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# STRENGTH PROPERTIES AND DRYING CHARACTERISTICS OF *EUCALYPTUS* WOOD GROWN IN BANGLADESH

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## บทคัดย่อ

การศึกษาคุณสมบัติทางกายภาพของไม้ *Eucalyptus tereticornis*, *E. brassiana* และ *E. camaldulensis* ที่ปลูกในประเทศบังคลาเทศ พบว่า ไม้ *E. tereticornis* มีความหนัก เนื้อไม้แน่น และแข็งแรงมาก ในขณะที่ไม้ *E. brassiana* และ *E. camaldulensis* มีความแน่น และแข็งแรงปานกลาง การทำไม้ยูคาลิปตัสให้แห้งเพื่อนำมาใช้ประโยชน์ต้องทำด้วยความระมัดระวัง

## ABSTRACT

The physical, mechanical and seasoning properties of *Eucalyptus tereticornis*, *E. brassiana* and *E. camaldulensis* planted in Bangladesh have been investigated. It is found that *Eucalyptus tereticornis* is a heavy, dense and strong timber while *E. brassiana* and *E. camaldulensis* are moderately dense and strong. The timbers are refractory to drying requiring care for seasoning.

## INTRODUCTION

*Eucalyptus* was first introduced in Bangladesh by tea estates in 1930's as an ornamental tree. The elimination trials on the species was carried out by the Bangladesh Forest Research Institute from 1978. After a series of investigation on thirty species of Eucalyptus, it was found that only three species, viz., *E. camaldulensis*, *E. tereticornis* and *E. brassiana* were suitable for Bangladesh soil and climate conditions (Davidson and Das, 1985). In the recent years, *Eucalyptus* particularly *camaldulensis* species are planted throughout the country by the farmers, Forest Department and individuals. The fast growing nature of these species makes them popular for timber and fuelwood. Due to the paucity of knowledge on the wood properties of these species, it is considered to be suitable for fuelwood only. This paper deals with the physical and mechanical properties and drying characteristics of these three eucalyptus which will

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ensure their proper utilization. The properties of *E. camaldulensis* studied earlier is included in this paper (Sattar, 1990)

## MATERIALS AND METHODS

The full length trees of *Eucalyptus tereticornis* and *E. brassiana* were collected from the Silvicultural Research Station on Charaljani, Tangail. Six trees of 12 year-old were taken for eac of the species. All the bolts were fairly straight and free from natural defects. Both ends of the bolt were coated with bituminous paint to check excessive evaporation of moisture and consequent checking. One disc was taken from each bolt for determination of moisture content, specific gravity and shrinkage. The size of the samples were 2.5 x 2.5 x 7.5 cm for these properties.

From each bolt, 6.35 cm x 6.35 cm x 2.50 m sticks were prepared in pairs for determination of mechanical properties. One stick was taken from each pair for conducting the test in green condition and the other for the test in air dry condition. The sticks for air dry test were dried to about 12% moisture content inside a drying shed. All the test sticks were thus dressed to 5.08 cm x 5.08 cm x 2.50 m strips and testing samples were prepared for the different mechanical properties according to ASTM standards (Anon, 1971). The mechanical tests were carried out in accordance with the specifications of this standard.

The drying characteristics were determined from the planks of 2.5 cm x 20 cm x 2 m dimension. Twelve planks were taken for each of the species. The samples were dried in a steam heated kiln following the drying schedule developed by the Bangladesh Forest Research Institute (Sattar, 1980).

## RESULTS

The physical properties, such as specific gravity and shrinkage of *E. tereticornis* and *E. brassiana* are presented in Table 1. The drying time and drying defects are shown in Table 2. The mechanical properties of these species are shown in Tables 3, 4 and 5. The properties of *E. camaldulensis* studied earlier are included in these tables for comparison with two other eucalypts. The physical and mechanical properties of Chittagong teak (*Tectona grandis*) of 40-year old tested earlier (Yakub *et al*, 1978) are also included in the tables to determine the suitability relative to teak. Taking teak as 100 the relative values of these species were calculated and are given in Tables 1, 3, 4 and 5 under the parenthesis.

