

Machining Properties of Eucalyptus (*Eucalyptus camaldulensis*) Wood and Its Utilization Potential for Furniture Manufacturing

Md. Ashaduzzaman Sarker, Md. Nazmul Ahasan Mridha, Md. Abdul Khaleque
and Mohammad Anisur Rahman

Abstract — There is no comfortable and environmentally friendly way to avoid using wood for manufacturing different kinds of furniture as well as other uses. Thus, it is highly needed to identify machining properties in any wood working of its selection for particular utilization. The study was conducted to ascertain planing, boring, shaping, mortising, turning, etc. machining properties of *Eucalyptus camaldulensis* wood species grown in the south-eastern region of Bangladesh. Some related handtool properties of this wood were also tested. In both machining and handtool property tests, the evaluation was based on the frequency of defects of the property samples. All of the property sample defects were assessed by both visual and tactile inspection, and the percentage of property tests was determined. Each property sample was classified five quality grades based on sample defects. Shellac and carpa polishing materials were also applied to determine finishing quality. Five furniture were manufactured with this wood and put under service test as well. The results introduced overall good working qualities, and the *Eucalyptus camaldulensis* wood could be suitable for the materials of furniture. Among different operations, only mortising property resulted in 100% qualified grade in machining and handtool tests when shaping and boring rated the same in machining tests. This wood exhibited 100 % and 90 % excellent shaping and mortising quality in machining tests respectively. Planing property yielded no excellent or good result in handtool tests. The property value of different tests should just be considered as indicator.

Keywords — Handtool properties, Mortising, Planning, Shaping, Wood working.

I. INTRODUCTION

Eucalyptus tree species is native to Australia and Tasmania. This is a large and fast growing evergreen tree that attains to 125-160 m or 375-480 ft. [1]. The word 'Eucalyptus' comes from two Greek words 'eu' expressing 'well', and 'kaluptos' expressing covered. Eucalyptus expresses in brief well-covered, botanical reference to trees, flowers and fruits. This tree belongs to the Family Myrtaceae. It is one of the diverse genus plants, and there are about 800 eucalyptus species in the whole world. It has high ecological and socio-economic advantages to the world [2].

Eucalypts are high yielding as well as well adapted to infertile, dry, degraded sites that are no longer suitable for agricultural crops [3]. Eucalypts are frequently demonstrated to be faster growing and better survive on degraded or difficult sites than any other species in the area of tropics and sub-tropics for plantation programs [4]. Though there is a debate on eucalypts plantation, these have been cultivated in marginal and waste land, roadside, and crop's land in Bangladesh. This tree has turned into very popular to the country people for getting quick return because of fast growing nature. Recently, it is considered that this kind of tree is one of the most emergent agroforestry tree species in Bangladesh as well.

For the survival of mankind and the improvement of civilization, wood is considered as the foremost and fundamental material [5]. Because of excellent appearance, physical and mechanical properties, wood is particularly used for different purposes around the world [6]. Marketing of chief and new species for fabricating many necessary wood products depends on the information of its importance [7]. It is highly needed to assess different machining properties and make a relation with them to the raw material characteristics [8].

Three species, viz. *E. tereticornis*, *E. brassiana* and *E. camaldulensis* have been showed to grow suitably in the soil and climatic conditions of Bangladesh [9]. Among the above three species, *E. camaldulensis* is the very important fast growing tree being cultivated in Bangladesh [10]. At present, this tree is being planted repeatedly in the whole country especially in northern part of Bangladesh, and it is socially acceptable for quick benefits to the farmers. Consequently, *E. camaldulensis* wood is available in our country. On the other hand, any working property of this wood is not known to the users at present. As we get very limited timber species in our country, we should use them properly. For this reason, it is extremely imperative to find out the different machining and handtool properties of this wood as an alternative to conventional timber species and magnifying its economic demand for sustainable development. This study will help to

Submitted on March 30, 2022.

Published on May 24, 2022.

Manuscript Details

Md. A. Sarker, Wood Working and Timber Engineering Division,
Bangladesh Forest Research Institute, Bangladesh.

