



SOME PHYSICAL AND MECHANICAL PROPERTIES OF KATHBADAM (*Terminalia catappa* Linn.) WOOD OF BANGLADESH

Md. Muktarul Islam, Md. Abul Kalam Azad, Md. Ashaduzzaman*
and Md. Obaidullah Hannan

Forestry and Wood Technology Discipline, Khulna University, Khulna-9208, Bangladesh

KUS 07/12-210507

Manuscript received: May 21, 2007; Accepted: January 30, 2008

Abstract: The present study was undertaken to represent mainly some strength properties of kathbadam (*Terminalia catappa* Linn.) wood of Bangladesh along with finding out some relevant physical properties of the same. The research works were carried out following standard test methods comparing the findings with those of standard Chittagong teak (*Tectona grandis* L.f.) reported earlier. The longitudinal, radial, tangential and volumetric shrinkages of *T. catappa* wood from green to oven-dry conditions were found 0.64%, 2.71%, 5.08% and 8.43% respectively. The specific gravity of the wood species based on oven-dry weight by green volume and oven-dry weight by oven-dry volume were found 0.46 and 0.52 respectively. The green moisture content of *T. catappa* wood was found 92.51%. Regarding green mechanical properties, the fibre stress at elastic limit and modulus of rupture was found 408.61 and 666.16 kg cm⁻² respectively. Similarly the revealed green compressive strength parallel to grain at elastic limit and at maximum load was 210.54 and 273.74 kg cm⁻² respectively. The green tensile strength parallel to grain at maximum load was revealed 438.41 kg cm⁻². At the same moisture conditions the screw withdrawal capacity was determined 187.16 kg at sawn face and 170.53 at edge. All these properties of *T. catappa* wood were found relatively and reasonably lower than those of Chittagong teak.

Key words: Physical properties, mechanical properties, *Terminalia catappa*, *Tectona grandis*

Introduction

Kathbadam (*Terminalia catappa* Linn.) is belongs to the family Combretaceae. It is a moderate to large size tree attaining an average height 30 meter and diameter of 0.5 meter and above (Dey, 1995). Mia and Huq (1986) described that the cylindrical bole height of *T. catappa* is up to 9 meter and diameter is 0.5 meter and above. *T. catappa* grows in sandy beaches and alluvial soils. It is light demanding and can tolerate waterlogging condition. *T. catappa* grows all over the tropical countries and in Bangladesh it grows a large number in plain land and homestead forest (Alam *et al.*, 1991). Sharma (1997) described that the origin or homeland of *T. catappa* is the seashore of Malaya and Andaman Nicobar islands. As a structural material, wood has high strength per unit

* Corresponding author. E-mail: <a_zaman24@yahoo.com>; Phone: +880-41-720171-3, Ext: 228; Fax: +880-41-731244.
DOI: <https://doi.org/10.53808/KUS.2007.8.2.0712-L>

weight and is easily shaped and fastened. Wood is a major source of energy and basic raw materials for cellulose and cellulose derivatives in chemical industries, and is also used in the manufacture of wood composites and panel products. The color patterns and textures of woods are often pleasing, leading to uses for many decorative purposes. Wood is available in a wide range of textures, colors, densities and chemical compositions, supporting many important uses (Zabel and Morrell, 1992). The wood of *T. catappa* is reddish brown to light or dark brown, moderately hard and heavy lustrous shallowly interlocked grained and coarse textured. It is a middle class wood and used for house building, general carpentry, furniture, posts and beams, fuelwood and ornamental plywood (Alam *et al.*, 1991).

Physical properties (e.g., specific gravity, shrinkage, moisture content etc.) are important in selecting wood for numerous uses, such as musical instruments, decorative surfaces, insulating media etc. Mechanical properties of wood indicate the ability of wood to resist various types of external forces, static or dynamic, which may act on it. Mechanical properties are very much important in case of constructional and structural purposes. The properties not only vary with species, with reference to the nature of their fiber structure but also with the moisture content, temperature and defects of wood. Sometimes the properties vary with reference to the varying conditions of growth and methods of testing (Anon, 1970). The wood of *T. catappa* has limited use in Bangladesh. Lahiry (2003, 2001, 1995, 1994a) described some physical properties such as the color, structure, equilibrium moisture content, flammability, workability, weight, density, natural durability, seasoning properties, treatability and some mechanical properties with main attention on modulus of rupture at green condition. The specific objective of this study is to determine the physical and mechanical properties of *T. catappa* wood to furnish the basic information for their effective utilization.

