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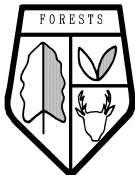

Government of the Union of Myanmar
Ministry of Forestry
Forest Department

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Forest Products Research

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သဒီနှင့် ထင်းရှူးသစ်များ၏ အရည်အချင်းနှင့် အင်အားကို စူးစမ်းလေ့လာခြင်း

ဝင်းကြည်
သစ်တောထွက်ပစ္စည်းသုတေသနဌာနခွဲ
သစ်တောသုတေသနဗဟိမာန်

စာတမ်းအကျဉ်းချုပ်

သဒီသစ်နှင့် ထင်းရှူးသစ်တို့၏အရည်အချင်းနှင့် အင်အားဆိုင်ရာဂုဏ်သတ္တိများကို ပျဉ်းမနား သစ်တောနယ်၊ တိုင်းသစ်တောကြိုးဝိုင်းနှင့် ရှမ်းပြည်တောင်ပိုင်း၊ တန်ဖတ်ကြိုးဝိုင်းများမှ စုဆောင်းရရှိခဲ့သော သစ်နမူနာများဖြင့် စမ်းသပ်တွေ့ရှိချက်များကို တင်ပြထားခြင်းဖြစ်ပါသည်။

Investigations on the Physical and Mechanical Properties of Thadi and Tinyu

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Abstract

The Physical and Mechanical Properties of Thadi (*Protium serratum* Eng.) and Tinyu (*Pinus merkusii* Jungh) are recorded from tests conducted on specimens obtained from Kaing reserve forest, Pyinmana forest division and Tumphat reserve forest, Southern Shan States.

Contents

1. Introduction

This study on the properties of Thadi *(Protium serratum* Eng. Syn. *Bursera serrata* Collebr.) and Tinyu (*Pinus merkusii* Jungh) is based on two fundamental investigations. The first deals with physical properties and the second dealing with mechanical properties of the above two mentioned species. The data given are the results of the investigation carried out at the Timber Physical an Mechanics Section of the Forest Research Institute in Yezin.

Some information from literature is also incooperated to make a ready reference for these particular species. It would be mentioned here that this work is just a very quick findings carried out within a limited time, further investigation with proper sampling technique and procedure will be achieved as the conditions favoured.

2. Material

Material for each species was obtained from five straight-grained trees of merchantable size. The trees for Thadi were selected from the Kaing Reserve Forest in Pyinmana Forest Division and those for Tinyu were selected from the Tumphat Reserve Forest in the Southern Shan States Forest Division.

The tree number and the position of bolts in the trees were indelibly marked on each log to avoid confusion. Botanical specimens were collected for identification.

3. Testing Procedure

3.1 Physical Properties

Four samples each measuring 1" x 1" x 4" were taken from each tree for radial and tangential shrinkage determination. Six samples each measuring 2" x 2" x 6" were taken from each tree for volumetric shrinkage and specific gravity determinations. Usual water displacement method is applied in determining the specific gravity.

3.2 Mechanical Properties

Each log was sawn into two pairs of 4 ft x 3 in x 3 in. blocks, one of each pair being for tests in green and the other for tests on dry material.

All blocks were dressed to 2 inches square before test specimen were cut. Test specimens were prepared to various sizes for different type of test as shown in table (1). Toughness tests could not be performed on account of lack of equipment. Care being taken to ensure that they were of relatively clear timber.

Proper sampling of trees could not be made from different locality because of the limitation of time.

The sizes and the testing procedure were in accordance with those specified by the American Society for Testing Materials (1).

Part I

THADI (*Protium Serratum* Eng. *Syn. Bursera serrata* Collebr.)

1. Trade Name

Thadi, Yitpadi (Burma), Ma-fan (Thailand), Indian red pear (India).

2. Tree and Distribution

It is a straight cylinderical stemmed tree, attaining a height of 50-70 feet and a girth of 5-7 feet. A clean bole of 30-40 feet is obtainabled. The bark of the tree is thin, rough and light brown. It occurs in the ever-green and semi-evergreen forests of the plains and the lower hills of both upper and lower Burma. Available in small quantity all over the country, but due to its potential use in construction work it is extracted on a commercial scale together with other hardwoods. According to the Inventory Data of Pyinmana and Yemethin Forest Division (1966 & 1967), it is observed that, the growing stock per acre is 1.44 and 1.04.

