PROPERTIES AND UTILIZATION POTENTIAL OF LOCALLY GROWN ROBINIA (*ROBINIA PSEUDO-ACACIA*) WOOD

G. M. Nasir[1] and Iqbal Mahmood[2]

Abstract

In continuation of work to introduce new wood species for utilization in wood and wood based industries, basic properties of locally grown Robinia (*Robinia pseudo-acacia*) wood were studied to assess its various technological properties and find out better utilization. For anatomical properties, permanent slides of cross, radial and tangential sections of the wood were prepared by standard laboratory procedure and observed under the microscope. For physical and mechanical properties (both in green and air dry conditions) the wood samples were prepared and tested according to ISO and ASTM standards. Results showed that Robinia wood is better in strength due to thick walled and long fibers. It is stronger than Shisham wood in different mechanical properties. The wood may be less durable but can be easily preserved with chemicals. Similarly the wood can be seasoned well without any difficulty. After careful processing, Robinia wood can also be used as substitute of Shisham wood for manufacturing of furniture and cabinet work etc. Furthermore, it may also be used for pulp and paper manufacturing due to higher morphological characteristics of fibers.

Introduction

Robinia (*Robinia pseudo-acacia)* is a fast growing tree species native to North America, where it is known as black locust. It is also known as false Acacia. It grows up to 15-18 meters in height and 0.6m in diameter. It was introduced into Europe during 17th century and has been extensively planted in Britain and other parts of the continent (Randle, 1969).

In Pakistan Robinia was introduced in less high climate near foothills and adjacent plains. It has been successfully established in Punjab and N.W.F.P. Plantations are also being raised in Gilgit and some other parts of Northern Areas. Robinia is a medium sized to large deciduous tree, with open crown and straight bole. It is an excellent farm forestry tree (Sheikh, 1993).

Robinia is reasonably stable wood when dry, but needs some attention during seasoning to avoid warping and shrinkage. Pre-boring for nails and screws is advisable but in all wood working processes it will handle well without alteration to standard equipment. The wood can be recommended for furniture, veneering, turnery piling etc. (Titmus, 1965). In France where the timber is more plentiful and its outstanding strength and durability are appreciated, it is also used as substitute of Ash wood for wheelwrights work, agricultural implements, ladder rungs and wooden pins (tree nails) for ship building (Randle, 1969).

This study has been carried out to test and evaluate the wood properties of locally grown Robinia wood to assess its various technological properties and find out better utilization so that pressure on the commercial timbers may be reduced and the wood workers are motivated to use less important non-commercial timbers also as substitute of traditional commercial timbers to meet the requirements.

1 Logging Officer, Pakistan Forest Institute, Peshawar

2 Wood Seasoning & Preservation Officer, Pakistan Forest Institute, Peshawar

Materials and Methods

To conduct the research work, Robinia (*Robinia pseudo-acacia)* wood was collected in log form from Parachinar, Kurram Agency and transported to PFI, Peshawar.

For anatomical properties, a disc of about 10 cm in thickness was cut form end face of the butt log and the sample blocks were removed from the disc. Then from each block, permanent slides of cross, radial and tangential sections were prepared by standard laboratory procedures (Anon, 1971) and observed under the microscope for various structural features. Observations were taken for the following microscopic features with the help of an eye-piece micrometer at suitable magnifications.

frequency of vessels (/mm^2)
Diameter of vessels
Number of rays in cross section (/mm)
Frequency of rays in tangential section (/mm^2)
Height of wood rays (both in microns and number of cells)
Width of wood rays (both in microns and number of cells)
Fiber length
Fiber diameter
Fiber wall thickness

In order to observe fiber length, small chips of the wood were macerated in a solution of 20% Nitric acid and Potassium chlorate to separate the fibers and observations were taken under the microscope after staining in methylene blue.

The data collected was analyzed for the statistical variables such as mean, standard deviation and co-efficient of variation for each feature and presented in the form of table.

For physical properties, a disc of 7 cm in thickness was removed from each log of the species and standard samples were prepared to determine moisture content, density and shrinkage. Remaining portion of both the logs were used for the determination of strength properties (ASTM standards, 1954).

For mechanical properties, logs of the species were converted into planks of 6 cm thickness. Half of the planks from each log were used for strength determination in green condition while the remaining portions were used for tests in air-dry condition. The planks to be tested in both conditions were surfaced to 2 cm thickness and the specimens of the following sizes were prepared from each plank according to International standards (ISO standards, 1975).