Materials and Methods

Collection of test samples: The wood samples of Kathbadam (*Terminalia catappa*) for tests were collected from Pirojpur, Bangladesh. Three representative trees of girth 49, 42 and 37 cm were randomly selected. Three 1 meter boles were collected from each tree keeping the breast-height (1.3 m above ground level) position of the trees at the center of the bolts. All the boles were fairly straight. For reducing excessive evaporation of moisture and consequent checking, both ends of the bolts were wrapped with polythene sheets.

Preparation of the samples: The samples were sawn followed by plain sawing method according to standard sawing diagram. The samples for determination of moisture content, specific gravity and shrinkage were prepared in the form of $5.08 \times 5.08 \times 2.54$ cm according to ASTM standards (Anon, 1971). The samples for compression test were in the form of $25 \times 5 \times 5$ cm and for tension study cylindrical samples of 1.5 cm diameter. The gauge length and diameter were 5.5 cm and 1 cm respectively and the length of grips was 7.5 cm at each end. In both cases samples were selected from the parallel to grain. For compression test both edges of the sample were taken parallel and smooth. The samples for bending test were in the form of $25 \times 5 \times 5$ cm. For each test both in physical and mechanical properties 9 representative samples were selected. While selecting the samples natural defect such as knot, decay pocket, dead streak, grain deviation, tension wood etc. were excluded for getting the clear specimen for the test. After preparation, the samples were smoothed by using sander.

Islam, M.M.; Azad, M.A.K.; Ashaduzzaman, M. and Hannan, M.O. 2008. some physical and mechanical properties of Kathbadam (*Terminalia catappa* Linn.) wood of Bangladesh. *Khulna University Studies*, 9(1): 00-00.

Determination of physical properties: For determining the specific gravity the specimens were dried in an oven at temperature of $103\pm 2^{\circ}\text{C}$ till the specimens attained constant weights. The oven dry weights of specimens were taken by an electric balance. Specific gravity based on oven dry weight of wood and oven dry volume was also determined. The moisture content of the specimens was determined by oven-dry method. For measuring shrinkage value the initial dimension was taken with the help of a dial gauge. The specimens were placed in an oven maintained initially at 60°C and then progressively raising the temperature to $103\pm 2^{\circ}\text{C}$. The dimension of each specimen was then recorded. The following formulae were used to determine specific gravity, moisture content and shrinkage respectively.

a) $S = W_o / V_g$ (Anon, 1970)

where, S = Specific gravity, W_o = The weight of oven dry wood, V_g = Volume in green condition.

b) $MC (\%) = [(W_w - W_o) \times 100] / W_o$ (Shrivastava, 1997)

where, MC = Moisture Content, W_w = Weight of samples in testing condition, W_o = Weight of samples in oven dry condition.

c) $S = [(GD - ODD) \times 100] / GD$ (Panshin and de Zeeuw, 1980)

where, S = Shrinkage, GD = Green dimension, ODD = Oven dry dimension.

Determination of mechanical properties: The samples were tested to determine the static bending strength in accordance with the specification of the American Standards of Testing Materials (Anon, 1971). The samples were tested in IMAL Universal Testing Machine (Model: IB 600, Italy). To determine different types of mechanical properties, the following formulae were used.

1. Static bending test

a) Fiber stress at limit of proportionality: FS at LP = $3 PI / 2bh^2$

b) Modulus of rupture: MOR = $3 P'I / bh^2$ (Anon, 1970)

where, FS at LP = Fiber stress at limit of proportionality in kg cm^{-2} , MOR = Modulus of rupture in kg cm^{-2} , P = Applied load at the limit of proportionality in kg, P' = Maximum load in kg, I = Span of the test sample in cm, b = Breadth of the test sample in cm, and h = Depth of the test sample in cm.

2. Compression parallel to grain

a) Compressive stress at limit of proportionality: CS at LP = P/A and,

b) Compressive stress at maximum load: CS at ML = P'/A (Anon, 1970)

where, CS at LP = Compressive stress at limit of proportionality in kg cm^{-2} , CS at ML = Compressive stress at maximum load in kg cm^{-2} , P = Applied load at the limit of proportionality in kg, P' = Maximum crushing load in kg, and A = Cross sectional area of the test sample, cm^2 .

3. Tension parallel to grain

Tensile stress at maximum load: TS at ML = P'/A (Anon, 1970)

where, TS at ML = Tensile stress at maximum load in kg/cm^2 , P' = Maximum load to cause the failure of the sample in kg, and A = Cross sectional area of the test sample, cm^2 .