3. Timber

Thadi has a narrow band of sapwood, light brown in colour. The heartwood is bright red when first exposed and turns dark red or dull brown on exposure. The timber has a smooth feel and no distinct odour or taste. Medium textured and generally straight grained but may occasionally develop interlocked or wavy grains.

Surface checks occurred during drying and the cracks being numerous, small and inconspicuous. Although end splitting was not prominent, generally this timber should be regarded as a refractory timber.

The sapwood is found to be susceptible to insect attack. It is farily durable under cover and graveyard test in India (2) showed that this timber last for 64 months on the average. Preservative treatment is said to be very difficult (2).

The timber is said to be not difficult to saw and work. Smooth surface is obtained and finishing to a beautiful surface.

This timber could be used as a structural timber and it is said to be farily good for sleepers (9). It is also used in making ploughs, cart-wheel and shafts, door and window frames.

4. Results

4.1 Physical Properties

Table (2) gives the mean value of the physical properties of Thadi as found by this investigation. The physical properties of Taukkyan (*Terminalia tomentosa*) and Ingyin (*Pentacme siamensis*) are also given for the purpose of comparing the relative merits of Thadi. Figures for Taukkyan and Ingyin were obtained from tests carried out at the Forest Research Institute, Dehra Dun, India (9).

4.1.1 Specific Gravity

The average green specific gravity is 0.71 and that of oven dry is 0.82. The data from India (8) is approximately 0.77 and that of Thailand (7) is 0.718 at air dry.

The average green weight at 53% moisture content is 66.9 lb/cu.ft and that of oven dry is 51.2 lb/cu.ft. This would be classified as a moderately heavy to heavy timber (8).

4.1.2. Shrinkage

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Measurements of the tangential and radial dimensions wee made for the green and oven dry conditions. Air dry measurements had not been recorded, due to lack of time.

4.2 Mechanical Properties

The mechanical properties of Thadi on green and air dry states are given in tables (3) and (4). These strength data presented were based on the tests of five trees, carried out at the Forest Research Institute, Yezin. The mean for each strength property together with other statistical data are also given in these tables. Moisture content of 43.7% and 17.9% respectively were present at the time of testing green and air dry.

Table (5) represents the mechanical properties of this timber together with Taukkyan (*Terminalia tomentosa*) and Ingyin (*Pentaceme siamensis*). The data on tests of Thadi in Thailand (4) is also given for comparison. The strength figures of this investigation tested at a moisture content of 17.9% is adjusted to 12% moisture content by applying the factors of the U.S. Forest Products Laboratory (5).

5. Discussion

Specific gravity of Thadi is similar to that of Taukkyan and is lower than that of Ingyin. In terms of weight, this timber is lighter than Ingyin but very similar to Taukkyan. Weight of Indian grown Thadi at 12% moisture content is 50 lb/cu.ft (8) and that of Thailand is 44.76 lb/cu.ft at 12% moisture content. Therefore it could be observed that Burmese Thadi is very similar to India Thadi but it is heavier than Thailand grown Thadi.

The magnitude of shrinkage of Thadi should be regarded as large.

Mechanical properties of Thadi, in static bending and compression parelled to grain tests, are almost similar to that of Ingyin. It is even slightly superior to Ingyin in other properties. It indicated that Thadi is farily strong and hence it should be up graded in utilization by proper seasoning and preservative treatment.

This timber is also superior to that of Thailand grown Thadi.

The coefficients of variations in tables (3) and (4) show that the tests carried out were statistically sound comparing to the data given by the U.S. Forest Products Laboratory (5).

Part II

Tinyu (*Pinus merkusii* Jungh)

1. Trade Name

Tinyu, Hna-khwa-tinyu (Burma), Son (Thailand), Sral (Cambodia), Thong mu (Vietnam).