(e-mail: asad.bfri@gmail.com)

Md. N. A. Mridha, Wood Working and Timber Engineering Division,
Bangladesh Forest Research Institute, Bangladesh.

(e-mail: nazmul.bfri.68@gmail.com)

Md. Abdul Khaleque, Wood Working and Timber Engineering Division,
Bangladesh Forest Research Institute, Bangladesh.

(e-mail: khaleque1953@yahoo.com)

M. A. Rahman, Wood Preservation Division, Bangladesh Forest Research
Institute, Bangladesh.

(e-mail: anischem26@gmail.com)

introduce it along with determining different machining and handtool properties for proper uses.

II. MATERIALS AND METHODS

The wood of *E. camaldulensis* was collected from Hinguli Forest Research Station, Minor Forest Product Division, Bangladesh Forest Research Institute, Mirsharai, Chattogram. The sawing property quality of this wood (main stem) was evaluated after converting into different sizes. All of the sawn timber were seasoned less than 15 % moisture content. Test samples were prepared in 2.2 cm × 12.3 cm × 123 cm size. Again, these samples were converted to smaller pieces keeping same (2.2 cm) thickness before conducting different tests (Fig. 1).

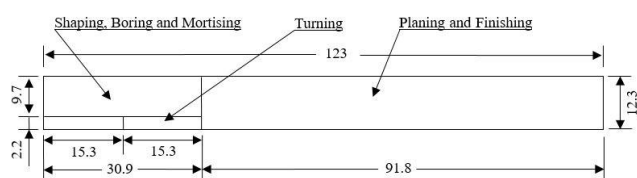


Fig. 1. Dimensions of the samples in cm for different property tests

The machining tests for the study were executed in accordance with ASTM D 1666-64 [11]. In this research study, similar property operations were also conducted using carpenter's handtools. The samples for different property tests were sound and free from any sort of defects. Twenty samples were tested by machines and twenty samples by handtools for each test. After completing the machining operations, the test samples were visually and tactilely investigated for sorting out the defect variations immediately.

Subsequently, each sample was classified on the basis of five quality grades that are excellent (grade A), good (grade B), fair (grade C), poor (grade D), and very poor (grade E). And accepted qualified grade of different properties were assumed as the summation of grade A and grade B except mortising property (sum of grade A, B, & C).

After determining all of the property, five furniture were manufactured with this wood. The research works were accomplished at Wood Working and Timber Engineering Division, Bangladesh Forest Research Institute, Chattogram during July 1989 to June 1990, and the service test of the furniture has been going on since then.

A. Planing and Finishing Property Test

The planing property test was conducted in a single surface planer with four cutter knives. The knives of the planer machine were freshly sharpened for each sample. The cutting and sharpness angles of those knives were 25° and 30° respectively. An equal number of samples was tested with the carpenter's hand planer, and similar procedure was applied for this test. The samples of all planing tests were utilized for the finishing property test after completing planing test. In terms of finishing property test, two types of polish, namely- shellac and carpa were applied to the samples. The performance of finishing property was recorded on the basis of the physical appearance and surface finish.

B. Boring Property Test

The test of boring was carried out in a hand-feed drill press of 508 mm single spindle. Two holes were bored on each sample. A single (one-inch) twist solid centre bred point type of boring bit was used in machining test. For maintaining a spindle speed of 2850 rpm, the drill was adjusted. In handtool property test, boring was made with a carpenter's hand drill. For avoiding tearing and splintering during boring for both machining and handtool operations, a solid type of hardboard was used as backing the underneath of the testing samples.

C. Shaping Property Test

The boring test samples were used for the shaping property test of machining and handtool respectively. This test was conducted in a special jig to make a curve pattern shape in machining. A hand feed single spindle shaper was used having two steel knives of 6500 rpm spindle speed. The samples were cut to acquire a pattern of quarter round that had a radius of 12.70 mm curvature. Here the cutter cutting angle was 25°. In handtool property operation, the shaping was done with carpenter's half-round chisel. The sample ripping was carried out with carpenter's handsaw to obtain the quarter round pattern.

