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COMPARATIVE STUDIES ON THE MECHANICAL STRENGTH OF DIFFERENT PANEL BOARDS (CHIPBOARD, BLOCKBOARD)

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Abstract:

Lignocellulosic composite materials have gained increasing attractiveness due to their physical and mechanical properties as well as their aesthetic properties for diverse applications. An essential quality of these is the possibility of manufacture in the form of panels of different thicknesses but with large surfaces, which, for solid wood can only be achieved by jointing. This research paper aims to perform a comparative study of the mechanical strengths of the most common lignocellulosic composites at this time in major use for specific markets from different producers. Their mechanical properties make these composites a strong competitor with traditional materials. Knowledge of mechanical properties is essential for those who are designing products that incorporate them.

Key words: *composite material; bending strength; HDF; blockboard; chipboard.*

INTRODUCTION

Although composite materials can be obtained from low-quality wood or wood residues, with the final product can have improved properties. Effective applications for them are based on knowing the properties, so there is a need to know the various physical and mechanical properties. The current composite materials are state-of-the-art materials, incorporating in their structure high and innovative technologies. There are also older composite materials made by laminating but these are part of the older generation, and may be termed e the 'classic' composites. From this point of view, composite materials are classified as classic composite materials (PB, PFL, plywood etc.) and modern (OSB, MDF etc.). Each of these materials has their industrial importance and their own fields of use, but uses can also be complementary.

The properties of the composite materials depend on many factors, but the most important ones are given by the nature of the materials comprising the matrix and the binder, the manufacturing procedure and the bond between the constituents. Usually, composite materials have properties different from those of the component materials, usually improved. Among the properties to be improved with wood composite materials are: high resistance to humidity, sound absorption, heat resistance/insulation, shock and fatigue resistance, mechanical properties (elasticity, plasticity, and mechanic resistances), ecological properties (biodegradability), durability and hardness, special aesthetic and design possibilities through form and finishing etc. Many authors have written about particleboards and panels (Youngquist 2011, Thoemen et al. 2010) both about the manufacturing technology and the tests performed on them.

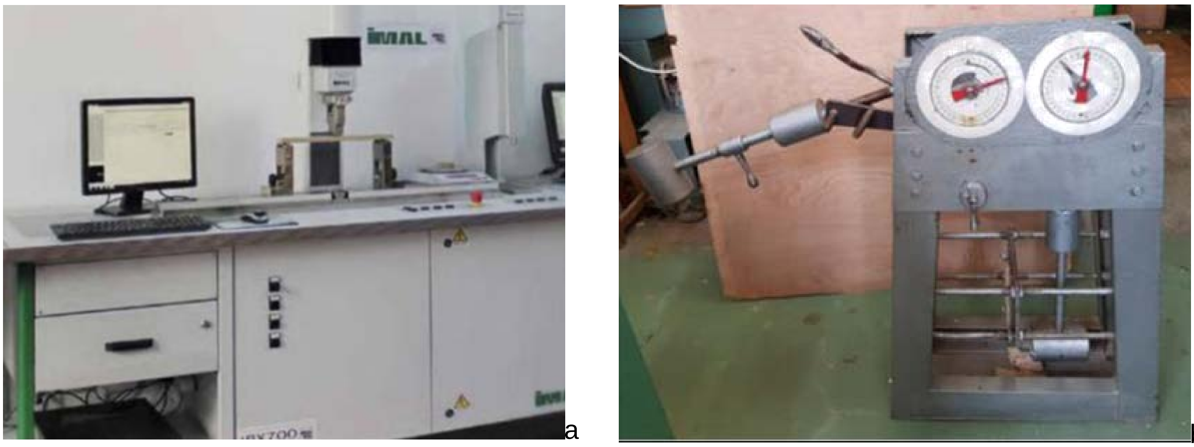
OBJECTIVES

The main objective of this work was to make a comparison between different existing composite materials (chipboard and blockboard) from the point of view of their physical and mechanical properties, for their effective use. Investigations were made into resistance to static bending, internal bond strength, and resistance to impact through the method of two-pendulum hammers type Charpy, nails withdrawing, moisture absorption and thickness swelling.

MATERIALS AND METHODS

The composite materials were procured from the company Holzindustrie and consisted of boards of size 500x500mm from PB with thicknesses of 12 and 18mm (denoted as Chipb 12 and Chipb 18) and veneered panels (denoted as Blocb 12V or Blocb 18V) or laminated with HDF (denoted as Blocb 12H or Blocb 18H), that were divided into test-pieces for the performance of the laboratory tests. The main properties taken into consideration were resistance to static banding, internal bond strength, impact resistance moisture absorption and thickness swelling.

Resistance to breaking through static bending. To determine the resistance to bending of the composite boards, an IMAL universal testing machine was used, according to Fig.1.a that could perform a complex series of mechanical tests, among which was resistance to static bending.



a b

Fig.1.
Equipment for strength testing: a. IMAL-testing machine for resistance to breaking through static bending; b. Two- hammer pendulum device to test impact strength.