2. Tree and Distribution

It is a large tree, which in exceptional cases reaches 10 feet in girth and 100 feet in height, more commonly from 6-7 feet in firth And 70-80 feet in height It is a straight cylinderical stemmed tree with rough-barked. Tinyu is found on dry hills in the Southern Shan States, on the Salween, in Martaban and in Tenasserim, at 900 feet to 2000 feet elevation.

3. Timber

Sapwood is whitish to creamy white. Heartwood is yellowish to orange-brown when freshly cut and on exposure becomes more brownish. It has considerably darker streaks present in the growth rings and many darker lines dominate the longitudinal resin canals. It is farily lustrous when first exposed but becoming more or less dull with age. It is uneven-grained and coarse-textured.

The timber has a resinous odour when freshly cut with faint resinous taste. Surface checking, splitting and warping and warping were did not appear during air seasoning. Generally this timber should be regarded as moderately - refractory.

It is not durable in exposed position but last well under cover. Very susceptible to attack by white ants but possible to prevent these pests by preservative treatment.

The timber saws easily and works to a good finish and polishes well.

It seems to be a good construction timber for indoor work. Used for furniture making and packing cases.

4. Results

4.1 Physical Properties

Table (6) gives the mean values of physical properties of *Pinus merkusii*, *Pinus isularies*, (6) *Pinus longifolia* and teak for comparison. Figures for *Pinus longifolia* and teak were obtained from tests carried out at the Forest Research Institute, Dehra Dun, India.

4.1.1 Specific Gravity

The average green specific gravity is 0.47 and that of oven-dry is 0.56.

The average green weight at 90.4% moisture content is 57.0 lb/cu.ft and that of oven-dry is 35.0 lb/cu.ft. The weight of Thailand grown Pinus merkusii ranges from 35 to 43 lb/cu.ft (4). Figure obtained from tests in India is 43 lb/cu.ft at 12% moisture content. This would be classified as a light to moderately heavy timber (8).

4.2 Mechanical Properties

The mechanical properties of Tinyu on green and air dry states, based on the tests of five trees, are given in tables (7) and (8). The mean for each strength property together with other statistical data are also given in these tables. Moisture content at the time of testing green and air dry were 65.7% and 12.7% respectively.

The mechanical properties of this timber are given n table (9), together with those of *Pinus insularis*, *Pinus logifolia* and teak. For comparison, the strength data on air dry were adjusted to 12% moisture content.

5. Discussion

Specific gravity and weight of *Pinus merkusii* are very similar to those of *Pinus insularis* and *Pinus longifolia*.

The shrinkage values of *Pinus merkusii* are also higher than those of *Pinus insularis* and *Pinus longifolia*.

Mechanical properties of *Pinus merkusii* is higher than that of *Pinus insularis* except in compression parallel to grain.

The coefficients of variation in air dry tests were within the limits according to the data given by the U.S. Forest Laboratory (5).

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Table 1

Sr.No.	Test	Over-all Dimension of Specimens
(1)	(2)	(3)
1	Static Bending	2" x 2" x 30"
2	Compression parallel to grain	2" x 2" x 8"
3	Compression perpendicular to grain	2" x 2" x 6"
4	Hardness	2" x 2" x 6"
5	Shear	2" x 2" x 2½"
6	Tension perpendicular to grain	2" x 2" x 2¼"
7	Cleavage	2" x 2" x 3¾"

TABLE 2
PHYSICAL PROPERTIES OF THADI AND OTHER SPECIES

Local Name	Scientific Name	Locality	Seasoning	Specific Gravity	Moisture Content per cent	Weight lb. Per cu.ft.	Radial shrinkage per cent Green to Oven dry	Tangential shrinkage per cent Green to Oven dry	Volumetric shrinkage per cent Green to Oven dry
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Protium								
Thadi	serratum	Burma	Green	0.71	53.3	66.9	5.46	8.94	13.30
`	`	`	Oven-dry	0.82	-	51.2	-	-	-
	Terminalia	United							
Taukkyan	tomentosa	Irovinces	Green	0.71	53.5	68.0	4.8	7.1	-
`	`	`	Air-dry	0.75	13.2	53.0	-	-	-
	Pentacme								
Ingyin	siamensis	Burma	Green	0.78	54.3	75.0	4.8	8.9	-
`	`	`	Air-dry	0.82	13.4	58.0	-	-	-

TABLE 3.