**Table 1. Physical properties of three *Eucalyptus* species (number in blanket shows relative value taken teak as 100)**

| Species | Locality of timber with age | Number of trees sampled | Seasoning condition | Moisture content | Specific gravity based on oven dry weight and | | Shrinkage(%) from green to oven dry condition based on green dimension | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | volume at test | volume at oven dry | Radial | Tangen -tial | Volume-tric |
| Chittagong teak (*Tectona grandis*) | Kaptai Chittagong Hill Tracts 40 years | 3 | green | 155.0 | 0.58 | 0.61 | - | - | 5.0 |
| | | | air dry | 12.0 | 0.59 | | | | |
| *Eucalyptus tereticornis* | Charaljani Tangail 12 years | 6 | green | 65.0 | 0.75 (129) | 0.87 (143) | 4.72 | 6.92 | 13.84 (277) |
| | | | air dry | 12 | 0.82 (139) | | | | |
| *Eucalyptus brassiana* | Keochia Chittagong 11 years | 6 | green | | 0.64 (110) | 0.76 (125) | 5.80 | 7.57 | 15.20 (304) |
| | | | air dry | | 0.67 (114) | | | | |
| *Eucalyptus camaldulensis* | Charaljani Tangail 10 years | 3 | green | 7.5 | 0.54 (93) | 0.68 (111) | - | - | 19.0 (380) |
| | | | air dry | 13.0 | 0.59 (100) | | | | |

**Table 2. Seasoning characteristics of three *Eucalyptus* species**

| Species | Drying time from green to about 12% mc (days) | Ease of drying | Drying defect |
|---|---|---|---|
| *E. tereticornis* | 12 to 14 | Difficult | Checks, warping twisting |
| *E. brassiana* | 10 to 12 | Difficult | Checks, warping bending |
| *E. camaldulensis* | 9 to 13 | Moderate | Checks, warping |

## DISCUSSION

### *Eucalyptus tereticornis*

The whitish sapwood is distinct from pale to brown heartwood. The grain is straight to shallowly interlocked. It is a high density timber with specific gravity of 0.82 in airdry condition. It exhibits volumetric shrinkage of 13.84% from green to ovendry condition (Table 1). *E. tereticornis* is a strong timber. The most of the strength properties are found higher than those of teak wood except modulus of elasticity (MOE). *E. tereticornis* grown in Bangladesh is found superior in density and strength to those of Tamil Naudu and Uttar Pradesh of India (Tewari, 1992). It is a highly refractory timber. The kiln drying time of

2.5 cm thick sawn timber from 65% moisture content (mc) to 12% mc is 14 days following standard drying schedule (Table 2). It develops surface checks and warping during kiln seasoning. Warping and spliting of this species during seasoning are also reported by Hedricks *et al.* (1969), Hallock (1972) and Thomson (1974). The drying defects may be minimized by adopting special sawing pattern of logs, proper humidity, oriented kiln drying schedule and top weighing of timber stack in the kiln during drying.

The species is suitable as poles for overhead power and telecommunications lines and falls under Group A according to the Bangladesh Standard specification (Anon, 1979) since its modulus of rupture (MOR) is more than 850 kg/cm$^2$. It may be used as structural timber and also for making furniture, door and windows, tool handles, etc.