D. Mortising Property Test

The boring and shaping property samples were also used for mortising test. In case of mortising property operation, two mortises were cut on each testing sample using a solid hardboard backing in both machining and handtool tests. Each mortise for the test was cut with parallel and perpendicular to the grain of the sample. The machining test was accomplished in a foot feed square hollow chisel mortiser. In terms of mortising property test, the 6.36 mm square chisel was used with 3600 rpm spindle speed.

E. Turning Property Test

With a variable speed of 2400 rpm, the test of turning property was conducted in a wood lathe. A high speedy single cutter was utilized for not getting various features of turning but the ability to cut at different angles with the property sample grains. With the limitation of technician, it was not accomplished handtool test of turning property.

F. Furniture Manufacturing

After evaluating all working properties, one three seated and two single seated sofas and two tea tables were manufactured using *E. camaldulensis* wood and put under service test at the office room of Director, Bangladesh Forest Research Institute, Chattogram in 1990. When fabricating this furniture, swan timber was seasoned properly and moisture content was less than fifteen percent. Any kind of chemical preservative for the purpose of treatment was not used before or after preparing furniture. Carpa polish was applied only once after the completion of manufacturing of that furniture till February 2019.

III. RESULTS AND DISCUSSION

Eucalyptus (*E. camaldulensis*) wood demanded more pressure on the saw blade that pointed out difficult to saw in accordance with the load applied to the saw blade, variation of fibre structure and the specific gravity (Table I). For the

comparison, it could be given that jhau (*Casuarina equisetifolia*) wood introduced hard and heavy; and thus, it exhibited difficult sawing quality [12]. In the same case, raintree (*Samanea saman*) wood type was light hard. This wood required less pressure on the saw blade which yielded easy to saw [13]. As different wood species have different fibre structure, density and strength, the applied load of the saw blade varies on the basis of those qualities. All sorts of finishing quality of *E. camaldulensis* wood responded good result. The type of *E. camaldulensis* wood was moderate heavy, and this wood showed overall good quality.

TABLE I: SAWING AND FINISHING QUALITY AND AGE OF *EUCALYPTUS CAMALDULENSIS* WOOD

Parameter	Quality /value	Remarks
Sawing quality	Difficult	According to load application
Finishing quality	Good	Two types of polish
Age of the tree	24 (Years)	According to plantation

The result of five quality grades for planing, boring, shaping, mortising and turning properties has been presented in Table II. In terms of machining property test, eucalyptus (*E. camaldulensis*) wood introduced excellent (no defect) shaping and mortising results that referred 100% and 90% defect free samples respectively. On the other hand, planing result revealed 10% poor (serious defects) quality, and there was no defect free sample in case of machining and handtool tests. But this property rated 20% and 90% fair (lots of slight defects) results in machining and handtool test respectively. Boring and turning property exhibited 100% and 60% good (few slight defects) quality respectively in machining tests.

TABLE II: FIVE QUALITY GRADES OF VARIOUS PROPERTIES FOR *EUCALYPTUS CAMALDULENSIS* WOOD

Property		Grade of property (%)				
Name	Type	Grade A	Grade B	Grade C	Grade D	Grade E
Planing	Machining	00	60	20	10	10
	Handtool	00	00	90	10	00
Boring	Machining	00	100	00	00	00
	Handtool	60	20	20	00	00
Shaping	Machining	100	00	00	00	00
	Handtool	00	30	60	10	00
Mortising	Machining	90	00	10	00	00
	Handtool	30	10	60	00	00
Turning	Machining	10	60	30	00	00

