymenodictyon excelsum)*	Taungoo	3.2	1.92	1.07	0.85
21	Kyana (*Xylocarpus moluccensis)*	Myanmar	3.0	1.80	1.00	0.80
22	Kyetyo (*Vitex peduncularis*)	Taungoo	4.9	2.94	1.63	1.31
23 (a)	Kyun (*Tectona grandis*)	Myanmar	2.3	1.38	0.77	0.61
24 (a)	Lein (Terminalia pyrifolia)	Pyinmana	4.8	2.88	1.60	1.28
(b)	Lein (Terminalia pyrifolia)	Taungoo	5.9	3.54	1.97	1.57
25	Letpan (*Salmalia malabarica*)	Taungoo	2.1	1.26	0.70	0.56
26 (a)	Leza (*Lagerstroemia tomentosa*)	Pyinmana	4.2	2.52	1.40	1.12
(b)	Leaz (*Lagerstroemia tomentosa*)	Taungoo	4.9	2.94	1.63	1.31
(c)	Leza (*Lagerstroemia tomentosa*)	Tatkone	4.7	2.82	1.57	1.25
27	Ma-u-lettan-she (*Anthocephalus cadamba*)	Taungoo	3.8	2.28	1.27	1.01

Table (4) continued

Sr. No.	Species	Locality	Radial Shrinkage (%)			
			Green to Oven Dry	Green to 12% MC	Green to 20%MC	20%MC to 12% MC
28 (a)	Myaukchaw (*Homalium tomentosa*)	Myanmar	4.4	2.64	1.47	1.17
(b)	Myaukchaw (*Homalium tomentosa*)	Taungoo	5.6	3.36	1.87	1.49
29 (a)	Myaukngo (*Duabanga grandiflora*)	Pyinmana	3.7	2.22	1.23	0.99
(b)	Myaukngo (*Duabanga grandiflora*)	Taungoo	3.2	1.92	1.07	0.85
30	Myaukthwegyi (*Myristica spp*)	Taungoo	4.0	2.40	1.33	1.07
31	Myaukthwethe (*Myristica angustifolia*)	Taungoo	4.3	2.58	1.43	1.15
32	Nabe (*Lennea grandis*)	Taungoo	3.5	2.10	1.17	0.93
33 (a)	Nyan (*Quercus serrata*)	Southern Shan State	4.4	2.64	1.47	1.17
(b)	Nyan (*Quercus serrata*)	Pyin Oo Lwin	5.3	3.18	1.77	1.41
34 (a)	Padauk (*Pterocarpus macrocarpus*)	Myanmar	3.4	2.04	1.13	0.91
(b)	Padauk (Plantation) (*P. macrocarpus*)	Pyinmana	3.8	2.28	2.28	1.27
35	Panga (*Terminalia chebula*)	Taungoo	5.4	3.24	1.80	1.44
36 (a)	Petthan (*Heplophrogma aderophyllum*)	Myanmar	4.6	2.76	1.53	1.23
(b)	Petthan **(***Heplophrogma aderophyllum*)	Taungoo	4.4	2.64	1.47	1.17
37	Pinlekanazo (*Heritiera fomes*)	Myanmar	5.9	3.54	1.97	1.57
38 (a)	Pyaukseik (*Holoptelea integrifolia*)	Taungoo	3.8	2.28	1.27	1.01
(b)	Pyaukseik (*Holoptelea integrifolia*)	Tatkone	4.6	2.76	1.53	1.23
39	Pyinkado (*Xylia xylocarpus*)	Myanmar	3.3	1.98	1.10	0.88
40	Pyinma (*Lagerstroemia speciosa*)	Taungoo	3.1	1.86	1.03	0.83
41	Sagawa (*Michelia champace*)	Myanmar	3.2	1.92	1.07	0.85
42	Seikche (*Bridelia retusa*)	Taungoo	2.2	1.32	0.73	0.59
43	Shaw (*Sterculia versicolor*)	Taungoo	1.9	1.14	0.63	0.51
44	Sit (*Albizzia procera*)	Taungoo	2.8	1.68	0.93	0.75
45	Taukkyan (*Terminalia tomentosa*)	Taungoo	5.7	3.42	1.90	1.52
46	Taung meok (*Alstonia scholaris*)	Taungoo	3.3	1.98	1.10	0.88
47	Taungokshit (*Elaeocarpus spp*)	Taungoo	3.0	1.80	1.00	0.80