4. Screw withdrawal test

The samples (50 mm x 50 mm) were prepared by drilling a hole on each of and then punched the screws by screw driver. The 1.5 inch screw was used and 12 mm was punched of each sample in both faces and edges. The samples were put into universal testing machine (IMAL IB 600) and data were collected directly.

Results

The results of the tests on the physical and mechanical properties of *T. catappa* wood in green condition are presented in Table 1 and Table 2. The physical and mechanical properties of Chittagong teak (*Tectona grandis*) of 40 years age group was tested earlier (Yakub *et al.*, 1978) to attain the optimum values and this was recommended as the standard for Bangladesh to which all other timber species of the country may be compared in determining their relative suitability for various purposes. Hence, the physical and mechanical properties of Chittagong teak in green condition are also given in Table 1 and Table 2.

Table 1. Physical properties of *Terminalia. catappa* wood.

Species	Specific gravity		Moisture (%)	Shrinkage (%) Green to Oven-dry			
	green condition	oven dry condition		Longitudinal	Radial	Tangential	Volumetric
<i>Tectona grandis</i>	0.58*	0.61*	155**	NA	2.28**	4.31**	5.0
<i>Terminalia catappa</i>	0.46 (0.020)	0.52 (0.019)	92.51 (2.393)	0.64 (0.066)	2.71 (0.541)	5.08 (0.395)	8.43 (0.739)

Note: Values in parenthesis are standard deviations. NA = Not Applicable.

Source: * Yakub *et al.* (1978), ** Sattar *et al.* (1980)

Physical properties: Specific gravity based on both condition of *T. catappa* wood was found lower compared to *T. grandis*. The average moisture content of *T. catappa* wood was found 92.51% which is lower than *T. grandis*. Moisture content of wood at test condition is also an important factor for variable strength properties. The higher initial MC in *T. grandis* wood indicates that it rather fast growing and contains more sap in sapwood. On the other hand the lower initial MC in *T. catappa* wood indicates slow growing species and test samples may contain considerable amount of heartwood. Contrary volumetric shrinkage of *T. catappa* wood was found higher than *T. grandis* (Table 1). Generally the longitudinal shrinkage of wood is very low but the shrinkage of *T. catappa* wood shown in Table 1 appears to be high indicating presence of some cross grains in natural wood samples due to whorled branches.

Table 2. Mechanical properties of *Terminalia. catappa* wood.

Species	MC% at test condition	Static bending (kgcm ⁻²)		Compression parallel to grain (kgcm ⁻²)		Tension parallel to grain (kg cm ⁻²)	Screw Withdrawal (kg)	
		Fibre stress at elastic limit	Modulus of rupture	Compressive stress at elastic limit	Max. crushing stress	Tensile stress at max. load	Face	Edge
<i>Tectona grandis</i>	Green	514*	867*	288*	383*	NA	NA	NA
<i>Terminalia catappa</i>	Green	408.61 (1.424)	666.16 (12.625)	210.54 (2.612)	273.74 (7.653)	438.41 (8.045)	187.16 (1.186)	170.53 (0.713)

Note: Values in parenthesis are standard deviations. NA = Not Applicable.

Source: * Yakub *et al.* (1978)

Mechanical properties: Table 2 represents the important strength properties of *T. catappa* wood which were lower than those of Chittagong teak (*T. grandis*). The presented data revealed that *T. catappa* wood is weaker than Chittagong teak. The mechanical properties, especially the MOR and MOE of round timbers such as poles/ posts/ logs are higher than those of any swan timbers. Therefore, comparing the mechanical properties of the present study is reasonably lower than those of round timbers described in BDS-809 (Anon, 1979) and REB Standard for wood poles (Anon, 2003).

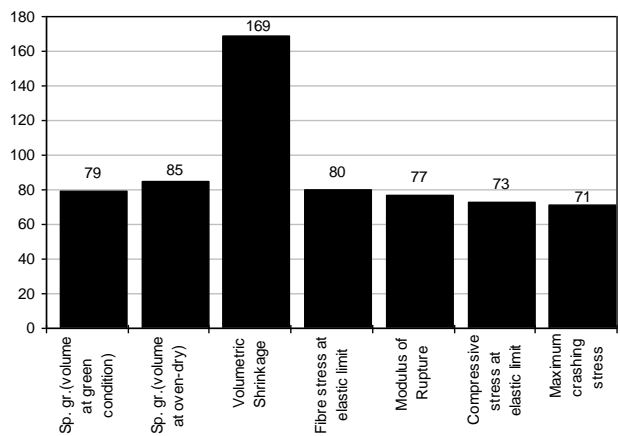


Fig. 1. Physical and Mechanical Properties of *T. Catappa* relative to Chittagong Teak (*T. grandis*) considering the values of Chittagong Teak as "100".

