EFFECT OF MOISTURE CONTENT ON SOUND ABSORPTION CO-EFFICIENT OF SOME INDIAN TIMBERS

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Abstract: Wood and wood-base materials frequently are used as interior finish in buildings where sound absorption (reduction of the level of sound generated in a room, within that room) needs to be estimated to compare the effectiveness of different species. Various wood based materials of three Indian timbers *(Dalbergia sissoo, Cedrus deodara* and *Populus deltoids)* were evaluated for acoustical absorption using the Bureau of Indian Standard (I.S: 10420 -1982) impedance tube method to determine the effect of moisture content based on their specific gravity on sound absorption. Absorption produced by different species at 25 and 35 percent moisture content at room temperature was affected. *Cedrus deodara* species shown best value for sound absorption coefficient at the frequency level of 1000 hertz while the *Populus deltoids* shown minimum values of sound absorption coefficient.

Keywords: Absorption, *Cedrus deodara*, Specific gravity

INTRODUCTION

Wood is a biologically renewable substance and a most fascinating material because of its very complex structure and variety of uses. Wood is defined as "the hard, fibrous tissue that comprises the major part of stems, branches and roots of trees." Wood can be considered as a biological composite that is produced by the living organisms of trees. The wood which is having submicroscopic components, are held together by specific interaction, assuring the high performance of the tree, without it suffering from debilitating damage in difficult environments (i.e. wind, snow, rain, etc.). The complex assemblies reveal a hierarchical organization of the structure. Before addressing the coexisting aspects of wood acoustics, let us consider the hierarchical structure of wood at the macroscopic level, in order to provide background to our understanding of the behavior of wood. Cremer and Muller (1982) demonstrated that it is possible to accomplish some predetermined acoustical design objectives by selecting the enclosure surfaces to absorb, reflect or transmit the incident wave. How well this objective is accomplished will depend upon the designer's knowledge and skill in the selection and use of materials. Similar statements have been advanced by all acousticians involved in architectural acoustics (Beranek, 1962; Egan, 1988). The acoustic efficiency of walls constructed with wood depends on the method of installation and on the basic properties of the material. A deeper understanding of the very complex phenomena related to the sound insulation of walls needs to consider the sound absorption of different wood species (Kollmann and Cote, 1968). Wood was and still is a basic building material. A wide range of structural applications of wooden members in foundations, light frame construction, beams and columns, bridges, etc. (Freas, 1989). Keeping in view of the importance the study was aimed to determine sound absorption coefficient of timbers at two moisture levels.

MATERIAL AND METHOD

Description of experimental setup:
Sound absorption coefficient of the all 12 samples at two different moisture content levels was determined with the help of standing wave method or tube method according to Bureau of Indian Standard IS:10420 -1982. It includes arrangement of different apparatus such as impedance tube, sinusoidal plane wave source, probe tube, output indicator and specimen. Description in detail given below:

Figure 1. Experimental setup.

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Impedence Tube

It consists of a long tube of fixed length and uniform cross section with rigid walls which absorb negligible sound energy and is vibration free. The one end of tube a source of sinusoidal plane wave is kept and on the other end the specimen mounted. The minimum length of the tube in meters and maximum diameter in cm shall be given below:

$$l_{Min} = \frac{300}{f_{Min}}$$

$$d_{Max} = \frac{2000}{f_{Max}}$$

Where, l_{Min} = Minimum length

d_{Max} = Maximum diameter

f_{Min} = Lowest frequency

f_{Max} = Highest frequency

Sinusoidal plane wave source

It is an audio signal generation used to excite a loud speaker in order to produce the sinusoidal plane waves.

Probe tube

It is a movable microphone fixed at the end of the probe tube on the axis of the impedance tube is use for exposing the standing wave pattern. The probe tube including support from inside the tube have cross sectional area of not greater than 5% of the cross sectional area of impedence tube and the wall thickness of the probe tube shall be not less than 1/8 of the outside diameter of the impedance tube.

Output indicator

It represents a cathode ray oscilloscope on suitable volt meter connected through an audio amplifier is used as output indicator.

Preparation of specimen

In the first stage test specimens of 15 mm thickness and disc of side diameter 50 mm more than the diameter of tube and free from defects such as cracks, splits, loose, decayed knots were prepared from the plank of each species taken for present study. Then these specimens were sanded manually to make smooth surface with the help of a sand paper of 40, 100. The specimens were conditioned at room temperature to get constant weight.

Figure 2. Samples of three different species.