Table (4) continued

Sr. No.	Species	Locality	Radial Shrinkage (%)			
			Green to Oven Dry	Green to 12% MC	Green to 20%MC	20%MC to 12% MC
48	Taungpeinne (*Artocarpus chaplasha*)	Taungoo	1.8	1.08	0.60	0.48
49	Taungpetwun (*Pterospermum cerifolium*)	Taungoo	3.8	2.28	1.27	1.01
50 (a)	Taungthayet (*Swintonia floribunda*)	Myanmar	3.2	1.92	1.07	0.85
(b)	Taungthayet (*Swintonia floribunda*)	Taungoo	2.7	1.62	0.90	0.72
51	Tawthayet (*Mangifera spp*)	Taungoo	3.6	2.16	1.20	0.96
52	Thabye (*Eugenia spp*)	Taungoo	4.3	2.58	1.43	1.15
53 (a)	Thadi (*Protium serratum*)	Pyinmana	5.5	3.3	1.83	1.47
(b)	Thadi (*Protium serratum*)	Taungoo	5.8	3.48	1.93	1.55
54	Thande (*Stereospremum personatum*)	Taungoo	4.8	2.88	1.60	1.28
55	Thaphan (*Ficus spp*)	Taungoo	2.7	1.62	0.90	0.72
56 (a)	Thingadu (*Parashorea stellata*)	Myanmar	4.2	2.52	1.40	1.12
(b)	Thingadu (*Parashorea stellata*)	Taungoo	3.8	2.28	1.27	1.01
57	Thingan (*Hopea odorata*)	Myanmar	3.4	2.04	1.13	0.91
68	Thinwin (*Millettia pendula*)	Pyinmana	4.3	2.58	1.43	1.15
59	Thitkha (*Pentace burmanica*)	Myanmar	3.1	1.86	1.03	0.83
60 (a)	Thitkado (*Cedrela toona*)	Myanmar	3.8	2.28	1.27	1.01
(b)	Thitkado (*Cedrela toona*)	Taungoo	3.1	1.86	1.03	0.83
61	Thitmagyi (*Albizzia odoratissima*)	Taungoo	2.9	1.74	0.97	0.77
62	Thitmin (*Podocar puswallichianus*)	Myanmar	3.7	2.22	1.23	0.99
63	Thitpagan (*Millettia brandisiana*)	Pyinmana	6.7	4.02	2.23	1.79
64	Thitpayaung (*Nauclea sessilifilia*)	Taungoo	6.6	3.96	2.20	1.76
65	Thitsein (*Terminalia bellerica*)	Taungoo	6.4	3.84	2.13	1.72
66	Thitswele (*Schrebera swietenioides*)	Taungoo	4.5	2.70	1.50	1.20
67	Thitya (*Shorea oblongifolia*)	Myanmar	5.4	3.24	1.80	1.44
68	Tinyu (hna-khwa) (*Pinus mercusii*)	Taungyi	6.5	3.90	2.17	1.73
69	Tinyu (thone-khwa) (*Pinus insularis*)	Kalaw	4.7	2.82	1.57	1.25

Table (4) concluded

Sr. No.	Species	Locality	Radial Shrinkage (%)			
			Green to Oven Dry	Green to 12% MC	Green to 20%MC	20%MC to 12% MC
70 (a)	Yemane (*Gmelina arborea*)	Myanmar	-	-	-	-
(b)	Yemane (*Gmelina arborea*)	Taungoo	3.0	1.80	1.00	0.80
71	Yindaik (*Dalbergia cultrate*)	Taungoo	6.2	3.72	2.07	1.65
72	Yinma (*Chukrasia tabularis*)	Taungoo	5.2	3.12	1.73	1.39
73	Yinzat (*Dalbergia fusca*)	Taungoo	4.2	2.52	1.40	1.12
74 (a)	Yon *(Anogeissus acuminata)*	Myanmar	4.2	2.52	1.40	1.12
(b)	Yon *(Anogeissus acuminata)*	Taungoo	5.4	3.24	1.80	1.44
75 (a)	Zaungbale (*Lagerstroemia villo*)	Myanmar	4.2	2.52	1.40	1.12
(b)	Zaungbale *(Lagerstroemia villo)*	Taungoo	4.7	2.82	1.57	1.25

According to table (3), it can be seen that the minimum tangential shrinkage(from green to oven dry) among thestudied species is 4.2%, for Kyun. High durability and minimum lateral movement with weather changes are the two most desirable properties for ship's decking (Wallis, 1970). This accounts for the great popularity of Kyun for this purpose. It was found that the maximum tangential shrinkage among the mentioned species is 15.3%, for Thitpayaung.

From table (3), it can also be seen that tangential shrinkage of Hmyaseik, Myaukngo, Sit, Taungmeok, Tawthayet, Yemane and Kyana are close to that of Padauk which is accepted as one of the most popular species for making fine furniture and construction materials in Myanmar.

Tangential shrinkage and radial shrinkage (green to oven dry) and dimensional stability are given in table (5).