The relative values of physical and mechanical properties of *T. catappa* wood to those of Chittagong teak (*T. grandis*) expressed as percentage are given in Fig 1.

Discussion

From the results it can be stated that all the physical properties except volumetric shrinkage and mechanical properties of *T. catappa* wood are lower than those Chittagong teak (*T. grandis*). The specific gravity of *T. catappa* wood on green and oven dry condition is 79% and 85% relatively to Chittagong teak as shown in Figure 1. Mia and Huq (1986) described that the *T. catappa* wood is light in weight, which is 513 kg m⁻³. Lahiry (2003) stated the basic density (based on green volume and oven-dry weight) of 500 ± 5%kg m⁻³. Sattar (1981) classify Bangladeshi timber of specific gravity from 0.51 to 0.65 as moderately heavy wood (based on oven-dry weight and oven dry volume). Thus, *T. catappa* (specific gravity 0.52; based on oven-dry weight and oven-dry volume) falls under the moderately heavy wood. On the other hand, Sattar and Akhtaruzzaman (1997) classified Bangladeshi timbers into four groups, of which timbers having specific gravity 0.445 to 0.624 are classified as medium density wood (based on oven-dry weight and green volume). Accordingly *T. catappa* wood (specific gravity 0.46; based on oven-dry weight and green volume) can be classified as medium dense. The volumetric shrinkage of *T. catappa* wood is found 169% of Chittagong teak (Fig. 1). Ghazali (1986) described that the radial and tangential shrinkage from green to air-dry conditions of Malaysian *T. catappa* wood is 0.9% and 1.6% respectively and the shrinkage of timber is considered as low. Sattar *et al.* (1999) classify the Bangladeshi timber having volumetric shrinkage 7% to 10% (based on green to oven-dry moisture content) as stable. According to this classification the timber of *T. catappa* (volumetric shrinkage 8.43%) can be classified as stable. Lahiry (2001, 1994b) suggested six shrinkage categories in which tangential shrinkage 76% to 100% higher than radial shrinkage is described as category (d). This

Islam, M.M.; Azad, M.A.K.; Ashaduzzaman, M. and Hannan, M.O. 2008. some physical and mechanical properties of Kathbadam (*Terminalia catappa* Linn.) wood of Bangladesh. *Khulna University Studies*, 9(1): 00-00.

study reveals that the timber of *T. catappa* (tangential shrinkage 87% higher than radial shrinkage) falls under the category (d). Timber under category (a) was found to be dimensionally very stable.

Fig. 1 explains that the fibre stress at elastic limit and modulus of rupture of *T. catappa* wood are 80% and 77% respectively of the Chittagong teak wood. Compression stress at elastic limit and maximum crushing stress of this species are 73% and 71% of Chittagong teak. Lahiry (2003, 2001, 1996, 1995) described the modulus of rupture (MOR) at green condition is $70 \pm 5\%$ N mm⁻², which is 97% of Bangladeshi teak considering the value of teak is $72 \pm 5\%$ N mm⁻² and both the timbers fall under same strength group, very strong having MOR of 60 to 79 N mm⁻². Sattar and Akhtaruzzaman (1997) classified the Bangladeshi timbers into strength group A, B, C, D and E (based on strength values relative to teak). According to this classification the *T. catappa* wood can be grouped as C. The Bangladesh Standards Institution specifies very strong timbers having modulus of rupture 850 kg cm⁻² and above (based on green condition) as group 'A' and group 'B' modulus of rupture ranging from 630 to 849 kg cm⁻² for using transmission poles (Anon, 1979). In the present study *T. catappa* meets the requirement of strength specification laid down by the Bangladesh Standards Institution for group 'B'.

Conclusion

Wood is a remarkable material of great importance in the world economy. It is used extensively as a structural material, fuel or industrial raw material depends on its physical and mechanical properties. The timber of *T. catappa* is found to be moderately heavy or medium dense and dimensionally stable. On the other hand the strength property of *T. catappa* wood falls under the strong wood group. Though the physical and mechanical wood properties of *T. catappa* wood are lower than those of Chittagong teak (*Tectona grandis*), it is very suitable for all constructional and structural uses. The resulting properties and values are usable for designing structures. *T. catappa* wood can be used for poles, posts, anchor logs, cross-arms etc. as the strength value of this wood confirm the specifications of group 'B' pole by Bangladesh Standards Institution.

Acknowledgement: The authors are thankful to the Manager and Officers of Akij Particle Board, Manikgonj, Bangladesh for their cordial assistance and for giving opportunities to use their laboratory for various tests.