Test Procedure

The specimen was mounted in the specimen holder in such a way that the grain directions being vertical with a rigid backing. The backing was made up of solid steel / brass plate which have a minimum thickness of 10 cm. The backing was provided with flying not screws to anchor it rigidity in the desired position. The fixing was so tight due to which there was no air transmission to outside the tube. The sinusoidal plane waves of known frequency transmitted longitudinally along the tube.

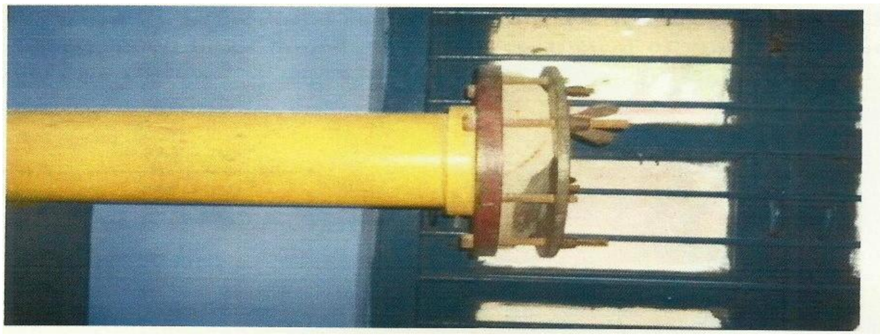

Figure 3. The specimens were mounted in specimen holder.

Waves of reduced amplitude reflected by the specimen, these were combined with the incident wave in order to form a standing wave pattern along the tube. The pattern was expand by the tube whose output was reflected on the output indicator due to which we get the relative and maximum pressure amplitude in the standing wave pattern and that was recorded. The stationary wave pattern was produced at the following test frequencies such as 250 hertz, 500 hertz and 2000 hertz. Sound absorption coefficient of sample was determined based on the formula given below:

$$\sigma = 1 - \frac{(M - N)^2}{(M - N)^2}$$

Where,

σ	=	Sound absorption coefficient
M	=	Maximum pressure amplitude
N	=	Minimum pressure amplitude

Sound absorption coefficient of all the test specimen taken from the three wood species viz. *Dalbergia sissoo, Cedrus deodara and Populus de!toides* was determined by the same procedure as described above at different two moisture content percent.

Determination of specific gravity and moisture content of timber

The relative density of a material is also known as specific gravity, it is defined as the ratio of the weight of material to the weight of an equal volume of water at 4 degree Celsius. In order to calculate the specific gravity, weight of a wood sample was recorded with the help of electronic balance as initial weight and dimensions of sample (length, width and height) was measured with the help of veneer caliper to calculate the volume of the sample. After that this specimen was kept in an oven for 24 hours at a temperature of 103 °C or till it gets constant weight. The weight of the specimen was recorded.

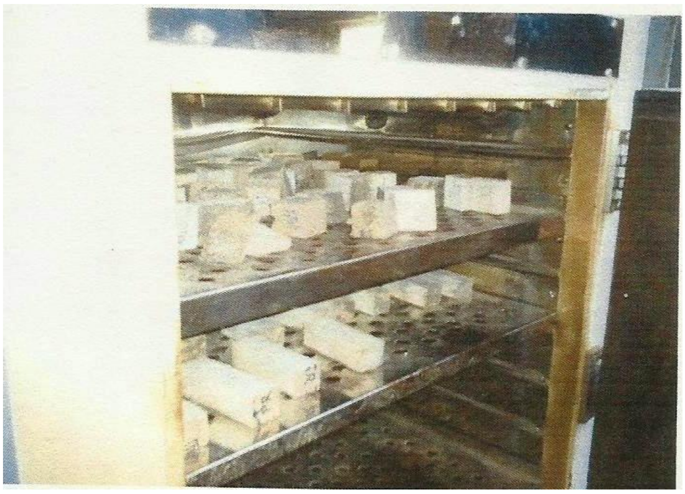

Figure 4. Samples in the electric oven.

The specific gravity of the sample was worked out based on the formula given below:

$$\mathbf{S = W_0 / V_s}$$

Where,

S = Specific gravity

W_0 = Oven dry weight of sample (grams)

V_S = Volume of sample in green condition (cm^3)

Moisture content % of each sample was calculated base on the formula given below:

M.C. % = (G.W. – O.D.W) / O.D.W * 100

Where,

M.C. = Moisture Content (%)

G.W. = Green weight of moisture strips (gm)

O.D.W = Oven dried weight of moisture strips (gm)

Specific gravity and moisture content of all the wood samples of *Dalbergia sisso, Cedrus deodara* and *Poplar deltoids* was determined by the similar test procedure described above.

