



A STUDY OF INTERRELATIONSHIP BETWEEN HUMIDITY AND EQUILIBRIUM MOISTURE CONTENT OF WOODS

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Abstract

The present study has been conducted to highlight the impact of change in relative humidity on the moisture contents of different kind of woods. Quite often, one finds that the doors and window frames exhibit different dimensions in the month of rainy seasons and hot summers. Such problems are more prominent in the areas witnessing significant changes in relative humidity level over the entire year period as compared to those where relative humidity remain in a constant range throughout the year. The engineers and interior decorators are therefore required to take into consideration this behavior of wood while using wood for constructing furniture, wooden floors and ceiling, etc. to prevent any deformity in the structure at a later date. Preventive measures such as leaving gaps between two adjacent pieces of woods or filling up with some other material may be used to deal with this kind of problem. Further, the amount of dimensional change also varies with the kind of wood being used. The study has been conducted in Delhi-NCR region which faces phenomenal changes in the relative humidity level in one year time and therefore many people experiences such problem in their wooden doors and windows. Under this study, different pieces of Teak and Black Oak wood having same dimensions were exposed to varying level of relative humidity in different months and the change in their dimensions were recorded. Statistical tests – t-test and ANOVA were used to test the statistical differences in the dimensions and inferences have been drawn. Based on the observations, meaningful conclusion and suggestions have been made.



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Introduction

In this study, a relationship between humidity level and change in equilibrium moisture content of wood has been studied. The study would be helpful in understanding the expansion and contraction of wooden structure due to change in humidity level and temperature and

accordingly ensuring proper measure to prevent any loss arising due to it. The prior knowledge of equilibrium moisture content enable us to assess the possible contraction and expansion in the size of wood intended to be used for construction purpose. The moisture content of wood is related to the relative humidity of the air around it. It has been observed that , higher the relative humidity the greater would be the moisture content of the wood. It is due to this reason that the recent bought wood is allowed to dry up in the area where it is intended to be used. It allows the material to reach its equilibrium moisture content level with the air. For example, if wood at 15% MC is exposed to 40% RH, the wood will dry to 5% MC (and shrink as it dries). The EMC helps us understand the response wood will have to relative humidity, whether it will shrink or expand. For woodworkers and carpenters, the EMC is more helpful than RH.

Objective and Basis of the study

As we know, wood is a hygroscopic material as a result of which its moisture content fluctuates with the change in level of relative humidity (RH)of the surrounding air. When humidity increases, the moisture content increases and the wood expands. Similarly, when humidity decreases , the moisture content decreases and the wood contracts. In the normal course, we have observed that a fresh piece of wood from the trees has higher moisture content. But, gradually when it is left to dry under sunlight, it tend to lose moisture content and the size of the piece also get shrink. This tendency of wood therefore can be associated with the change in relative humidity because when moisture content is low , relative humidity is low and when relative humidity is high , moisture content is high. The extent to which a wood reacts to change in level of relative humidity depends on its nature. With this background, different type of woods were collected and exposed to different levels of relative humidity at different point of time. The dimensions of the wood were observed before and after they are exposed to different level of relative humidity.

Hypothesis of the study

The study has been conducted to examine the impact of different levels of relative humidity on the dimensions of the wood. It has also been observed that the impact of relative humidity also varies depending upon the species of the wood. In other words, different type of woods exhibit different type of dimensional change for a given change in the level of relative humidity. In view of this, the following two hypothesis have been tested in the study:

Null Hypothesis 1: The change in relative humidity has no impact on the equilibrium moisture content of woods and hence dimensions of the wood.

Null Hypothesis 2: The change in dimension of one species of wood is not significantly different from the changes observed in other species of wood for any change in relative humidity level.

Procedure of the study

In order to conduct the study, two different species of wood namely – Teak and Black Oak , were taken . Ten pieces of the dimensions 24cm X 52 cm from the core part and outer part of the stems were cut out from the different lumps of wood and exposed under different levels of relative humidity. The length and breadth of these forty pieces of wood were observed and recorded. Each pieces were coded to ensure their identification during the course of entire experiment. Among the different species of wood available , these two species were taken because it has been the experience of the users of the wood that the impact of change in relative humidity on Black Oak is relatively more as compared to that of Teak. The readings of relative humidity has been observed using MCP Digital Room thermometer with humidity indicator. The period during which these reading were observed are the month of May, 2015 (when Relative humidity is around 31to 36) and August, 2015 (when relative humidity is around 70 to 76) in Delhi NCR region. The readings observed with regard to their dimensions under different humidity levels and the changes observed in case of Teak wood and Black Oak are given below in table 1 and 2 respectively.