**Table 3. Mechanical properties of three *Eucalyptus* species (number in blanket is relative value taken teak as 100)**

| Species | Seasoning condition | Static bending | | | | | | Compression parallel to grain | |
|---|---|---|---|---|---|---|---|---|---|
| | | Stress at proportional limit kg/cm$^2$ | Modulus of rupture kg/cm$^2$ | Modulus of elasticity 1000 kg/cm$^2$ | Work-in cm-kg/cm$^3$ To prop. limit | To max. load | Total | Stress at proportional limit kg/cm$^2$ | Maximum crushing strength kg/cm$^2$ |
| Chittagong teak (*Tectona grandis*) | green | 514 | 867 | 120 | 0.124 | 0.747 | 1.613 | 288 | 383 |
| | air dry | 628 | 1008 | 131 | 0.170 | 0.622 | 1.225 | 374 | 513 |
| *Eucalyptus tereticornis* | green | 607 (118) | 911 (105) | 114 (95) | 0.180 (145) | 0.743 (99) | 2.428 (150) | 313 (1001) | 431 (113) |
| | air dry | 664 (106) | 1033 (102) | 123 (94) | 0.201 (118) | 1.216 (195) | 3.118 (254) | 413 (110) | 606 (118) |
| *Eucalyptus brassiana* | green | 443 (86) | 682 (79) | 87 (73) | 0.129 (104) | 0.656 (88) | 1.398 (87) | 316 (110) | 304 (79) |
| | air dry | 551 (88) | 799 (79) | 95 (73) | 0.178 (105) | 0.723 (116) | 1.583 (129) | 287 (77) | 316 (62) |
| *Eucalyptus camaldulensis* | green | 489 (95) | 720 (83) | 91 (76) | 0.147 (118) | 0.634 (85) | 1.644 (102) | 200 (69) | 295 (77) |
| | air dry | 525 (84) | 807 (80) | 9 (75) | 0.156 (88) | 0.671 (108) | 1.620 (132) | 325 (87) | 386 (75) |

**Table 4. Mechanical properties of three *Eucalyptus* species (number in blanket is relative value taken teak as 100)**

| Species | Seasoning condition | Compression perpendicular to grain | Hardness, load required to embed a 1.13 cm ball to 1/2 its dia | | | Shear parallel to grain | | Nail withdrawal | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Stress at proportional limit kg/cm$^2$ | Radial kg | Tangential kg | End kg | Radial kg/cm$^2$ | Tangential kg/cm$^2$ | Radial kg | Tangential kg | End kg |
| Chittagong teak *(Tectona grandis)* | green | 67 | 495 | 518 | 495 | 86 | 103 | 145 | 132 | 95 |
| | airdry | 119 | 532 | 550 | 532 | 107 | 115 | 82 | 77 | 68 |
| *Eucalyptus tereticornis* | green | 86 | 599 | 698 | 623 | 104 | 107 | 177 | 169 | 93 |
| | | (128) | (121) | (135) | (126) | (121) | (104) | (122) | (128) | (98) |
| | airdry | 138 | 843 | 906 | 1005 | 111 | 110 | 162 | 166 | 127 |
| | | (116) | (158) | (165) | (189) | (104) | (96) | (198) | (226) | (187) |
| *Eucalyptus brassiana* | green | 78 | 490 | 538 | 547 | 81 | 88 | 178 | 172 | 110 |
| | | (116) | (99) | (104) | (111) | (94) | (85) | (123) | (130) | (116) |
| | airdry | 101 | 467 | 542 | 561 | 114 | 118 | 150 | 155 | 110 |
| | | (85) | (88) | (99) | (105) | (107) | (103) | (183)¤ | (201) | (116) |
| *Eucalyptus camaldulensis* | green | 60 | 453 | 492 | 498 | 88 | 92 | 181 | 157 | 111 |
| | | (95) | (92) | (95) | (101) | (102) | (89) | (125) | (119) | (117) |
| | airdry | 108 | 463 | 492 | 592 | 95 | 105 | 188 | 212 | 123 |
| | | (91) | (87) | (89) | (111) | (89) | (91) | (299) | (275) | (129) |