Table (5) Dimensional Stability of Seventy-FiveTimbers

Sr. No.	Species	Locality	Shrinkage Green to Oven Dry(%)		Dimensional Stability
			Tangential	Radial	
1	Baing *(Tetrameles nudiflora)*	Taungoo	8.5	3.5	2.43
2(a)	Binga *(Mitragyna rotundifolia*	Burma	7.3	3.8	1.92
(b)	Binga *(Mitragyna rotundifolia*	Taungoo	8.2	4.0	2.05
3	Bonmeza *(Albizzia chinensis)*	Taungoo	6.2	2.2	2.82
4	Chinyoke (*Garuga pinnata)*	Taungoo	6.1	3.3	1.85
5	Didu (*Salmalia insignis)*	Taungoo	5.9	2.8	2.10
6	Dwabok (*Kydia calycina)*	Taungoo	6.6	3.0	2.20

Table (5) Continued

Sr. No.	Species	Locality	Shrinkage Green to Oven Dry		Dimensional Stability
			Tangential	Radial	
7	Dwani (*Eriolaena candollei*)	Taungoo	6.9	4.2	1.64
8	Eucalypt (*Eucalyptus camaldulensis*)	Kyauk-padaung	7.3	3.9	1.87
9	Gwe (*Spondias pinnata*)	Taungoo	5.6	2.1	2.67
10	Gyo (*Schleichera oleosa*)	Taungoo	10.8	5.0	2.16
11	Hmyaseik (*Antiaris toxicaria*)	Taungoo	5.3	2.7	1.96
12	Hnaw (*Adina cordifolia*)	Taungoo	6.5	3.6	1.81
13	In (*Dipterocarpus tuberculatus*)	Myanmar	9.1	4.4	2.07
14	Ingyin (*Shorea siamensis*)	Myanmar	8.9	4.8	1.85
15	Kanyaung (*Shorea argentea*)		10.9	5.5	1.98
16	Kanyin-byu (*Dipterocarpus alatus*)	Myanmar	8.6	3.6	2.39
17	Kanyin-ni (*Diptero-carpus turbinatus*)	Myanmar	8.9	4.2	2.12
18	Kaunghmu (*Anisoptera scaphula*)	Myanmar	-	-	-
19	Kokko (*Albizzia lebbek*)	Taungoo	6.0	3.0	2.00
20 (a)	Kuthan (*Hymenodic-tyon excelsum*)	Pyinmana	6.9	3.9	1.77
20 (b)	Kuthan (*Hymenodictyon excelsum*)	Taungoo	6.1	3.2	1.91
21	Kyana (*Xylocarpus moluccensis*)	Myanmar	5.5	3.0	1.83
22	Kyetyo (*Vitex peduncularis*)	Taungoo	9.2	4.9	1.88
23	Kyun (*Tectona grandis*)	Myanmar	4.2	2.3	1.83
24 (a)	Lein (Terminalia pyrifolia)	Pyinmana	9.1	4.8	1.90
(b)	Lein (Terminalia pyrifolia)	Taungoo	9.2	5.9	1.56
25	Letpan (*Salmalia malabarica*)	Taungoo	4.9	2.1	2.33
26 (a)	Leza (*Lagerstroemia tomentosa*)	Pyinmana	6.4	4.2	1.52
(b)	Leaz (*Lagerstroemia tomentosa*)	Taungoo	7.6	4.9	1.55
(c)	Leza (*Lagerstroemia tomentosa*)	Tatkone	6.9	4.7	1.50
27	Ma-u-lettan-she (*Anthocephalus cadamba*)	Taungoo	8.0	3.8	2.11
28 (a)	Myaukchaw (*Homalium tomentosa*)	Myanmar	10.1	4.4	2.30

Table (5) continued

Sr. No.	Species	Locality	Shrinkage Green to Oven Dry		Dimensional Stability
			Tangential	Radial	
(b)	Myaukchaw (*Homalium tomentosa*)	Taungoo	10.7	5.6	1.91
29 (a)	Myaukngo (*Duabanga grandiflora*)	Pyinmana	6.6	3.7	1.78
(b)	Myaukngo (*Duabanga grandiflora*)	Taungoo	5.1	3.2	1.59
30	Myaukthwegyi (*Myristica spp*)	Taungoo	7.0	4.0	1.75
31	Myaukthwethe (*Myristica angustifolia*)	Taungoo	8.4	4.3	1.95
32	Nabe (*Lennea grandis*)	Taungoo	6.0	3.5	1.71
33 (a)	Nyan (*Quercus serrata*)	Southern Shan State	10.1	4.4	2.30
(b)	Nyan (*Quercus serrata*)	Pyin Oo Lwin	12.9	5.3	2.43
34 (a)	Padauk (*Pterocarpus macrocarpus*)	Myanmar	5.1	3.4	1.50
(b)	Padauk (Plantation) (*P. macrocarpus*)	Pyinmana	5.6	3.8	1.48
35	Panga (*Terminalia chebula*)	Tungoo	11.0	5.4	2.04
36 (a)	Petthan (*Heplophrogma aderophyllum*)	Myanmar	7.8	4.6	1.79
(b)	Petthan **(***Heplophrogma aderophyllum*)	Taungoo	7.5	4.4	1.70
37	Pinlekanazo (*Heritiera fomes*)	Myanmar	11.6	5.9	1.97
38 (a)	Pyaukseik (*Holoptelea integrifolia*)	Tungoo	8.5	3.8	2.24
(b)	Pyaukseik (*Holoptelea integrifolia*)	Tatkone	7.6	4.6	1.65
39	Pyinkado (*Xylia xylocarpa*)	Myanmar	6.7	3.3	2.03
40	Pyinma (*Lagerstroemia speciosa*)	Taungoo	7.4	3.1	2.39
41	Sagawa (*Michelia champace*)	Myanmar	5.2	3.2	1.63
42	Seikche (*Bridelia retusa*)	Taungoo	5.9	2.2	2.68
43	Shaw (*Sterculia versicolor*)	Taungoo	5.9	1.9	3.11
44	Sit (*Albizzia procera*)	Taungoo	5.5	2.8	1.96
45	Taukkyan (*Terminalia tomentosa*)	Taungoo	8.4	5.7	1.47
46	Taung meok (*Alstonia scholaris*)	Taungoo	5.5	3.3	1.57
47	Taungokshit (*Elaeocarpus spp*)	Taungoo	8.1	3.0	2.67
48	Taungpeinne (*Artocarpus chaplasha*)	Taungoo	4.3	1.8	2.39