Mechanical Properties of Green (M.C. 43.7%) Thadi

Property	Unit	Mean	Characteristics of frequency distributions				No. of Specimens
			Standard deviation	Coefficient of variation Percent	Observed minimum	Observed maximum	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Static bending							
Fibre stress at E.L.	lb/sq.in	6782	915	13.49	3979	9240	87
Modulus of rupture	lb/sq.in	12206	1433	11.75	8073	15173	87
Modulus of elasticity	10^3 lb/sq.in	1577	196	12.45	1182	1991	87
Work to E.L.	lb/cu.in	1.68	0.38	22.38	0.89	2.77	87
Comp. Parellel to grain							
Fibre stress at F.L.	lb/sq.in	2874	617	21.49	1463	4439	80
Maximum crushing strength	lb/sq.in	5035	527	10.48	3431	6488	80
Comp. Perpendicular to grain							
Fibre stress at E.L.	lb/sq.in	1341	299	22.34	726	2194	43
Hardness							
Radial surface	lb	1719	240	13.98	1120	2060	50
Tangential surface	lb	1644	214	13.02	1120	2100	50
End surface	lb	1646	185	11.29	1220	2050	50
Shear							
Maximum shear stress							
Plane of failure – radial	Lb/sq.in	1536	261	17.02	961	2160	48
- tangential		1643	201	12.27	1308	2078	48
Tension perpendicular to grain							
Plane of failure - radial	lb/sq.in	727	217	29.84	351	1524	40
- tangential	lb/sq.in	1120	213	19.07	565	1503	45
Cleavage							
Maximum strength							
Plane of failure - radial	lb/in	411	109	26.54	158	617	43
- tangential	lb/in	504	125	24.87	235	737	47

TABLE 4
Mechanical Properties of Air-dry (M.C.17.9%) Thadi.

Property	Unit	Mean	Characteristics of frequency distributions				No. of Specimens
			Standard deviation	Coefficient of variation Percent	Observed minimum	Observed maximum	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Static bending							
Fibre stress at E.L.	lb/sq.in	6948	1054	15.18	5197	10041	69
Modulus of rupture	lb/sq.in	13714	1634	11.92	8820	16267	69
Modulus of elasticity	10^3 lb/sq.in	1704	241	14.15	1366	2321	69
Work to E.L.	lb/cu.in	1.61	0.45	27.73	0.85	2.86	69
Comp. Parellel to grain							
Fibre stress at F.L.	lb/sq.in	3379	749	22.18	2020	3000	53
Maximum crushing strength	lb/sq.in	6081	614	10.10	5520	7040	53
Comp. Perpendicular to grain							
Fibre stress at E.L.	lb/sq.in	1744	246	14.15	1257	2379	35
Hardness							
Radial surface	lb	1742	274	15.77	1250	2120	40
Tangential surface	lb	1746	231	13.28	1370	2170	40
End surface	lb	1758	251	13.98	1350	2140	40
Shear							
Maximum shear stress							
Plane of failure – radial	Lb/sq.in	1377	490	35.61	393	2333	60
- tangential		1537	533	34.72	738	2432	59
Tension perpendicular to grain							
Plane of failure - radial	lb/sq.in	982	413	42.09	231	1770	47
- tangential	lb/sq.in	1225	377	30.80	271	1790	46
Cleavage							
Maximum strength							
Plane of failure - radial	lb/in	480	151	31.54	152	694	65
- tangential	lb/in	652	131	20.18	219	867	66

