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MEASUREMENT PROTOCOL OF WOOD-WATER RELATIONS:

Black Locust & Douglas Fir

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1. Wood species

Black Locust *(Robinia pseudoacacia)*

Black Locust is fast growing hard wood specie. It is possible to make high quality products from Black Locust. It has a narrow, yellow-light green sapwood area. Its heartwood is yellow-brownies and in fresh cut it is greenish. Its density is about 770kg/m^3

Utilization: Parquet, furniture, barrel staves, board for mining purposes, sawn props and poles, railroad sleepers, laminated scantlings for window and door frames and for fuel. Black Locust has high mechanical properties, but its processing is quite hard. There are tyloses in a wood so it dulls an edge of saw. (3)

Douglas Fir *(Pseudotsuga Douglasii)*

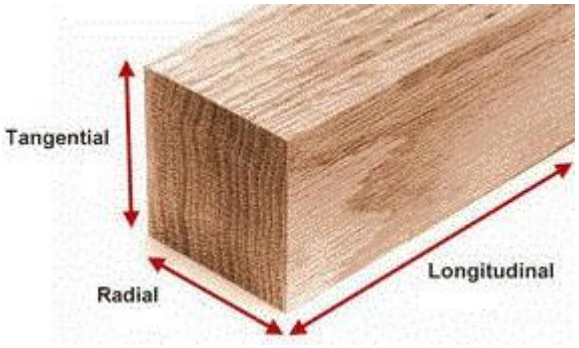
Douglas fir is a fast growing soft wood from America. Its heartwood is reddish and sapwood is yellowish. Annual rigs are easily to separate and latewood is thick. It is one of the strongest of soft wood species and its density is about 530kg/m^3. Douglas fir is one of the most appreciates building wood species. It is used in wood buildings, windows, doors, furniture, floor materials, railway sleepers and to boat building. (2)

2. Materials & Methods

There were two different tests what was made. Test number one was about shrinking and swelling and test number two was about absorption.

There were 10 different samples in the test number one, 5 samples of Douglas fir and 5 samples of Black Locust. Every sample was marked from 1 to 10. After that the samples were weighted one by one with accuracy of two decimals. When weights were listed, were measured dimensions of wood samples (tangential, longitudinal and radial) by automatic thickness meter. Dimensions are showed in picture /1/. These weight and thickness measurements were repeated two times, once after drying and once after wetting. There were three different measurement conditions: 1. normal air humidity and temperature ~23°C 2. oven-dry conditions: 102°C & humidity

0% 3. wet conditions – humidity 100% and temperature ~23°C. Results are showed in a chapter 4. There are no calculated results about longitudinal measurements, because its modification values are so small.



/1/ Directions of wood sample

In absorption test there were 10 samples of Black Locust and 10 samples of Douglas Fir. The samples were only weighted in different conditions. There were 5 different conditions: 1. Normal room temperature and humidity 2. oven-dried - 105°C and humidity of 0%, 3. Humidity cabinet – 20% humidity and 20°C, 4. Desiccator – 60% humidity and 20°C, 5. Desiccator – 100% humidity and 20°C. Conditions to desiccator were made by $NaNO_3$ (60%) and $CuSO_4$(100%)- solutions. Matrix about the results is showed in the chapter 4.

3. Equations

1. Equation for shrinking

$$Z = \frac{l_u - l_0}{l_u} * 100\%$$

2. Equation for swelling

$$D = \frac{l_u - l_0}{l_0} * 100\%$$

3. Equation for moisture content

$$U = \Delta U = \frac{m_u - m_0}{m_0} * 100\%$$

4. Equation for maximum moisture content

$$U_{max} = \frac{m_{max} - m_0}{m_0}$$

5. Shrinking coefficient

$$K_Z = \frac{Z_{l,r,t}}{\Delta U}/100$$

6. Swelling coefficient

$$K_D = \frac{D_{l,r,t}}{\Delta U}/100$$

Where l_u = length, wet

l_0 = length, dry

m_u = weight, in room conditions

m_0 = weight, dry

m_{max} = weight, 100% wet

4. Results

4.1 Shrinking and swelling results

	My results		Values from literature(1)	
	Douglas fir	**Black Locust**	**Douglas fir****	**Black Locust**
ΔU	5,95	7,91		
Δumax	59,33	54,11		
Zr	0,89	1,70	3,8	4,6
Zt	1,36	1,95	6,9	7,2
Dr	4,18	6,62	?	?
Dt	6,50	8,01	?	?
K_{Zr}	0,0015	0,0021	0,00130*	0,00158*
K_{Zt}	0,0023	0,0025	0,00241*	0,00252*
K_{Dr}	0,0007	0,0012	0,00130*	0,00158*
K_{Dt}	0,0011	0,0015	0,00241*	0,00252*