Property	**Specimen Size**
Static bending	30 cm x 2 cm x 2 cm
Impact bending	30 cm x 2 cm x 2 cm
Compression parallel to grain	6 cm x 2 cm x 2 cm
Tensile strength perpendicular to grain	7 cm x 2 cm x 2 cm
Cleavage	4.5 cm x 2 cm x 2 cm
Hardness	10 cm x 2 cm x 2 cm

For shear parallel to grain, the test specimens were prepared in accordance with the British standard (BSI, 1951).

Shear parallel to grain 2.5 inches x 2 inches x 2 inches

After preparation of test samples, the strength properties were determined both in green and air dry conditions according to the testing procedures given in the standards. Testing of shear parallel to grain was carried out on Losen Hausenwerk Universal wood testing Machine with a total loading capacity of 20,000 kg. While all the other tests were performed on Amsler Universal Wood Testing Machine with a total loading capacity of 4,000 kg. Care was taken to use only defect free specimens for determination of strength properties.

Results and Discussion

General characteristics of wood

The sapwood is white, heartwood is yellowish brown, shining on longitudinal surface. The bark is rough, yellowish brown having longitudinal fissures. The wood is hard and strong, lustrous, with rough feel, without characteristics odour or taste, moderately heavy to heavy, usually straight or somewhat interlocked grained and coarse and uneven textured.

Anatomical properties

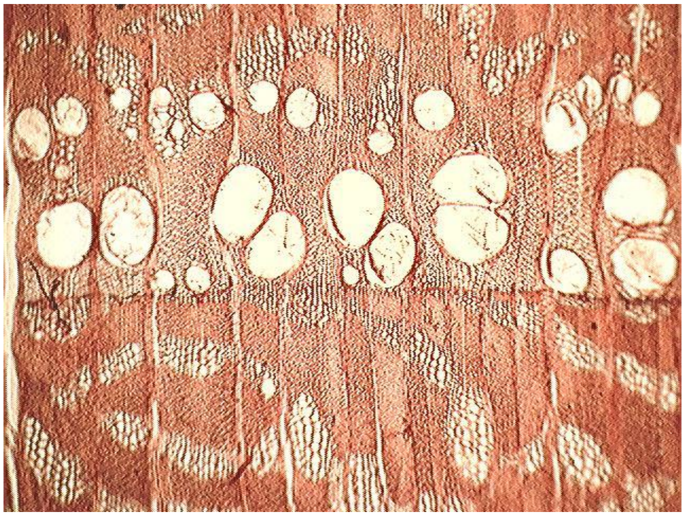
The growth rings are distinct and well defined due to the large size of earlywood vessels, somewhat undulating and not much variable in width. The wood is ring porous.

The vessels are moderate sized to large, often subdivided. The earlywood vessels are larger and not continuous making a well marked annual ring, circular to oval shaped in outline, 87.3u – 378.4u in diameter and are 4-7/mm^2 in number. The latewood vessels are smaller and scattered in light patches arranged more or less concentrically in latewood portion forming oblique and tangential or radial bands. They are oval to angular in outline, 19.12u – 59.92u in diameter and are 59 – 88 /mm2 in number. Tyloses are present in earlywood vessels.

Wood rays are fine to medium, short not deep, undulating due to larger size of earlywood vessels, lighter than the back ground due to denser fibrous tissue, 4-5/mm in cross section and 16 – 21/mm^2 in number in tangential section. The largest rays are 532 u (39 cells) high and 14 u (5 cells) in width.

The fibers are gelatinous, non-septate, angular in outline and are not arranged in radial rows. They are 0.676 mm – 1.82 mm long, 12.75 u – 28.05 u in diameter and the fiber walls are 2.55 u - 5.1 u thick.

Parenchyma is paratracheal, forming complete sheath (vesicentric) around the earlywood vessels and in short bands connecting the latewood pores. Terminal parenchyma occasionally present, forming 1-2 seriate discontinuous sheath delimiting the growth rings.



Photomicrograph showing the wood structure of Robinia (*Robinia pseudo-acacia)*

Table 1. Frequency and dimensional measurements of different wood elements/structures in Robinia (*Robinia pseudoacacia*) wood

(Statistical analysis)

Microscopic feature		Average value	Standard deviation $\pm$	Co-efficient of variation %
Number of earlywood vessels	(/mm^2)	5.56	0.62	11.16
Number of latewood vessels	(/mm^2)	72	9.47	13.10
Diameter of earlywood vessels	(microns)	285.90	74.74	26.14
Diameter of latewood vessels	(microns)	40.50	10.63	26.24
Number of rays in cross section	(/mm)	4.53	0.17	3.88
Number of rays in tang. Section	(/mm^2)	18.18	1.22	6.71
Height of ray	(microns)	262.65	118.40	45.08
	(cells)	18.08	8.05	44.52
Width of ray	(microns)	43.06	12.41	28.83
	(cells)	3.52	0.98	27.97
Fiber length	(mm)	1.16	0.231	19.91
Fiber diameter	(microns)	20.10	4.53	22.53
Fiber wall thickness	(microns)	4.11	1.06	25.79
Fiber lumen width	(microns)	11.88	-	-

