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Water absorption and desorption characteristics of wood

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■ **ABSTRACT :** The demand of wood products is continuously increasing in spite of rapid depletion of forests around the globe. Water absorption and desorption in wood are of practical importance since they also affect the mechanical properties of the product. The five wood varieties teak, beechwood, mango, jackfruit and ain were used for study that are popular for timber and furniture in Konkan. These five varieties showed initial high rate of moisture uptake and drying followed by comparatively slower rate. Drying rate was eight times higher than absorption process. Shear strength of all wood varities decreased with increase in moisture content.

■ **KEY WORDS :** Absorption, Desorption, Wood

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Wood is exposed to both periodic water absorption and desorption process. In residential buildings and in industrial applications some of the components are often of wood or wood based. The ability of micro-organisms to attack wood depends on the moisture content of the wood cell wall. Wood changes dimensions as it gains or looses moisture from the cell wall and swells when gaining moisture in the cell wall. This shrinking and swelling can result in warping, splitting and loosening of tool handles, gas in wooden applications or performance problems that detract from the usefulness of wood products. The study was undertaken to determine the moisture content of wood wrt time and shear strength wrt moisture content. Turner (1996) reported that untreated wood consists of approximately 75 per cent of its mass as water, and to ensure a suitable and usable end product, most of that moisture content must be removed during processing. Reeb (1997) observed that as wood dries, it shrinks in several dimensions. Gerhards (1998) observed that moisture has the least effect on parallel to grain properties of modulus of elasticity and tensile strength and the greatest effect on comparessive strength parallel to grain. Fredrikson (2010) studied that upto the fibre saturation point at about 30 per cent moisture content, water is bound in the cell wall. Above the fibre saturation point the cell lumen starts to be filled with water. Since swelling of wood occur when water is bound in the cell wall, wood only swells upto the fibre saturation point. Naik *et al.* (2013) reported that the tensile and flexural strength of wood reduces with time when subjected to condition of moisture absorption. the wood specimens exposed to water absorption for 21 days show decrease of ultimate tensile strength by 34.38 per cent, young's modulus by 35.76 per cent and yield strength by 32.40 per cent.

■ METHODOLOGY

The five varieties of wood *viz.*, teak (*Tectona grandis*), beechwood (*Gmelina arborea*), mango (*Magnifera indica*), jack fruit (*Artocarpus heterophyllus*) and ain (*Terminalia tomentosa* L.) were selected for study. The stick sizing machine, universal testing machine hot air oven, Vernier callipers and digital weighing balance were used for study. A shear test die made up of mild steel was fabricated for determining shear strength. It was made up of base and top plates. The dimensions of plate were 75mm × 75 mm × 10 mm. Top plate was made such that it could be fitted in base plate. Wood samples were cut in cuboids shape with approximate length, breadth and thickness of 50 mm, 40 mm and 20 mm, respectively. All the wood samples of five varieties were placed in a container containing water to obtain absorption data. Before commencement of the experiment, initial moisture content of samples was determined. At certain time intervals the samples were taken out of container and superficially dried on a filter paper to remove surface water. The samples were then weighed to determine moisture uptake. The samples were put back in the container, and the process was repeated until moisture content became stable. Initially when the moisture uptake rate was high, readings were taken at two hours interval. Later, when the moisture uptake rate decreased time interval for readings was increased. When the moisture absorption process was completed the same samples were used for desorption test. The wet samples of the wood were dried under indoor drying with natural convection air. At regular time intervals the samples were weighed to determine the loss of moisture. This process was repeated till weight of sample becomes stable.

The moisture content determination method in accordance of IS: 22157-1.The moisture content was determined by following formula:

$$\text{Moisture content} = \{\frac{m - m_0}{m_0}\} \times 100 \text{ (on dry basis)}$$

where,

m = the mass of the test piece before drying, g

m_0= the mass of the test piece after drying, g

The shear test determination method was taken in accordance of IS: 22157-1. The formula for calculation of shear strength of bamboo is given below:

$$\tau \text{ ult} = \frac{F \text{ ult}}{\sum (t \times L) \text{ MPa}}$$

where,

τ_{ult} - Shear strength, (N/mm^2)

F ult - Maximum load at which the bamboo sample fails, N

Σ (t × L) is the sum of the products of t and L.

■ RESULTS AND DISCUSSION

The initial moisture content of ain, teak, jackfruit, mango and beech wood was found to be 22.07 per cent, 12.93 per cent, 15.02 per cent, 37.33 per cent and 20.36 per cent, respectively.

Water absorption test :

The average moisture content of five wood varieties taken daily over a period of thirty three days is shown in Table 1. Initial moisture content of ain was 22.07 per cent and it increased upto 52.87 per cent at the end of absorption test. This range for teak was 12.93 per cent to 62.95 per cent. The moisture content of jackfruit, mango and beech wood was in the range of 15.02 to 72.38 per cent, 37.33 to 110.66 per cent and 20.36 to 73.06 per cent, respectively.