Table (5) continued

Sr. No.	Species	Locality	Shrinkage Green to Oven Dry		Dimensional Stability
			Tangential	Radial	
49	Taungpetwun (*Ptero-spermum cerifolium*)	Taungoo	6.7	3.8	1.76
50 (a)	Taungthayet (*Swintonia floribunda*)	Myanmar	6.0	3.2	1.88
(b)	Taungthayet (*Swintonia floribunda*)	Taungoo	5.9	2.7	2.19
51	Tawthayet (*Mangifera spp*)	Taungoo	5.6	3.6	1.56
52	Thabye (*Eugenia spp*)	Taungoo	9.3	4.3	2.16
53 (a)	Thadi (*Protium serratum*)	Pyinmana	8.9	5.5	1.62
(b)	Thadi (*Protium serratum*)	Taungoo	10.2	5.8	1.76
54	Thande (*Stereospermum personatum*)	Taungoo	8.4	4.8	1.75
55	Thaphan (*Ficus spp*)	Taungoo	6.7	2.7	2.48
56 (a)	Thingadu (*Parashorea stellata*)	Myanmar	9.8	4.2	2.33
(b)	Thingadu (*Parashorea stellata*)	Taungoo	7.4	3.8	1.95
57	Thingan (*Hopea odorata*)	Myanmar	6.5	3.4	1.91
58	Thinwin (*Millettia pendula*)	Pyinmana	7.7	4.3	1.79
59	Thitkha (*Pentace burmanica*)	Myanmar	6.5	3.1	2.10
60 (a)	Thitkado (*Cedrela toona*)	Myanmar	6.3	3.8	1.66
(b)	Thitkado (*Cedrela toona*)	Taungoo	6.4	3.1	2.06
61	Thitmagyi (*Albizzia odoratissima)*	Taungoo	6.3	2.9	2.17
62	Thitmin (*Podocarpus wallichianus)*	Myinmar	6.6	3.7	1.78
63	Thitpagan (*Millettia brandisiana)*	Pyinmana	14.5	6.7	2.16
64	Thitpayaung (*Nauclea sessilifilia)*	Taungoo	15.3	6.6	2.32
65	Thitsein (*Terminalia bellerica)*	Taungoo	9.7	6.4	1.52
66	Thitswele (*Schrebera swietenioides)*	Taungoo	7.1	4.5	1.58
67	Thitya (*Shorea oblongifolia)*	Myanmar	9.7	5.4	1.80
68 (a)	Tinyu (hna khwa) (*Pinus mercusii)*	Taungyi	9.7	6.5	1.49
69	Tinyu (thone khwa) (*Pinus insularis)*	Kalaw	8.0	4.7	1.70
70 (a)	Yemane (*Gmelina arborea)*	Myanmar	-	-	-

Table (5) concluded

Sr. No.	Species	Locality	Shrinkage Green to Oven Dry		Dimensional Stability
			Tangential	Radial	
(b)	Yemane (*Gmelina arborea)*	Taungoo	5.5	3.0	1.83
71	Yindaik (*Dalbergia cultrate)*	Taungoo	10.1	6.2	1.63
72	Yinma (*Chukrasia tabularis*)	Taungoo	9.7	5.2	1.87
73	Yinzat *(Dalbergia fusca*)	Taungoo	9.7	4.2	2.31
74 (a)	Yon *(Anogeissus acuminata)*	Myanmar	8.1	4.2	1.93
(b)	Yon *(Anogeissus acuminata)*	Taungoo	9.4	5.4	1.74
75 (a)	Zaungbale (Lagerstroemia villo)	Myanmar	7.6	4.2	1.81
(b)	Zaungbale *(Lagerstroemia villo)*	Taungoo	7.1	4.7	1.51

According to this table it can be found that minimum and maximum dimensional stability of mentioned species were found to be 1.47 for Taukkyan and 3.11 for Shaw.