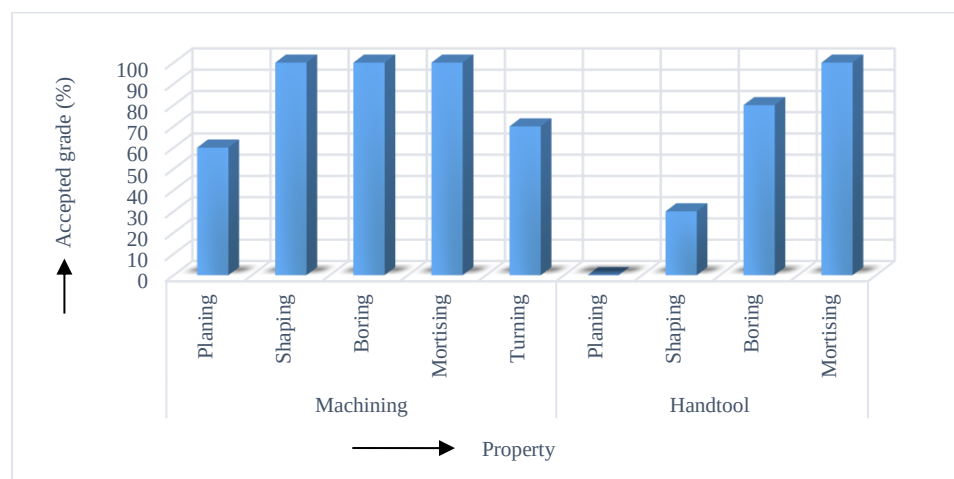


Fig. 2. Comparison of accepted grade in percentage among different properties.

Shaping property did not show any defect free sample in handtool operation whereas boring property showed the same result in machining tests. Here, it could be compared with the local and familiar wood species among the same property operations. For example, raintree (*Samanea saman*) wood pointed out excellent 70 % shaping and 50 % mortising quality in machining tests whereas it scored defect free 30% for planing and 40 % for boring in handtool property tests [13]. It was exhibited that any property of *E. camaldulensis* wood did not yield very poor (very serious defects) result except 10% planing in machining tests.

Comparisons of accepted grades (qualified grades) in percentage for different machining and handtool property operations have been shown in Fig. 2. Among these property operations, boring and shaping revealed only 100% accepted grade in machining whereas turning properties indicated 70% accepted grade. On the other hand, mortising tests resulted in 100 % accepted grade in case of machining and handtool properties. In terms of planing test, machining property rated 60% accepted grade whereas no accepted grade showed in handtool property test.

For instance, it could be shown that all properties of another fast-growing wood species, acacia hybrid (*A. mangium* × *A. auriculiformis*), pointed out 100% accepted grade in terms of machining and handtool operations except 90% in shaping test of machining [12]. And another local popular species, mahogany (*Swietenia macrophylla*) wood could be compared with *E. camaldulensis* wood. It was determined that all of the properties of mahogany wood revealed 100% accepted grade but 95% in planing test of machining [14].

The main defects of planing property tests for *E. camaldulensis* wood were fuzzy grains. Torn grains and chip marks were the other defects of this wood species in planing tests. In terms of mortising and boring tests, crushing out was the major defects of this wood. Tear out was present in only handtool shaping tests. It could also be stated that there were no serious or very serious defects in different property tests of mahogany [14] and acacia hybrid wood species [12]. Some knife marks were present in the property tests of *E. camaldulensis* wood. But they were not considered as defects of the property test samples. It was not possible to quantify the defects properly as they were evaluated by visual and tactile investigation. And at the time of different property tests, all necessary machines were sharpened properly for getting optimum results.

Wood workers found some difficulties during wood working and related machining activities because of its hardness. Gluing properties indicated to work easily, but it was difficult to do nailing and screwing. Five furniture, one three seated and two single seated sofas and two tea tables (Fig. 3), which were manufactured and kept under service test since 1990 for durability test were still looking gorgeous. The service test results of those *E. camaldulensis* wood furniture has been showing no deformation, and any sort of wood deteriorated agent has not attacked till now. The polishing colour of tea table surfaces and handles of sofa has slightly been changed whereas no discolouration was found under the foam of sofas.



Fig. 3. Furniture - (a) one three seated sofa, (b) two tea tables and (c) two single seated sofas (Photographs of furniture captured in 2015).

IV. CONCLUSION

Though the different property results should be considered as indicative value, *E. camaldulensis* wood is moderate heavy and resistant to termites as well as borers. The findings of the study indicated that *E. camaldulensis* wood had mostly good working properties, and furniture from this wood would be substantially durable. Since the wood was long-lasting

without treating by any chemical preservative, it would be used as a furniture material for sustainable economic development. The wood may also be suitable as toy, novelty and flooring materials for its outward ornamental appearances, even though it is somewhat uncomfortable to the wood workers as well as comparatively heavy to the users. And it could be said that using this wood in terms of fabricating furniture and other various purposes would reduce pressure on traditional timber species and have a great impact on environment. Further investigation should be required for more information.