Results given in table 1 reveal that the fibers are longer and thick walled and the wood may be better in strength properties. The wood rays are larger in size and higher in frequency because of which the wood may be less durable, however, it can be easily preserved with chemicals as the springwood vessels are sufficient large in diameter which may ease seasoning process of the wood also. Moreover, the wood can also be used for pulp and paper manufacturing as the fibers are wide lumened and can produce better properties in paper.

Physical properties

Robinia (*Robinia pseudo-acacia)* wood grown in the country has been tested for the first time for its wood properties.

Results of the physical properties of Robinia wood have been given in table 2. Average density of the wood has been calculated as 0.737 and the wood is classified as heavy wood. The timber needs to be seasoned at the level of moisture content 12 ± 2% before utilization. Maximum shrinkage (green to oven dry) in radial and tangential sides has been calculated as 4.36% and 10.61% respectively whereas, its value along longitudinal direction is negligible (0.38%).

Table 2. Physical properties of Robinia (*Robinia pseudo-acacia)* wood

S.No	Property		Average value
1.	Density (air-dry weight / air dry volume)		0.737
2.	Basic density (oven-dry weight / green volume)		0.605
3.	Moisture content % Air-dry		9.0
4.	Moisture content % Green (maximum)		68
5.	Longitudinal shrinkage	From green to air-dry %	0.24
		From green to oven dry %	0.38
6.	Radial shrinkage	From green to Air-dry %	3.62
		From green to oven-dry %	4.36
7.	Tangential shrinkage	From green to Air-dry %	9.78
		From green to oven-dry %	10.61

Mechanical properties

Robinia pseudo-acacia wood has been tested and evaluated for its strength properties in green as well as air-dry conditions. The strength figures of various properties tested in green condition gave minimum values because of excess of moisture content (68%) of the wood specimens at the time of testing (Table. 3).

Results of different properties tested in air-dry condition as given in Table. 4 reveal that the wood has excellent average values of modulus of rupture (1186kg/cm^2) which is also known as ultimate bending strength and modulus of elasticity (102845 kg/cm^2) also defined as fiber stress at elastic limit. This means that the wood behaves well when it is used as beams, furniture, joinery work, cross arms, railway sleepers etc.

Average value of maximum compression parallel to grain came out as 709 kg/cm^2 which indicates that Robinia wood is very strong when it is used vertically to the applied load particularly in athletic and sporting goods, bolted timbers, joints, notched timbers, sleepers, tool handles, columns etc.

Similarly the wood has higher value of shear stress parallel to grain (175 kg/cm^2). This property of the wood is also needed for the uses discussed under static bending and compression parallel to grain.

Outstanding values of hardness and cleavage tests provide technical information that timber is suitable when used for carving and nail/screw withdrawal resistance respectively.

Resistance to sudden shocks (impact bending) is of high value (5.01 m-kg) which means that the wood has capacity to absorb sudden shocks when used under similar situation.

Table 3. Strength properties of Robinia (*Robinia pseudo-acacia)* wood in green condition

S.No	Property	Average value	Standard deviation ±	Coefficient of variation %
1	Modulus of rupture: Kg/cm^2	1025	203	19.80
2	Modulus of elasticity: Kg/cm^2	78913	15084	19.11
3	Maximum compression parallel to grain: Kg/ cm^2	337	14	4.15
4	Compression parallel to grain at elastic limit: Kg/cm^2	220	8	3.64
5	Cleavage: Kg/ cm	21	2.82	13.43
6	Tensile strength perpendicular to grain: Kg/cm ^{2}	37	2.0	5.41
7	Impact bending/ 4cm^2 :m -Kg	8.63	0.11	1.27
8	Hardness: Kg Side:	535	49	9.15
	End:	598	53	8.86
9	Shearing strength parallel to grain: Kg cm^2	127	10.31	8.11

Table 4. Strength properties of Robinia (*Robinia pseudo-acacia)* wood in air dry condition.