RESULT AND DISCUSSION

The result obtained during the present course of investigation was carried out to visualize significant influence moisture content on Sound Absorption Co-efficient of Some Indian timbers. Data recorded on specific gravity, moisture content and sound absorption coefficient determined at four different frequencies viz 250Hz, 500 Hz, 1000 Hz and 2000 Hz for individual specimens of wood species viz. *Dalbergia sissoo, Cedrus deodara* and *Populus deltoids* are reflected in the table 1 and average values are also presented in the Table 2. The data reveals that specific gravity was found maximum for *Dalbergia sissoo* (0.683) and minimum for *Populus deltoids* (0.459). The data also indicate that the values of sound absorption coefficient determined at four frequencies at moisture content level viz. 20.1 % are lower than the value found at moisture content 32.3% for *Dalbergia sissoo*. Similar type values of sound absorption coefficient are also found for *Cedrus deodara* at 19.0 % & 34.8% and 14.0% & 30.7% for *Populus deltoids* moisture content levels (Table 1 and 2). If we focus on the values of sound absorption coefficient of three given species then we found that there is a continuous increase in these values at different ranges of frequency from 250 – 1000 Hz for *Cedrus deodara* but *Dalbergia sissoo* and *Populus deltoids* do not show similar trend was also found by Hui *et al.* (2004) in case of Eucalypt species. The value of sound absorption coefficient at 2000Hz is found to decline in comparison to the value at 1000 Hz for each wood species. It means sound absorption coefficient has no clear trend with frequencies.

Table 1. Individual value of moisture content and sound absorption coefficient of three different species.

Species	Sample No	Moisture Content (%)	Sound absorption coeff. (σ)			
Frequency (Hz) →			250	500	1000	2000
Populus deltoides	A_1	13.16	0.776	0.692	0.776	0.438
		30.25	0.711	0.640	0.726	0.396
	A_2	14.05	0.703	0.750	0.853	0.750
		30.72	0.622	0.692	0.720	0.596
	A_3	14.47	0.692	0.653	0.750	0.490
		30.88	0.596	0.653	0.750	0.396
	A_4	14.42	0.750	0.674	0.783	0.692
		30.82	0.532	0.556	0.674	0.640
Cedrus deodara	B_1	18.58	0.582	0.674	0.809	0.665
		33.09	0.472	0.750	0.817	0.582
	B_2	20.08	0.532	0.730	0.817	0.582
		35.84	0.396	0.674	0.779	0.438
	B_3	18.48	0.582	0.726	0.840	0.582
		35.45	0.510	0.692	0.794	0.463
	B_4	19.08	0.556	0.716	0.840	0.610
		34.64	0.423	0.571	0.766	0.610
Dalbergia sissoo	C_1	19.88	0.776	0.720	0.711	0.575
		32.09	0.582	0.640	0.720	0.604
	C_2	18.19	0.703	0.654	0.750	0.640
		31.67	0.617	0.684	0.674	0.556
	C_3	20.50	0.726	0.674	0.750	0.660
		32.47	0.665	0.674	0.711	0.472
	C_4	21.84	0.750	0.700	0.783	0.575
		33.11	0.640	0.622	0.692	0.538

Table 2. Average value of specific gravity, moisture content and sound absorption coefficient of three different species.

Species	Specific Gravity (O.D. wt / Vol. green)	Moisture Content (%)	Sound absorption coeff. (σ)			
Frequency (Hz) →			250	500	1000	2000
Populus deltoides	0.459	14.0	0.615	0.635	0.717	0.506
		30.7	0.730	0.692	0.790	0.592
Cedrus deodara	0.556	19.0	0.450	0.671	0.788	0.523
		34.8	0.562	0.711	0.826	0.610
Dalbergia sissoo	0.683	20.1	0.626	0.655	0.699	0.542
		32.3	0.738	0.687	0.748	0.612

Comparison of sound absorption coefficient values of three different species at different frequency levels in both green as well as dry condition were one in order to determine which species shows minimum and maximum values of sound absorption coefficient. For this purpose graphical analysis of these species one separately an found that average values of sound absorption coefficient of is relatively more in green condition as compared to the dry condition in timber species at different level of frequencies

CONCLUSION

Three species were analyzed on the basis of their specific gravity in order to determine the effect of moisture content on sound absorption coefficient. It was revealed that the sound absorption coefficient is always more at higher moisture content level than lower moisture content level in timbers taken for the present study. It is also observed that the value of sound absorption coefficient at four different levels of frequencies were varies from 0.44 to 0.78. *Cedrus deodara* species shown best value for sound absorption coefficient at the frequency level of 1000hertz while the *Populus deltoides* shown minimum values of sound absorption coefficient.

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