According to the past experience on the Myanmar's commercial timbers, those timbers which have dimensional stability less than or equal to 2 and dimensional changes i.e; radial shrinkage and tangential shrinkage less than or equal to 3.5% and 7% are found to be suitable for making high quality wood products (Win Kyi-1, 2000). He also reported that in considering the transverse shrinkage, the tangential shrinkage is mainly taken into account since it is the major factor which can influence the dimensional changes of a wood product in use and almost all of the lumber used in daily practice are flat-sawn (i.e; tangential cut) lumber.

Moreover, Wallis (1970) stated that a ratio of tangential to radial shrinkage of more than 2 to 1 can cause considerable distortion in the right angle corners of sawn squares and planks. Shrinkage of 5% or less in a tangential direction across the fibers from green to air dry may be considered as relatively low, while similar shrinkage of 10% or more is above average

Dimensional stability of Kyun (*Tectona grandis*) 1.83 is obtained by dividing the tangential shrinkage 4.2% by the radial shrinkage 2.3%. Similarly, dimensional stability of Hnaw (*Adina cordifolia*) 1.81 is obtained by dividing the tangential shrinkage 6.5% by the radial shrinkage 3.6%. Although the dimensional stability of Kyun and that of Hnaw is nearly the same, Kyun is better than Hnaw for making high quality wood products, because the tangential shrinkage of Kyun is less than that of Hnaw.

According to Table (1), it can be seen that out of seventy-five timber species, thirty-six timber species have tangential shrinkage less than or equal to 7% whereas forty-five timber species have dimensional stability less than or equal to 2.0. However, only twenty-three species namely, Chinyoke, Dwani, Hmyaseik, Hnaw, Kokko, Kuthan, Kyana, Kyun, Leza, Myauk-ngo, Myauk-thwe-gyi, Nabe, Padauk, Pyinkado, Sagawa, Sit, Taungmeok, Taungpetwun, Taungthayet, Tawthayet, Thingan, Thitkado, Thitmin and Yemane have both dimensional stability less than or equal to 2 and tangential shrinkage less than or equal to 7.0 percent. Thus, these twenty-three species could be assessed as the best suited species for making high quality wood products among the studied species.

Out of the studied species, Binga, Didu, Eucalypt, Leza, Petthan, Thingadu, Thinwin, Thitka, Thitkado, Thitmagyi, Thitswele and Zaungbale could be taken as the second best suited timber species since their dimensional stability and tangential shrinkage are close to 2.0 and 7.0%.

Out of the above mentioned species, although Hmyaseik, Kuthan, Myaukthwegyi and Taungmeok are dimensionally stable, the basic specific gravity of these species is low. Thus, they will not be suitable for use as construction materials and some wood products where the strength is to be considered as the prime factor.

In this study, the selection of the best suited timbers is mainly based on the dimensional stability and tangential shrinkage. However, the mechanical properties such as MOE, MOR, compression stress, and hardness have to be taken into account to get precise decision. For the decorative wood products, color, texture and feature of the wood have to be taken into consideration. The method applied in this study can be used as a quick and easy approach for selecting the suitable species from the newly introduced species.

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. The ratio of tangential shrinkage to radial shrinkage appears to be more or less independent of structure (Brown *et al,* 1952). According to Table (5), it can be seen that dimensional stability of Bonmeza, Gwe and Letpan which have the lowest basic specific gravity among the timber species given in this paper are found to be greater than 2.0 whereas dimensional stability of Kyetyo, Myaukchaw, Taukkyan, Yinma, Ingyin, Thinwin, Thitya, Yindaik and Yon which have high basic specific gravity are found to be less than 2.0.

In this study, statistical analysis by using simple linear regression method was tested on specific gravity Vs tangential shrinkage and specific gravity Vs dimensional stability of 75 timber species. It was found that the tangential shrinkage of the mentioned species are significantly correlated to the basic specific gravity at 0.05 α - level by the equation **$Y = 6.3749\ X + 3.90$** where X = basic specific gravity and Y = tangential shrinkage (Fig. 3) and there is no correlation between dimensional stability and basic specific gravity (Fig. 4).

It is found that the findings were nearly the same with the result given by Win Kyi–1 (2000). According to that study, he reported that the tangential shrinkage of the tested 54 LUS are significantly correlated to the basic Sp. Gr. at 0.05 α - level by the equation **$Y= 6.8392\ X + 3.73$** where X = basic specific gravity and Y = tangential shrinkage. However, there was no correlation between dimensional stability and basic specific gravity.