S. No.	Property		Average value	Standard deviation ±	Coefficient of variation %
1.	Modulus of rupture: Kg/cm^2		1186	146	12.31
2.	Modulus of elasticity: Kg/cm^2		102845	5793	5.63
3.	Maximum compression parallel to grain: Kg/cm^2		709	120	16.93
4.	Compression parallel to grain at elastic limit: Kg/cm^2		509	73	14.34
5.	Cleavage: Kg/ cm		30	3.0	10.00
6.	Tensile strength perpendicular to grain: Kg/cm^2		30	1.0	3.33
7.	Impact bending/ $4cm^2$:m -Kg		5.01	0.30	6.00
8.	Hardness: Kg	Side:	725	106	14.62
		End:	790	98	12.40
9.	Shearing strength parallel to grain: Kg cm^2		175	26.90	15.37

On comparison with the reported values given in literature for Robinia wood from America (CWAR USA, 2005), it has been found that in local Robinia wood density and end Hardness values are higher, maximum compression parallel to grain and shearing strength parallel to grain are comparable and the value of modulus of rupture and modulus of elasticity are lower than the reported values as shown in Table.5.

Table 5. Comparison of strength properties of Robinia wood determined in air-dry condition with the reported values

Property	Determined value	Reported value
Density (Air-dry) g/cm^3	0.737	0.691
Modulus of rupture Kg/cm^2	1186	1364
Modulus of elasticity Kg/cm^2	102845	144336
Max. compression parallel to grain Kg/ cm^2	709	717
Shear parallel to grain Kg/cm^2	175	174
End Hardness Kg	790	771

Comparison of Robinia wood with Shisham wood

In Pakistan, Shisham is the finest wood for high class furniture and cabinet work, it is a good constructional wood employed in house building, flooring and general joinery and carpentry works. There is tremendous pressure on the shisham wood regarding its over utilization whereas, its supply does not meet the requirement. Under these circumstances, it is essential to use the alternate wood species. In this respect, strength properties of Robinia wood has been compared with that of shisham wood already tested (Siddique, Ayas, and Iqbal Mahmood, 1996) as shown in Table 6.

Table 6. Comparison of strength properties of Robinia with Shisham wood

Property	Robinia	Shisham
Density (Air-dry) g/cm^3	0.737	0.730
Modulus of rupture Kg/cm^2	1186	1122
Modulus of elasticity Kg/cm^2	102845	87541
Max. compression parallel to grain Kg/ cm^2	709	571
Cleavage Kg/cm	30	22
Impact bending m-kg	5.01	1.79
Tensile strength perpendicular to grain Kg/cm^2	30	17
Shear parallel to grain Kg/cm^2	175	173
Hardness Kg Side	725	637
End	790	785

From the results, it is evident that Robinia wood belongs to the compareable density class of Shisham wood and has better strength properties than Shisham wood for all the mechanical tests carried out under this study.

Conclusions

Robinia wood is better in strength due to thick walled and long fibers. It is stronger than Shisham wood in different mechanical properties and can be used as substitute of Shisham for furniture and cabinet work after careful processing.

On the basis of strength data, Robinia wood is also suggested as a suitable timber for axels, beams, bearing blocks, cross arms, sleepers, tool handles, wedges, rural construction and cart and carriage building.

The wood may be moderately durable because of higher frequency and larger size of wood rays, but it can be easily preserved with chemicals due to larger size of springwood vessels. Similarly the wood can be seasoned well without any difficulty.

Robinia wood is also suitable for pulp and paper production due to higher morphological characteristics of fibers.

References

Anon. 1971. Examination of Timbers, Teaching Aid No. 7. Timber Research and Development Association, Hunghenden Valley, High Wycombe, Bucks.

American Society for Testing Materials, 1954. Standard methods of testing small clear specimens of timbers. Serial Designation: D 143-148, book of standards, Am. Soc. Test. Mat., Philadelphia, pt. 11.

British Standards Institution, 1957. Methods of testing small clear specimens of timber. BSI: 373.

CWAR, 2005. Center for Wood Anatomy Research. http://www2.fpl.fs.fed.us/ Techsheets/HardwoodNA/htmlDocs/robiniapseudo.html.

Organization for International Standards, 1975. Wood sampling methods and general requirements for physical and mechanical tests ISO: 3129.

Randle. B. J., 1969. World Timbers, Vol. 1, University of Toronto Press, Ernest Benn Limited, London. pp: 54.

Sheikh, M. I., 1993. Trees of Pakistan, Pakistan Forest Institute, Peshawar, Pakistan. pp. 117.

Siddique, K. M., M. Ayaz and Iqbal Mahmood, 1996. Properties and uses of Pakistani Timbers. Forest Products Research Division, Pakistan Forest Institute, Peshawar. Pakistan. pp.42.

Titmus, F. H., 1965. Commercial Timbers of the World, 3rd Edition, The Technical Press Limited, London. pp.213.