Teak Wood						
	Outer Part			Core Part		
S.No.	When RH	When RH	%	When RH	When RH	%
	73	33	Change	73	33	Change
1	24	23.1	3.75	23.9	22.6	5.44
2	23.8	22.9	3.78	23.7	22.3	5.91
3	23.6	22.7	3.81	23.8	22.5	5.46
4	24.1	23	4.56	24	22.9	4.58
5	24.2	23.1	4.55	24.1	23.1	4.15
6	52	51.1	1.73	52.1	50.8	2.50
7	52.1	51.2	1.73	52	50.9	2.12
8	51.8	50.8	1.93	51.9	50.7	2.31

9	52.3	51.2	2.10	52.2	51.1	2.11
10	51.9	50.9	1.93	51.1	50.1	1.96
11	52.2	51.2	1.92	52.1	51	2.11

Table1: Change in dimensions of different pieces of Teak wood

BLACK OAK						
OUTER PART				CORE PART		
S.No.	When RH 73	When RH 33	% Change	When RH 73	When RH 33	% Change
1	24	22.2	7.50	24	22	8.33
2	23.9	21.9	8.37	23.8	21.6	9.24
3	23.6	21.7	8.05	23.7	21.4	9.70
4	24.1	22.1	8.30	23.9	21.6	9.62
5	23.8	22	7.56	24.1	22.1	8.30
6	52	50.6	2.69	52	50.4	3.08
7	51.9	50.7	2.31	52.1	50.6	2.88
8	51.8	50.6	2.32	51.8	50.4	2.70
9	51.7	50.6	2.13	51.7	50.2	2.90
10	51.8	50.4	2.70	51.6	50	3.10
11	52	50.8	2.31	52	50.4	3.08

Table 2: Change in dimensions of different pieces of Black Oak wood

As can be observed from the data above, the change in relative humidity level results in change in dimensions of different pieces of wood. Though the humidity has been around in the range of 70 to 76 during the month of August and in the range of 30 to 36 in the month of May , however, mean level of humidity has been taken into consideration. The change was found to be more significant in case of pieces taken out from the core part as compared to the those taken from outer part. Further, the difference was also observed in respect of species of the wood. The impact of contraction and expansion was observed to be more in case of Black Oak as compared to Teak wood.

Using the above data, following statistical tests were employed to test the hypotheses under study :

- a) Statistical t-test to test the statistical difference between change in core part wood and the outer part of Teak wood and Black Oak wood.

b) ANOVA test to test the significant difference between change observed in all four different sets of woods under study.

The output obtained from SPSS package in respect of t-test for core part and outer part of Teak wood is given below in table 3

Group Statistics					
Type		N	Mean	Std. Deviation	Std. Error Mean
TeakWood	Teak Wood (Outer)	10	2.987359	1.2018124	.3800464
	Teak Wood (Central)	10	3.652835	1.6133418	.5101835

Table 3 : SPSS output of T-test for Teak Wood

It can be observed from the above that mean and standard deviation for outer part is 2.98 and 1.20 respectively and it is quite different from the mean and standard deviation of the core part which was 3.65 and 1.61 respectively. However, to examine if the difference are statistically significant different or not ,Levene’s test has been used and its output is given below in table 4.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
TeakWood	Equal variances assumed	3.638	.073	-1.046	18	.309	-.6654761	.6361780	-2.0020365	.6710843

Equal	-	16.6	.310	-	.636178	-	.67897
variances not assumed	1.046	37		.6654761	0	2.0099300	78

Table 4 : SPSS output of Levene’s-test for Teak Wood

From the value obtained under Levene’s Test for equality of variance, we can observe that sig level is 0.07 which is more than 0.05 implying that that the variability in the two segments is not significantly different from each other. Thus, we can accept the null hypothesis that there is no significant difference between the change in dimensions of the core part and outer part of the teak wood if these have been cut out from the same tree.

Similar, test were conducted for the Black Oak wood, and its output are given in table 5 and 6 respectively.

Group Statistics					
TypeWood	N	Mean	Std. Deviation	Std. Error Mean	
BlackOak	Black Oak (Outer)	10	5.193224	2.9298947	.9265141
	Black Oak (Central)	10	5.986469	3.2534747	1.0288390

Table 5 : SPSS output of T-test for Black Oak Wood

It can be observed from the above that mean and standard deviation for outer part is 5.19 and 2.92 respectively and it is quite different from the mean and standard deviation of the core part which was 5.98 and 3.25 respectively. However, to examine if the difference are statistically significant different or not ,Levene’s test has been used and its output is given below in table 6.

Independent Samples Test

Levene's Test for Equality of Variances	t-test for Equality of Means
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	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	2.636	.122	-.573	18	.574	-.7932451	1.3845353	-3.7020459	2.1155557
BlackOak									
Equal variances not assumed			-.573	17.806	.574	-.7932451	1.3845353	-3.7043190	2.1178288

Table 6 : SPSS output of Levene’s-test for Teak Wood

From the value obtained under Levene’s Test for equality of variance, we can observe that sig level is 0.122 which is more than 0.05 implying that that the variability in the two segments is not significantly different from each other. Thus, we can accept the null hypothesis that there is no significant difference between the change in dimensions of the core part and outer part of the Black Oak wood if these have been cut out from the same tree. However, to ascertain if change in relative humidity can have different impact on different species of wood, ANOVA test has been used with the help of SPSS. For the purpose of inferring on the basis of ANOVA, the assumption of normality of data and homogeneity of variances has been checked using K-S test and Levene’s test respectively. Finally, Post - hoc analysis using multiple comparison and mean plot has been used to find the areas in which differences are significant.