**Table 5. Mechanical properties of three *Eucalyptus* species (number in blanket is relative value taken teak as 100)**

| Species | Seasoning condition | Cleavage | | Tension perpendicular to grain | | Toughness | | Tension parallel to grain kg/cm$^2$ |
|---|---|---|---|---|---|---|---|---|
| | | Redial kg of width | Tangential kg of width | Radial kg/cm$^2$ | Tangential kg.cm$^2$ | Radial cm - kg/ specimen | Tangential cm - kg/ specimen | |
| Chittagong teak *(Tectona grandis)* | green | 68 | 77 | 44 | 49 | 387 | 419 | |
| | airdry | 66 | 79 | 41 | 47 | 321 | 326 | |
| *Eucalyptus tereticornis* | green | 49 | 57 | 44 | 48 | 420 | 499 | 1597 |
| | | (72) | (74) | (100) | (98) | (109) | (119) | |
| | airdry | 62 | 65 | 36 | 46 | 355 | 362 | 2164 |
| | | (94) | (82) | (88) | (98) | (111) | | |
| *Eucaluptus brassiana* | green | 47 | 47 | 41 | 39 | 443 | 478 | 1358 |
| | | (69) | (96) | (93) | (80) | (114) | (114) | |
| | airdry | 73 | 76 | 35 | 44 | 421 | 452 | 1563 |
| | | (111) | (96) | (85) | (94) | (131) | (139) | |
| *Eucalyptus camaldulensis* | green | 53 | 52 | 45 | 42 | 358 | 414 | 1003 |
| | | (78) | (68) | (102) | (86) | (93) | (99) | |
| | airdry | 56 | 59 | 46 | 54 | 302 | 311 | 1213 |
| | | (85) | (75) | (112) | (115) | (94) | (95) | |

***Eucalyptus brassiana***

The sapwood is light greyish brown, gradually merging pale brown heartwood. The grain is straight to slightly interlocked and fine to medium textured. *E. brassiana* is a heavy dense timber with specific gravity of 0.67 in air dry condition (Table 1). The volumetric shrinkage of the species is higher than *E. tereticornis* though specific gravity is lower. The specific gravity is 110 to 125 percent relative to teak wood. The timber possesses moderate strength with MOR less than teak. It has a very good nail holding capacity with values 116 to 201 percent relative to teak (Table 4).

The drying time of 2.5 cm thick sawn timber is 10 to 12 days in a steam heated kiln (Table 2). Drying defects, such as surface check and warp occur during drying and thus it needs care for proper drying.

*E. brassiana* may be used as poles for overhead power and telecommunication lines. The species is included in Group B for pole of Bangladesh standard specification ranging bending strength of 630 to 850 kg/cm$^2$ (Anon, 1979). It has a very good uses as fuelwood having high calorific value (Davidson and Das, 1985). It may be used for construction, furniture, tool handles and other purposes requiring moderate strength.

***Eucalyptus camaldulensis***

*Eucalyptus camaldulensis* is a large bole, medium to tall tree with distinct sapwood and heartwood. The sapwood is white in colour while the heartwood is reddish brown. The wood is even and fine textured. The arrangement of grain is interlocked and wavy. It is a medium dense timber with specific gravity of 0.59 in air dry condition. The specific gravity of Bangladesh *E. camaldulensis* is found lower than that of Uttar Pradesh of India. (Tewari, 1992). It is a moderately strong timber with MOR of 807 kg/cm$^2$. The strength properties of the species are lower than those of teak in most of the cases except nail holding capacity where higher values are observed.

It is a refractory timber and develops check and warp during drying. It is reported that drying defect can be mininised if quarter sawn timber is used (Anon, 1985). The drying time of a 2.5 cm thick sawn timber in a steam heated kiln is 9 to 13 days from 75% to 12% moisture content (Table 2).

*E. camaldulensis* has a wide and multipurpose uses. The wood is suitable for fuelwood having high calorific value compared to some other fuelwood species grown in Bangladesh (Davidson and Das,

1985). The species is suitable for moderate grade furniture, cabinet, door and window shutter and frames, tool handles, railway sleepers, hardboard and particle board. It may be used as poles representing Group B and Bangladesh Standard Specification (Anon, 1979).

## CONCLUSION

*E. tereticornis* is a heavy, dense and strong timber with higher values relative to teak. *E. brassiana* is a dense and moderately strong timber while *E. camaldulensis* is a moderately dense and strong timber.

*Eucalyptus* timber develops defects during drying. It thus has to be dried with proper care. These species are suitable for making pole, door and windows, furniture, tool handles and construction purposes.

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