The locality in which a tree grows in its geographical range is not an important consideration in arriving at data on the properties of its wood. Such minor departures as do occur can usually be explained on the basic of environment, soil fertility, etc. In many instances, differences in strength that have been accredited to geographical region are actually within the limits of normal variation on a given site and therefore statistically insignificant (Brown *et. al.,* 1952).

On the other hand, Wilson (1986) stated that, wood properties may also influence by environmental sites (eg. soil type, rainfall, mean and maximum, minimum temperature, solar radiation, altitude and latitude) and anthropogenic factors (eg. tree spacing, thinning and pruning, irrigation, weed control and pest control) which exert and influence on cambial activity.

In this study, statistical analysis by Statistica microsoftware was made on locality and some physical properties (specific gravity, tangential and radial shrinkage and dimensional stability) on 16 species namely Binga, Kuthan, Lein, Leza, Myaukchaw, Myaukngo, Nyan, Padauk, Petthan, Pyaukseik, Taungthayet, Thadi, Thingadu, Thitkado, Yemane,Yon and Zaungbale. Analysis of variance revealed that there were not significantly different between locality and some physical properties.

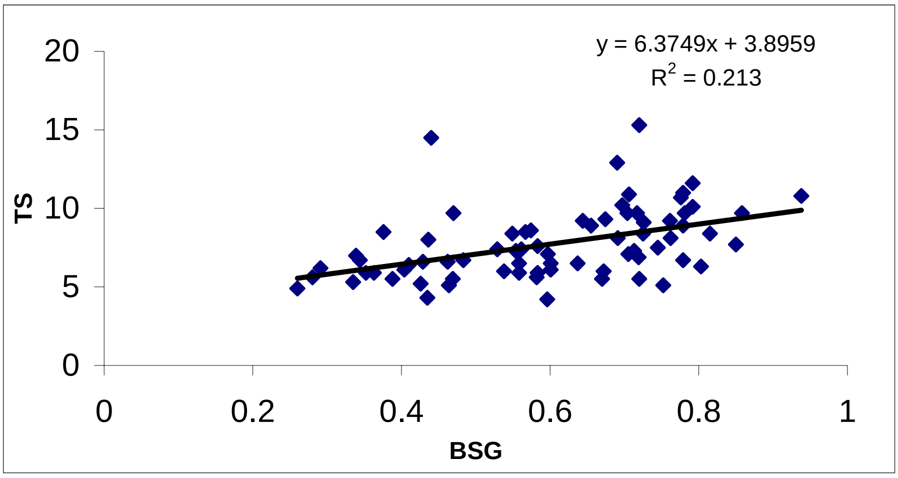

Fig. (3) Correlation between Basic Specific Gravity and Tangential Shrinkage

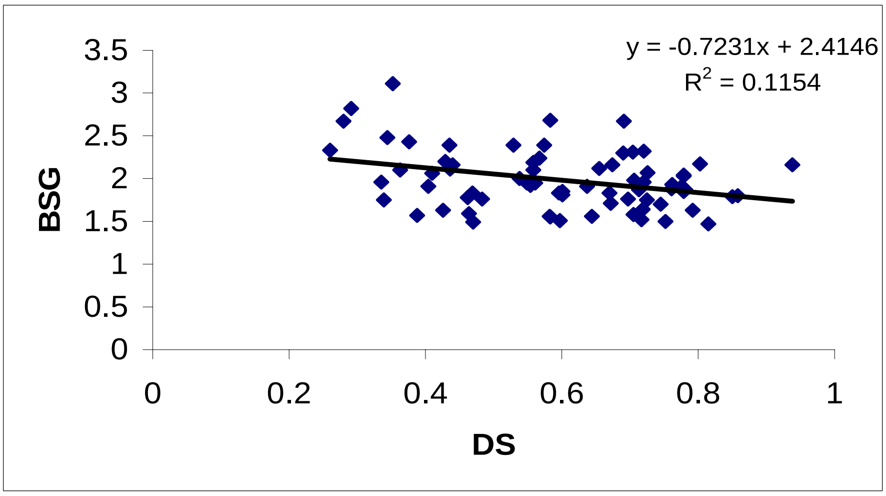

Fig. (4) The relationship between Basic Specific Gravity and Dimensional Stability

5. Conclusions

As the results of this study, the following conclusions can be drawn.

(1) Out of the presented seventy-five species, seven species are light, sieventeen species are moderately heavy, forty-six species are heavy and five species are very heavy.

(2) Letpan is the lightest and Gyo is the heaviest among the studied seventy-five 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, Thitya, Thinwin, Thitmagyi, Taukkyan, Pinlekanazo, Yindaik, Yinma and Panga are above or equal to that of Pyinkado.

(5) Tangential shrinkage of Hmyaseik, Myaukngo, Sit, Taungmeok, Tawthayet, Yemane and Kyana are close to that of Padauk.