Matrix 1, shrinking and swelling results. *Within moisture condition limits of 6% to14%. There were same values to shrinking and swelling in the book. ** Douglas Fir interior north-values.(1)

Douglas fir	m_u	L_u	R_u	T_u	m_0	L_0	R_0	T_0	m_{max}	L_{max}	R_{max}	T_{max}
	7,12	30,226	21,03	20,633	6,72	30,190	20,844	20,292	10,98	30,293	21,822	21,892
	7,75	30,313	21,318	20,941	7,31	30,283	21,124	20,657	11,65	30,313	22,001	22,010
	7,64	30,172	21,449	21,133	7,20	30,139	21,275	20,886	11,45	30,216	22,029	22,012
	7,06	30,114	21,158	21,04	6,68	30,075	20,959	20,759	10,77	30,182	21,875	22,068
	7,84	30,289	21,314	20,955	7,40	30,250	21,122	20,681	11,41	30,303	22,003	22,007
Average	7,48	30,223	21,254	20,940	7,06	30,187	21,065	20,655	11,25	30,261	21,946	21,998

Matrix 2, measurements of Douglas Fir, weight [g], length [mm].

Black Locust	m_u	L_u	R_u	T_u	m_0	L_0	R_0	T_0	m_{max}	L_{max}	R_{max}	T_{max}
	8,38	30,295	19,728	20,353	7,76	30,274	19,37	20,038	11,6	30,428	20,979	21,209
	8,12	30,325	19,854	20,202	7,52	30,282	19,544	19,798	11,82	30,462	20,801	21,405
	8,08	30,361	19,647	20,171	7,49	30,325	19,334	19,743	11,74	30,438	20,568	21,491
	8,19	30,325	20,006	19,966	7,59	30,297	19,679	19,574	11,86	30,426	20,872	21,228
	8,69	30,298	20,332	20,283	8,06	30,266	19,981	19,855	12,19	30,405	21,167	21,604
Average	8,292	30,321	19,913	20,195	7,684	30,289	19,582	19,802	11,842	30,432	20,877	21,387

Matrix 3, measurements of Black Locust, weight [g], length [mm]

4.2 Absorption results

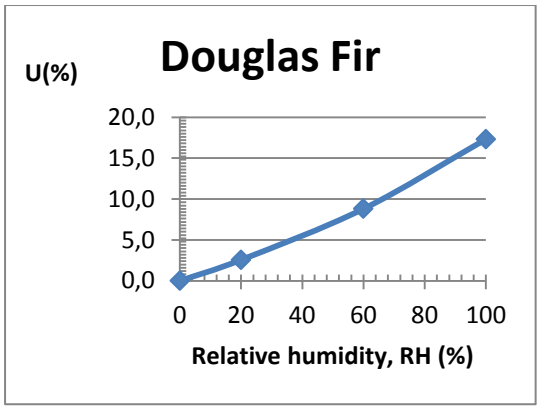


Diagram 1.