ACKNOWLEDGEMENT

We are very grateful to the authority of Bangladesh Forest Research Institute (BFRI) for providing all sorts of facilities to do research on *E. camaldulensis* wood species. We are also grateful to Md. Ramiz Uddin, Divisional Officer, Wood Working and Timber Engineering Division (WWTED), BFRI for his cordial support and cooperation in preparing the manuscript. And our sincere thanks to all colleagues of WWTED, BFRI for their research assistance while conducting the study.

REFERENCES

- [1] Sani I, Abdulhamid A, Bello F. *Eucalyptus camaldulensis*: Phytochemical composition of ethanolic and aqueous extracts of the leaves, stem-bark, root, fruits and seeds. *Journal of Scientific and Innovative Research*, 2014; 3(5): 523-526.
- [2] Gil L, Tadesse W, Tolosana E, Lopez R. Proceeding of the conference on Eucalyptus Species Management, History, Status and Trends in Ethiopia. *Ethiopian Institute of Agricultural Research*, 2010 Sep 15-17; pp. 414, Addis Ababa, Ethiopia.
- [3] Quang TH. Applications of Molecular Characters to Breeding of *Eucalyptus urophylla* Vietnam. Doctoral Thesis. Faculty of Natural Resources and Agricultural Sciences, Uppsala University; 2010.
- [4] Hossain MK, Rafiqul Hoque ATM. *Eucalyptus Dilemma in Bangladesh*. Institute of Forestry and Environmental Science. University of Chittagong, Chittagong; 2013.
- [5] Sattar MA, Bhattacharjee DK, Kabir MF. *Physical and Mechanical Properties and uses of timbers of Bangladesh*. Seasoning and Timber Physics Division, Bangladesh Forest Research Institute, Chittagong; 1999.
- [6] Tu D, Liao L, Yun H, Zhou Q, Cao X, Huang J. Effects of Heat Treatment on the Machining Properties of *Eucalyptus urophylla* × *E. Camaldulensis*. *BioResources*, 2014; 9 (2):2847-2855. doi:10.15376/biores.9.2.2847-2855.
- [7] Qasem MA, Hannan MO, Khaleque MA, Haque MS. Some machining properties of five hardwoods of Bangladesh. *Bano Biggyan Patrika*, 1981; 10(1 & 2):1-7.
- [8] Sofuoglu SD, Kurtoglu A. Some machining properties of 4 wood species grown in Turkey. *Turkish Journal of Agriculture and Forestry*, 2014; 38:420-427. doi:10.3906/tar-1304-124.
- [9] Davidson J, Das S. *Eucalyptus in Bangladesh*. Silviculture Research Division Series, Bulletin 6. Bangladesh Forest Research Institute, Chittagong; 1985.
- [10] Sattar MA, Bhattacharjee DK. *Physical and Mechanical Properties of Eucalyptus camaldulensis*. Timber Physics Series, Bulletin 12, Bangladesh Forest Research Institute, Chittagong; 1990.
- [11] Anon. *Annual Book of ASTM Standards*, Part 16. D 1666-64. *American Society for Testing and Materials*. 1971, pp. 655-679.
- [12] Sarker MA, Khaleque MA, Mridha NA, Dey TK. Working and Finishing Properties of Five Wood Species Grown in Bangladesh. *Bangladesh Journal of Forest Science*, 2015; 34(1 & 2):65-74.
- [13] Hannan MO, Khaleque MA, Uddin MR, Qasem MA. *Machining properties of ten village tree species*. Wood Working Series, Bulletin 6, Bangladesh Forest Research Institute, Chittagong; 1992.
- [14] Sarker MA, Mridha NA, Dey TK. Machining and Handtool Properties of Bangladeshi Mahogany Wood. *Bangladesh Journal of Forest Science*. 2019; 35(1 & 2):54-61.