(6) Among the studied seventy-five species, twenty- three species could be suitable for making high quality wood products.

(7) Tangential shrinkage of tested species are significantly correlated to their basic specific gravity at 0.05 α - level by the equation **$Y = 6.3749 X + 3.90$.**

(8) Dimensional stability of tested species is not correlated to their basic specific gravity.

(9) Some physical properties (specific gravity, tangential and radial shrinkage and dimensional stability) between localities are not significantly different.

REFERENCES

Anon (1974): Wood Handbook, Wood as an Engineering Material.

Anon (1986): 100 Malaysian Timbers. The Malaysian Timber Industry Board, Kuala Lumpur, Malaysia.

Beckett, R.S. (1986) : Market Opportunities for Timber Through Engineering. Topic 24. 22 nd Forest Products Research Conference, CSIRO, Melbourne, Australia.

Brown, H.P., A.J.Panshin and C.C.Forsaith (1952): Textbook of Wood Technology Vol.II. Mc. Graw Hill Book Company Inc., New York.

Dinwoodie, J.M. (1986): Timber, Its Nature and Behavior.

Bello, D. Emmanuel (2000): Research Framework to Increase Utilization of LUS. The International Workshop on Introducing Myanmar's LUS to the World Market. ITTO Project PD 31/ 96 Rev:2 (MFI).

Forest Product Laboratory, Forest Services. US Dept. of Agriculture, Agri Handbook No. 72.

Negi. S.S., IFS. (1997): Wood Science and International Book Distributions, Dehra Dun, India.

Norman. K. Wallis (1970): The relationship of Timber Properties to Utilization. Australian Timber Handbook, page 299 - 315.

Panshin, A.J. and Carl de Zeeuw (1980): Textbook of Wood Technology Vol.II. Mc. Graw Hill Book Company Inc., New York.

Pearson (1965): The Establishment of Working Stress for groups of Species. Div; of For. Prod: Tech: Paper No. 35, CSIRO, Australia.

Reineke L.H. (1965): Sawing Methods in Relation to Stiffness of Studs. Paper, Forest Product Laboratory, University of Wiseonsin, USA.Dept: of Agri: at the Meeting of International Union of research Organizations, Melbourne.

Skaar, Christen (1972): Water in Wood. Syracuse University Press, Syracuse. New York.

Win Kyi-1 (1993): Physical and Mechanical Properties of Some Myanma Timbers. Timber Digest Vol.1. No.3. 1993. FRI. Yezin, Myanmar.

Win Kyi-1(2000): Dimensional Stability of Fifty-Four Lesser- Used Timber Species of Myanmar. The International Workshop on Introducing Myanmar's LUS to the World Market. ITTO Project PD 31/ 96 Rev:2 (MFI).

Win Kyi-1, Win Oo Naing and Cho Cho Myint (2002): Density and Specific Gravity of Fifty-Four Lesser- Used Timber Species of Myanmar. F.R.I. Paper.

Appendix I

Regression on Relating Between Various Mechanical Properties and Density of Australian Timber

Property	Regression	Corr: Coeff:	No. of species
Bending	$R_g = 252\ BD + 510$	0.89	95
	$R_g = 182\ DD + 1{,}350$	0.86	74
	$Eg = 129\ R_g + 310{,}000$	0.84	76
	$E_d = 161\ R_g + 360{,}000$	0.79	77
	$E_d = 115\ R_d + 180{,}000$	0.93	73
	$R_d = 1.44\ R_g + 1160$	0.88	81
Compression // to G	$C_g = 0.532\ R_g – 220$	0.97	94
	$C_d = 0.860\ R_g + 1750$	0.92	81
Compression $\perp$ to G	$L_g = 0.147\ R_g – 500$	0.78	74
	$L_d = 0.198\ R_g – 580$	0.84	74
Shear	$S_g = 0.134\ R_g – 40$	0.92	93
	$S_d = 0.140\ R_g + 620$	0.78	77
Modulas of rigidity in tension	$G_g = 7.44\ R_g + 30{,}000$	0.85	65
	$G_d = 10.3\ R_g + 40{,}000$	0.79	64

Source: Pearson (1965)

Where, BD = Basic Density (lb/cu ft)

DD = Density at 12% MC (lb/cu ft)

C = Maximum crushing strength (lb/sq in)

E = Modulus of Elasticity (MOE) (lb/sq in)

G = Modulus of Rigidity (lb/sq in)

L = Stress at Proportional Limit in radial direction on 6x 2x 2 specimen

R = Modulus of Rupture (MOR) (lb/sq in)

S = Maximum Shear strength (lb/sq in) lower of two values for shear in radial and tangential planes

Subscripts ‘g’ and‘d’ refer to green and air-dry (12% MC) material respectively.