It was observed that all the wood varieties showed initial fast rate of moisture absorption for first five days followed by a comparatively slower rate. After 25 days, moisture contents of the samples were almost constant. Mango showed fastest rate of absorption followed by beech wood, jackfruit, teak and ain.

Water desorption test :

The average moisture content of five wood varieties over a period of five days while desorption test are shown in Table 2. It was found that moisture content decreased continuously with drying time. During drying, initially fast rate of moisture reduction was observed for first two days followed by constant drying rate period.

The time to reach final moisture content during drying was found to be 5 days. It is evident that drying rate was 8 times higher than the water absorption process.

Shear strength :

The observations of shear strength with increasing moisture content are shown in Table 3 for the wood samples. The observations were taken at 0th, 01st, 10th, 16th and 22nd day after water absorption.

The Table 3 showed continuous decrease in shear strength with increase in moisture content. There was a considerable decrease in shear strength of mango after 24 h of absorption time. On 10th day of absorption

Table 1 : Moisture content observations of wood

Day	Moisture content, %				
	Ain	Teak	Jackfruit	Mango	Beech wood
1.	22.07	12.93	15.02	37.33	20.36
2.	32.29	21.56	30.21	64.00	32.64
3.	34.97	26.74	35.22	73.00	39.33
4.	37.65	29.32	41.98	80.00	43.41
5.	41.51	34.50	45.32	82.66	47.48
6.	41.51	35.35	46.99	85.33	47.48
7.	42.32	37.94	48.75	85.33	50.16
8.	43.18	40.53	50.33	89.33	50.16
9.	44.01	42.26	53.75	92.00	54.24
10.	44.01	43.99	55.51	93.33	54.24
11.	46.69	46.58	58.85	97.33	56.92
12.	46.69	46.58	58.85	97.33	56.92
13.	46.69	48.29	58.85	97.33	58.15
14.	46.69	48.29	60.60	97.33	59.54
15.	46.69	50.87	60.60	100.00	59.54
16.	46.69	51.73	60.60	100.00	62.23
17.	48.53	53.46	62.36	100.00	62.23
18.	48.53	54.31	62.36	102.66	63.46
19.	49.36	56.05	65.78	104.00	64.91
20.	50.37	56.90	65.78	104.00	66.30
21.	50.37	57.98	67.37	106.66	67.53
22.	51.21	60.36	67.37	108.00	68.98
23.	51.21	60.36	67.37	109.33	68.98
24.	51.21	60.36	67.37	109.33	68.98
25.	52.04	62.95	72.38	110.66	73.06
26.	52.87	62.95	72.38	110.66	73.06
27.	52.87	62.95	72.38	110.66	73.06
28.	52.87	62.95	72.38	110.66	73.06
29.	52.87	62.95	72.38	110.66	73.06
30.	52.87	62.95	72.38	110.66	73.06
31.	52.87	62.95	72.38	110.66	73.06
32.	52.87	62.95	72.38	110.66	73.06
33.	52.87	62.95	72.38	110.66	73.06

Table 2 : Moisture content of wood during drying

Day	Moisture content, %				
	Ain	Teak	Jackfruit	Mango	Beech wood
1.	52.87	62.95	72.38	110.66	73.06
2.	40.15	50.04	48.83	86.66	55.47
3.	28.08	33.64	21.78	50.66	39.33
4.	21.06	23.30	15.02	30.66	31.19
5.	18.20	17.25	08.26	18.66	25.88

Table 3 : Shear strength of wood varieties during absorption

Absorption time, day	Ain		Teak		Jackfruit		Mango		Beechwood	
	Moisture content, %	Shear strength, N/mm^2	Moisture content, %	Shear strength, N/mm^2	Moisture content, %	Shear strength, N/mm^2	Moisture content, %	Shear strength, N/mm^2	Moisture content, %	Shear strength, N/mm^2
0th	22.07	16.24	12.93	17.90	15.02	28.02	37.33	12.98	20.36	20.31
1st	32.29	10.81*	21.56	10.72	30.21	17.24	70.66	09.08	35.26	13.08
10th	44.01	11.64	43.99	10.06	55.51	15.88	93.33	11.52	54.24	13.26
16th	46.69	11.46	51.73	10.24	60.60	12.24	100.00	11.04	62.23	12.55
22nd	51.21	11.40	60.36	08.40	67.37	11.26	108.00	10.26	68.98	10.55

shear strength suddenly increased. This is due to the fact that mango has lost grain structure and become soft after gaining moisture. Thus, during shear test the samples showed crushing effect instead of shearing, which resulted in higher strength values.

Conclusion :

The following conclusions were drawn from the study:

– The moisture absorption and desorption rate was higher during initial stage of absorption and desorption period by slower rate in later stage.

– Mango had highest moisture absorption capacity while absorption capacity of ain was lowest among five varieties of wood.

– Shear strength of wood decreased with increase in moisture content.

– Jackfruit was found to have higher shear strength among five varieties of wood.

– Drying rate of wood was 8 times higher than absorption process.

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