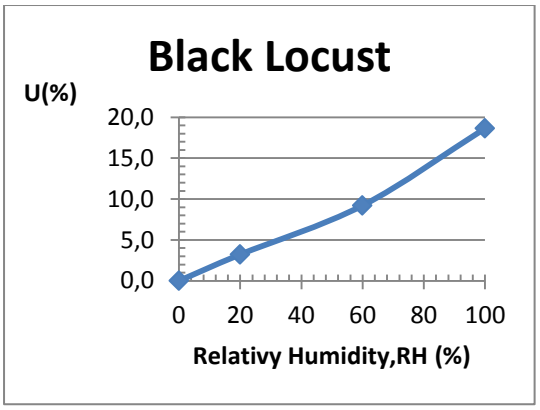


Diagram 2

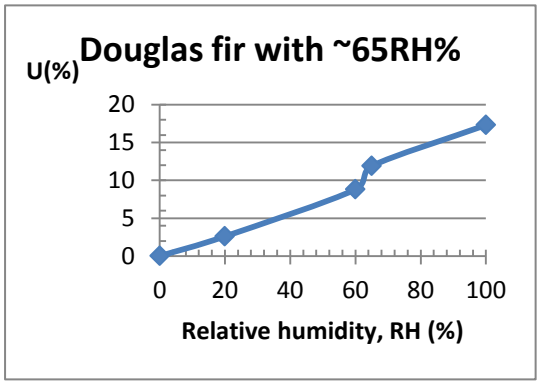


Diagram 3

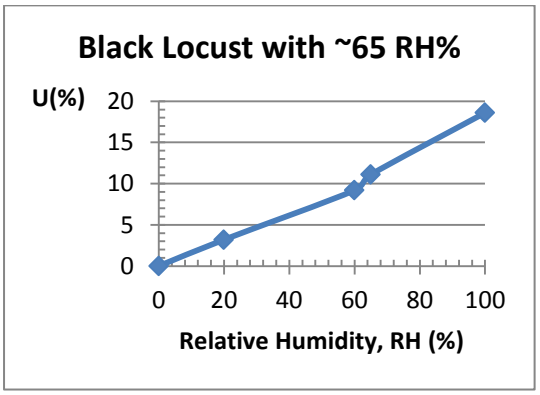


Diagram 4

U[(1]	RH	Douglas Fir	Black Locust
U_0	0	0	0
U_{20}	20	2,6	3,2
U_{60}	60	8,8	9,2
U_{65}	65	11,9	11,1
U_{100}	100	17,3	18,6

Matrix 4, moisture content.

[(1] U is calculated according to an equation number 3.

	~23°C ~65%	105°C 0 %	20 %	$NaNO_3$ 60 %	$CuSO_4$ 100 %
	mu	mo	m20	m60	m100
1.	4,43	3,96	4,07	4,31	4,67
2.	4,56	4,07	4,17	4,42	4,77
3.	4,61	4,11	4,22	4,47	4,84
4.	4,56	4,07	4,17	4,43	4,77
5.	4,43	3,96	4,07	4,31	4,65
6.	4,65	4,17	4,26	4,52	4,87
7.	4,54	4,06	4,16	4,42	4,76
8.	4,64	4,15	4,26	4,52	4,87
9.	4,51	4,03	4,14	4,39	4,72
10.	4,41	3,95	4,05	4,31	4,63
Average	4,53	4,05	4,16	4,41	4,76

Matrix 5, measurements of Douglas Fir

	~23°C ~65%	105°C 0 %	20 %	$NaNO_3$ 60 %	$CuSO_4$ 100 %
	mu	mo	m20	m60	m100
1.	3,18	2,86	2,96	3,13	3,40
2.	3,21	2,90	2,99	3,16	3,45
3.	3,25	2,92	3,02	3,19	3,47
4.	3,22	2,89	2,99	3,17	3,43
5.	3,22	2,90	2,99	3,17	3,42
6.	3,17	2,86	2,95	3,12	3,41
7.	3,17	2,85	2,94	3,11	3,38
8.	3,21	2,89	2,98	3,15	3,41
9.	3,20	2,88	2,97	3,15	3,44
10.	3,23	2,91	3,00	3,17	3,43
Average	3,21	2,89	2,98	3,15	3,42

Matrix 6, measurements of Black Locust

5. Conclusions

If I at first look the results of shrinking and swelling tests,(Matrix 1) can be noted that results are very bad. Results are much smaller than in literature. But if is looked a results of shrinking and swelling coefficient is seen that tangential shrinking coefficient is almost same as in literature in both wood

species. My results in a radial shrinking are little bit bigger than in literature. There were same results for shrinking and swelling in a literature, and my results are far away from this results I have got a bigger results to Black Locust, compared to Douglas fir and on this way it is in literature too. Even if the results are not good I can understand the meaning of these measurements better and how this shrinking and swelling will effect to wood.

If is looked to results of absorption tests is seen that there is not enough measurements. There should be an S-form in diagrams, but it's not showed (diagrams 1 &2). If is added a value, where the samples were before measurements, then it is seen that S-form.(diagrams 3&4). It is important to understand that the moisture content of wood doesn't rise linearly. By comparing to Douglas fir to Black Locust is seen that Black Locust has a little bit bigger moisture content, when relative humidity is rising. To get to better results and more describable diagrams more measurements are needed. By doing these measurements is easier to understand how wood changes its form in different moisture conditions.

Sources:

1. Wood handbook – Wood as an Engineering Material, Author/Editor: Forest Products Laboratory, publisher: U.S. Department of Agriculture
2. http://www.puuproffa.fi/proffin/index.php?option=com_content&task=view&id=72&Itemid=48, read 6.12.2013
3. Dr. Nemeth teaching material about wood anatomy (based on book made by Bariska M.)

Pictures:

/1/http://workshopcompanion.com/KnowHow/Design/Nature_of_Wood/2_Wood_Movement/2_Wood_Movement.htm, showed 4.12.2013