Appendix II

Specific Gravity - Strength Relation

Strength Property	Equation: Green wood	Equation: Air-dry wood (12%MC)
Static Bending: Fiber stress at proportional limit, p.s.i.	$\sigma = 10{,}200G^{1.25}$	$\sigma = 16{,}700G^{1.25}$
Modulus of rupture, p.s.i.	$R = 17600G^{1.25}$	$R = 25{,}700G^{1.25}$
Work to maximum load, in.-lb./cu.in.	$W= 35.6G^{1.75}$	$W= 32.4G^{1.75}$
Modulus of elasticity, 1000p.s.i.	$E = 2360G$	$E = 2800G$
Impact Bending: Fiber stress at proportional limit, p.s.i.	$\sigma = 23{,}700 G^{1.25}$	$\sigma = 31{,}200 G^{1.25}$
Modulus of elasticity, 1000p.s.i.	$E = 2940G$	$E = 3380G$
Height of hammer drop, in.	$H = 114G^{1.75}$	$H = 94.6G^{1.75}$
Compression parallel to grain: Fiber stress at proportional limit, p.s.i.	$\sigma = 5{,}250G$	$\sigma = 8{,}750G$
Maximum crushing strength, p.s.i.	$C = 67{,}30G$	$C = 12{,}200G$
Modulus of elasticity, 1000p.s.i.	$E = 2.91G$	$E = 3.38G$
Compression perpendicular to grain, Fiber stress at proportional limit, p.s.i.	$C = 3{,}000G^{2.25}$	$C = 4{,}630G^{2.25}$
Hardness, lb.: End Side (radial) Side (tangential)	 $H_e = 3740G^{2.25}$ $H_{SR} = 3380G^{2.25}$ $H_{ST} = 3460G^{2.25}$	 $H_e = 4800G^{2.25}$ $H_{SR} = 3720G^{2.25}$ $H_{ST} = 3820G^{2.25}$

* Wood Handbook, Table 4-9.

Appendix III

Sr. No.	SPECIES	SITES	BSPGR	RAD_SHR	TGT_SHR	DS
1	Binga	Myanmar	0.553	3.80	7.30	1.92
2	Binga	Taungoo	0.554	4.00	8.20	2.20
3	Kuthan	Pyinmana	0.376	3.90	6.90	1.77
4	Kuthan	Taungoo	0.404	3.20	6.10	1.91
5	Lein	Pyinmana	0.625	4.80	9.10	1.90
6	Lein	Taungoo	0.644	5.90	9.20	1.56
7	Leza	Pyinmana	0.522	4.20	6.40	1.52
8	Leza	Taungoo	0.830	4.90	7.60	1.55
9	Myaukngo	Pyinmana	0.429	3.70	6.60	1.78
10	Myaukngo	Taungoo	0.464	4.00	7.00	1.59
11	Nyan	S. Shan State	0.650	4.40	10.10	2.30
12	Nyan	Pyinoolwin	0.690	5.30	12.90	2.43
13	Padauk	Myaunmar	0.652	3.40	5.10	1.50
14	Padauk	Pyinmana	0.706	2.30	3.40	1.48
15	Petthan	Myaunmar	0.726	4.60	7.80	1.79
16	Petthan	Taungoo	0.745	4.40	7.50	1.70
17	Pyaukseik	Taungoo	0.567	3.80	8.50	2.24
18	Pyaukseik	Tatkone	0.580	4.60	7.60	1.65
19	TaungThayet	Myaunmar	0.551	3.20	6.00	1.88
20	TaungThayet	Taungoo	0.558	2.70	5.90	2.19
21	Thadi	Pyinmana	0.710	5.50	8.90	1.62
22	Thadi	Taungoo	0.697	5.80	10.20	1.76
23	Thingadu	Myaunmar	0.589	4.20	9.80	2.33
24	Thingadu	Taungoo	0.561	3.80	7.40	1.95
25	Thitkado	Myaunmar	0.473	3.80	6.30	1.66
26	Thitkado	Taungoo	0.410	3.10	6.40	2.06
27	Yemane	Myaunmar	0.419	2.40	4.90	2.00
28	Yemane	Taungoo	0.469	3.00	5.50	1.83
29	Yon	Myaunmar	0.739	4.20	8.10	1.93
30	Yon	Taungoo	0.769	5.40	9.40	1.74
31	Zaungbale	Myaunmar	0.610	4.20	7.60	1.81
32	Zaungbale	Taungoo	0.597	4.70	7.10	1.51

Analysis of Variance
Marked effects are significant at p < .05000

	SS Effect	df Effect	MS Effect	SS Error	df Error	MS Error	F	p
Basic sp. gr.	0.002757	1	0.002757	0.595576	30	0.019853	0.13885	0.712046
Radial shrinkage	0.28125	1	0.28125	26.13875	30	0.871292	0.322797	0.57416
Tagential shrinkage	0.125	1	0.125	106.935	30	3.5645	0.035068	0.852714
Dimensional stability	0.02205	1	0.02205	2.145938	30	0.071531	0.308257	0.582868