The assumption of normality of data has been examined using one sample Kolmogorov-Smirnov test (K-S test) using SPSS. The result of the output are summarized below in table 7.

One-Sample Kolmogorov-Smirnov Test			
		WOOD	TYPE
N		40	40
Normal Parameters ^{a,b}	Mean	4.4550	2.50
	Std. Deviation	2.61076	1.132
Most Extreme Differences	Absolute	.198	.171
	Positive	.198	.171
	Negative	-.148	-.171
Kolmogorov-Smirnov Z		1.252	1.079
Asymp. Sig. (2-tailed)		.007	.195

a. Test distribution is Normal.

Table 7: SPSS output for K-S Test (Testing Normality of the data)

As can be observed from above calculation , p-value (Asymp. Sig) is less than .05 , therefore, we can concluded that our data complies with the condition of normality . In order to test the homogeneity of variances among the change in dimensions ,Levene statistic has been calculated using SPSS , as shown below in table 8:

Levene Statistic	df1	df2	Sig.
55.530	3	36	.000

Table 8 : SPSS output of Test of Homogeneity of Variances

Since the Levene statistic is greater than 0.05 we therefore conclude that the variability among the readings observed are significantly different. Once , it is ensured that the test of homogeneity of variance and normality of data are complied, ANOVA test has employed and the output obtained is given below in table 9:

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	56.878	3	18.959	3.267	.032
Within Groups	208.949	36	5.804		
Total	265.828	39			

Table 9 : SPSS output of ANOVA test

It can be observed from the output that p value (Sig.) is less than .05 ,it implies our null hypothesis is rejected which means there is significant difference between the change in dimensions of different set of woods under study . The difference among these value which have been observed can be concluded to have occurred due to different impact on the equilibrium moisture content of various species of wood.

In order to ascertain difference of each set of reading vis-à-vis other sets of readings , multiple comparison test was conducted and its output is given in table 10

Multiple Comparisons

Dependent Variable: WOOD

Tukey HSD

(I) TYPE	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound
2	-.66548	1.07742	.926	-3.5672	2.2363
1 3	-2.20586	1.07742	.190	-5.1076	.6959
4	-2.99911*	1.07742	.041	-5.9008	-.0974
1	.66548	1.07742	.926	-2.2363	3.5672
2 3	-1.54039	1.07742	.490	-4.4421	1.3613
4	-2.33363	1.07742	.042	-5.2354	.5681
1	2.20586	1.07742	.190	-.6959	5.1076
3 2	1.54039	1.07742	.490	-1.3613	4.4421
4	-.79325	1.07742	.882	-3.6950	2.1085
1	2.99911*	1.07742	.041	.0974	5.9008
4 2	2.33363	1.07742	.042	-.5681	5.2354
3	.79325	1.07742	.882	-2.1085	3.6950

*. The mean difference is significant at the 0.05 level.

Here Type 1 refers outer part of teak wood, Type 2 refers central part of teak wood, Type 3 refers outer part of Black Oak wood and Type 4 refers central part of Black Oak wood.

Table 10 : SPSS output of Multiple Comparisons (Post Adhoc Analysis)

It can be observed from the above data that significant differences occurred when the part of woods happened to be from different species. However, in most of the cases difference were not found to be very significantly different as significance values were greater than 0.05. The same behavior is also visible from the mean plot of the values shown in figure 1 .

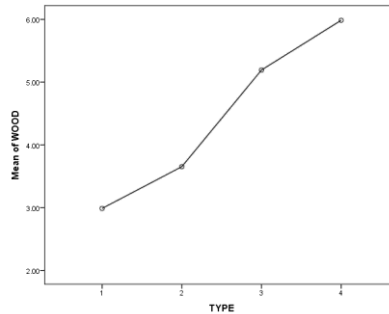


Figure 1 : SPSS output of Mean Plot (Post Adhoc Analysis)

CONCLUSION

The impact of change in relative humidity on the moisture content and hence the dimensions of the wood has been theoretically discussed in many research papers. However, to examine this fact, statistical test has been employed and it was found the impact of is more visible if the wood species are different whereas if the part of wood happens to be cut out from the same tree or specie, the impact of change in relative humidity on different sets of wood is very nominal and it is not found to be statistically different. This implies a furniture made up of entirely from the same species of wood shall be preferred over the ones made up of different woods. The ability to withstand the change in relative humidity level in such cases is relatively more than the cases where different species of wood have been used for any construction purpose.

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