TABLE 5

Mechanical Properties of Thadi and other Species

Local Name	Scientific Name	Locality	Seasoning	Moisture Content percent	STATIC BENDING				COMPRESSION PARELLEL TO GRAIN		COMPRESSIONPERPENDICULAR TO GRAIN		HARDNESS		SHEAR		TENSION	
					Fibre Stress At Elastic Limit p.s.i.	Modulus of Rupture p.s.i.	Modulus of Elasticity, 1000 p.s.i.	Work to Elastic Limit in, lb.per cu.in.	Fibre Stress At Elastic Limit p.s.i.	Maximum crushing strength p.s.i.	Fibre Stress at Elastic Limit	Radial lb. Load	Tangential lb. load.	End lb. load	Radial p.s.i.	Tangential p.s.i.	Radial p.s.i.	Tangential p.s.i.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Thadi	Protium Serrotum	P.M.N	Green	43.7	6782	12206	1577	1.68	2874	5035	1341	1719	1644	1646	1536	1643	72.7	1120
Thadi	Protium Serrotum	P.M.N	Airdry	12.0	8998	16951	1905	2.37	4376	8234	2310	1999	2004	2173	1621	1809	1069	1333
Thadi	Protium Serrotum	Thailand	Airdry	12.0	8489	15401	1392	-	-	6840	-	1620	1607	-	2389	2631	483	597
Taukkyan	Terminalia tomentosa	United	Green	53.5	6898	11290	1662	1.62	3890	5590	1270	1540	1470	1450	1070	1385	525	630
Taukkyan	Terminalia Tomentosa	Provinces	Airdry	12.0	9800	16118	1962	2.79	5157	8871	1834	2112	2209	2311	1663	1761	881	916
Ingyin	Pentacme siamensis	Burma	Green	54.3	8645	12830	2012	2.09	4985	6835	2225	1510	1585	1365	1305	1450	810	1110
Ingyin	Pentacme siamensis	Burma	Airdry	12.0	10636	16975	2342	2.72	5387	8537	1626	1697	1770	1605	1584	1829	710	995

TABLE 6

PHYSICAL PROPERTIES OF PINES AND TEAK

Local Name	Scientific Name	Locality	Seasoning	Specific Gravity	Moisture Content per cent	Weight lb. per cu. ft.	Radial shrinkage per cent Green to Oven-dry	Tangential shrinkage per cent Green to oven-dry	Volumetric shrinkage per cent Green to Oven-dry
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Pinus								
Tinyu	merkusii	Taungyi	Green	0.47	90.4	57.0	6.5	9.6	16.1
Tinyu	merkusii	Taungyi	Oven-dry	0.56	-	35.0	-	-	-
Tinyu	Pinus	Kalaw	Green	0.46	96.6	57.0	4.7	8.0	13.3
Tinyu	Insularis	Kalaw	Air-dry	0.49	12.8	35.7	-	-	-
Chir	Pinus longifolia	India	Green	0.45	81.0	-	5.9	7.1	-
Chir	Pinus Longifolia	India	Air-dry	0.55	12.0	38.0	-	-	-
Kyun	Tectona grandis	Burma	Green	0.59	51.8	57.0	2.3	4.2	-
Kyun	Tectona grandis	Burma	Air-dry	0.59	13.9	42.0	-	-	-

TABLE 7

Mechanical Properties of Green (M.C.65.7%) Pinus merkusii

Property	Unit	Mean	Characteristics of frequency distributions				No. of Specimens
			Standard deviation	Coefficient of variation per cent	Observed minimum	Observed maximum	
Static bending							
Fibre stress at E.L.	lb/sq.in	4179	1160	27.76	2368	8400	61
Modulus of rupture	lb/sq.in	8368	1913	22.85	5609	13049	61
Modulus of elasticity	10^3 lb/sq.in	1565	409	26.12	886	2590	61
Work to E.L.	lb/cu.in	0.66	0.31	46.95	0.15	2.03	61
Comp. Parallel to grain							
Fibre stress at E.L.	lb/sq.in	1943	535	27.54	1145	2956	44
Maximum crushing strength	lb/sq.in	3165	470	14.84	2300	4173	44
Comp. Perpendicular to grain							
Fibre stress at E.L.	lb/sq.in	422	121	28.61	201	709	48
Hardness							
Radical surface	lb	604	141	23.36	320	1060	106
Tangential surface	lb	613	156	25.49	300	1080	106
End surface	lb	680	191	28.02	420	1460	106
Shear							
Maximum shear stress							
Plane of failure - radial	lb/sq.in	897	199	22.14	331	1408	44
- tangential	lb/sq.in	921	201	21.80	633	1580	43
Tension perpendicular to grain							
Plane to failure - radial	lb/sq.in	494	196	39.72	143	777	42
- tangential	lb/sq.in	579	225	38.74	181	1267	42
Cleavage							
Maximum strength							
Plane of failure - radial	lb/in	412	151	36.68	118	737	42
- Tangential	lb/in	442	169	38.10	166	834	43

TABLE 8

Mechanical Properties of Air-dry (M.O. 12.7%) Pinus merkusii.