References

- Alam, M.K.; Mohiuddin, M. and Guha, M.K. 1991. *Trees for Low Lying Area in Bangladesh*. Bangladesh Forest Research Institute, Chittagong, p. 73.
- Anon. 1970. *Indian Forest Utilization*. Vol. I, Forest Research Institute and Colleges, Dehra Dun, India, 505 pp.
- Anon. 1979. Bangladesh Standards Specification for Wood Poles for Overhead Power and Telecommunication Lines. BDS-809, Bangladesh Standards Institute, Dhaka, 27 pp.
- Anon. 2003. *REB Standard for Wood Poles*. Publication 460-1988, Revision 14, June 2003, Rural Electrification Board, Dhaka, 46 pp.
- Anon.1971. Annual Book of ASTM Standards. Part 16, Structural sandwich construction, woods, adhesives, American Society for Testing Materials, Philadelphia, pp. 64-121.

- Islam, M.M.; Azad, M.A.K.; Ashaduzzaman, M. and Hannan, M.O. 2008. some physical and mechanical properties of Kathbadam (*Terminalia catappa* Linn.) wood of Bangladesh. *Khulna University Studies*, 9(1): 00-00.
- Dey, T.K. 1995. *Useful Plants of Bangladesh*. Shitu-Tumi Book House, Comilla, 223 pp.
- Ghazali, B.H.J. 1986. *100 Malaysian Timbers*. 1st edn., The Malaysian Timber Industry Board, Kuala Lumpur, 226 pp.
- Lahiry, A.K. 1994a. Age of trees Vs durability of woods (theory vs. experience). *Journal of Timber Development Association of India*, 40 (2): 20-33.
- Lahiry, A.K. 1994b. Study of density, shrinkage, fibre stress and CCA treatability of ten timber species grown in Bangladesh. *Journal of Timber Development Association of India*, 40 (4): 33-39.
- Lahiry, A.K. 1995. *Kath Sangrashkhan Bijnan* (Wood Preservation Science). 1st edn., Bangla Academy, Dhaka, 184 pp., (In Bangla).
- Lahiry, A.K. 1996. Mechanical strength of green, air-dried and preservative treated 153 timbers of Bangladesh. *Journal of Timber Development Association of India*, 42 (2): 39-46.
- Lahiry, A.K. 2001. *Applied Wood Preservation*. 1st edn., Magnum Opus, Dhaka, Bangladesh, 428 pp.
- Lahiry, A.K. 2003. *Kath Projuktibidya: Bangladesh Prekshapot* (Wood Technology: Bangladesh Context). 1st edn., Bangla Academy, Dhaka, 376 pp., (In Bangla).
- Mia, M.M.K. and Huq, Y.A. 1996. *Timber Plants of Bangladesh (Wild and Cultivated)*. 1st edn., Bangladesh National Herbarium, BARC, Dhaka, 72 pp.
- Panshin, A.J. and de Zeeuw, C. 1980. *A Text Book on Wood Technology*. McGraw Hill, Inc., USA, 402 pp.
- Sattar, M.A. 1981. Some Physical Properties of 116 Bangladeshi Timbers. Bulletin 7 (Wood seasoning series), Bangladesh Forest Research Institute, Chittagong, 15 pp.
- Sattar, M.A. and Akhtaruzzaman, A.F.M 1997. Enduse Classification of Lesser Used or Unused Wwood Species. Bulletin 1 (Forest Products Branch), Bangladesh Forest Research Institute, Chittagong, 117 pp.
- Sattar, M.A.; Bhattacharjee, D.K. and Kabir, M. F. 1999. Physical and Mechanical Properties and Uses of Timbers of Bangladesh. Bangladesh Forest Research Institute, Chittgong, 57 pp.
- Sattar, M.A.; Talukdar, Y.A and Sarker, S. B. 1980. Shrinkage and density studies on twenty-one wood species of Bangladesh. Bulletin 5 (Wood Seasoning Series), Bangladesh Forest Research Institute, Chittagong, 10 pp.
- Shrivastava, M.B. 1997. *Wood Technology*. Vikas Publishing House (Pvt.) Limited, New Delhi, India, 180 pp.
- Yakub, M.; Ali, M.O. and Bhattacharjee, D.K. 1978. Strength properties of Chittagong teak (*Tectona grandis*) representing different age groups. Bulletin 4 (Timber Physics Series), Forest Research Institute, Chittagong, 28 pp.
- Zabel, R.A. and Morrell, J.J. 1992. *Wood Microbiology: Decay and its Prevention*. Academic Press, Inc., New York, 476 pp.