Property	Unit	Mean	Characteristics of frequency distributions				No. of Specimens
			Standard deviation	Coefficient of variation per cent	Observed minimum	Observed maximum	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Static bending							
Fibre stress at E.L.	lb/sq.in	6950	1543	22.19	4117	13582	77
Modulus of rupture	lb/sq.in	12211	2217	18.15	6060	18446	77
Modulus of elasticity	10^3 lb/sq.in	1895	462	24.39	1041	3039	77
Work to E.L.	lb/cu.in	1.46	0.45	30.98	0.62	3.37	77
Comp. Parallel to grain							
Fibre stress at E.L.	lb/sq.in	3403	716	21.05	2222	5445	75
Maximum crushing strength	lb/sq.in	5787	881	15.22	4033	8161	75
Comp. Perpendicular to grain							
Fibre stress at E.L.	lb/sq.in	832	132	15.90	596	1086	38
Hardness							
Radical surface	lb	1037	266	25.63	600	2060	66
Tangential surface	lb	1023	270	26.38	580	1980	66
End surface	lb	1302	298	22.90	800	2440	68
Shear							
Maximum shear stress							
Plane of failure - radial	lb/sq.in	1286	245	19.07	762	2211	59
- tangential	lb/sq.in	1314	192	14.62	882	1912	58
Tension perpendicular to grain							
Plane to failure - radial	lb/sq.in	483	239	49.47	41	1013	39
- tangential	lb/sq.in	637	250	39.23	310	1303	31
Cleavage							
Maximum strength							
Plane of failure - radial	lb/in	335	188	56.01	111	836	56
- Tangential	lb/in	377	175	46.48	189	790	55

TABLE 9

Mechanical Properties of Pines & Teak

Local Name	Scientific Name	Locality	Seasoning	Moisture Content per cent	STATIC BENDING			COMPRESSION PARALLEL TO GRAIN			COMPRESSIONPERPENDICULAR TO GRAIN		HARNNESS		SHEAR		TENSION	
					Fibre Stress At Elastic Limit p.s.i.	Modulus of Rupture p.s.i.	Modulus of Elasticity, 1000 p.s.i.	Work to Elastic Limit in, lb. per cuin.	Fibre Stress At Elastic Limit p.s.i.	Maximum crushing strength p.s.i.	Fibre Stress at Elastic Limit	Radial lb. load	Tangential lb. load	End lb. load	Radial p.s.i.	Tangential p.s.i	Radial p.s.i.	Tangential p.s.i.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Tinyu	Pinus Merkusii	Taungyi	Green	65.7	4179	8368	1565	0.66	1943	3165	422	604	613	680	897	921	494	579
Tinyu	Pinus Merkusii	Taungyi	Airdry	12.0	7194	12551	1921	1.54	3522	6030	864	1055	1040	1338	1313	1341	487	642
Tinyu	Pinus insularis	Kalaw	Green	61.9	2989	6559	1278	0.42	1797	2889	413	531	547	600	801	866	318	385
Tinyu	Pinus insularis	Kalaw	Airdry	12.0	5343	11833	1704	0.97	3294	6480	777	791	806	1000	1380	1437	425	484
Tinyu	Pinus longifolia	India	Airdry	12.0	7300	11020	1827	-	4515	7630	1135	910	1070	1560				
Kyun	Tectona grandis	Burma	Green	49.4	6935	11460	1640	1.65	3815	5710	930	980	960	910	990	1080	515	685
Kyun	Tectona grandis	Burma	Airdry	12.0	10415	15680	1907	3.19	5950	8455	1428	1010	1042	932	951	1478	521	588