Resistance to static bending used the European methodology SR EN 310, whose determination principle is showed in Fig 2 and resistance to breaking was determined with the help of Eq. 1:

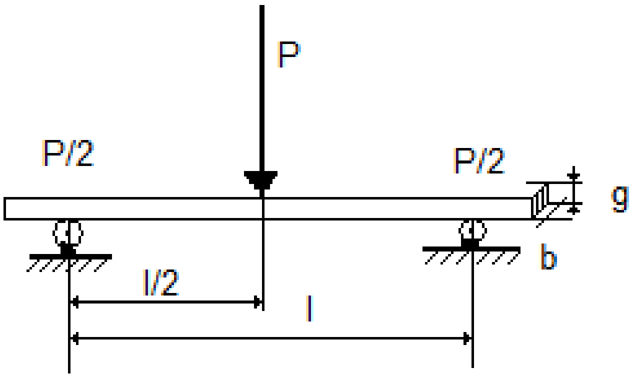


Fig 2.
The principle for determining resistance to bending (three point bending): P-force, g-thickness; l-distance between supports.

$$\sigma_i = \frac{3}{2} \cdot \frac{P_{\max} \cdot l}{b \cdot g^2} \quad [N/mm^2] \qquad (1)$$

Determination of resistance to impact. Resistance to impact was determined with an Izod/Charpy machine (Fig 1.b) equipped with two pendulum hammers. The principle of the method is based on the work of transfer of the energy on impact between the two swinging hammers used to break the test sample and the residual mechanical work transferred to the second pendulum hammer. The mechanical work of the two-hammer pendulum was expressed through the two angles α_1 and α_2 visible on the two dials with active and worn indicators. To determine resistance to puncture of the composite boards, the two-hammers pendulum device was used, which measures the energy consumed to penetrate the test sample, resulting from the difference between the mechanical work initially read on the dial of the first hammer and the value of the mechanical work read on the dial of the second hammer.

The relationship for determination of resistance to impact, also called resilience to impact, was the following:

$$K = \frac{L}{g}[MPa] \qquad (2)$$

where: L is the mechanical work consumed to break the test sample through dynamic efforts, expressed in N.mm; g- thickness of the transversal section of the test sample.

Determination of transversal internal bond of the composite boards. This determination measures the adhesion of the surface of veneers or interior chips. Transverse internal bond (SR EN 319) or resistance to traction perpendicular on the surface of the board is given by the force that produces the break of the test sample and they area of the surface of the broken, A. The test samples must contain humidity in accordance with the standard and so were conditioned to a relative humidity of 55% and 20ºC temperature.

In Fig. 3 shows test device and Fig 4.a shows the mechanical testing machinery for determining (internal bond).

Fig 3.
Transverse internal bond of the test samples.

a.

b.

Fig. 4.
Determination of internal bond (a) and the resistance to nails withdrawal (b) of the composite boards.

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Resistance to screw withdrawal in different types of boards. Determination of resistance to withdrawal of the screws is done both perpendicular to the plane of the board and parallel with the surface (core) Tests for screw withdrawal is done immediately after insertion into the test sample. All the dimensions were measured to an accuracy of 0.1mm. In Fig. 4.b shows the device for the testing screw and nail withdrawal.

Water absorption and thickness swelling. Dimensional stability of the composite materials can be expressed as the mass of the water absorbed after 2 or 24 hours, as well as the variation in thickness, depending on the amount of water absorbed. The experimental method consists of measuring the dimensional variation of the test samples immersed into water, and the mass variations of the 50x50mm test samples. The measurement of volume, as well as the weight of the tested samples is done at certain time intervals, so as to make a correlation between the dimensional stability of panels. Fig. 5 shows the apparatus used for absorption and thickness swelling.

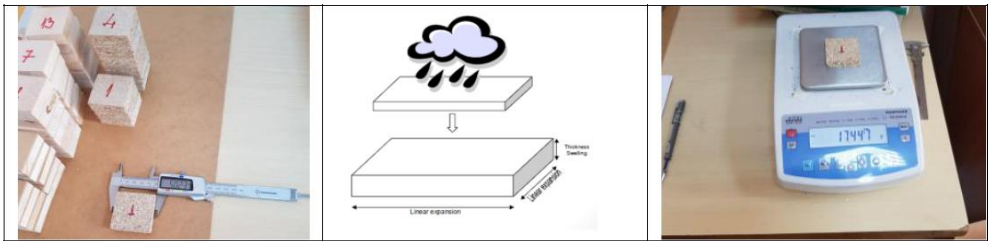

Fig. 5.
Equipment used to determine water absorption and thickness swelling.

Relationships to determine water absorption and thickness swelling are showed below (Eq. 3).

$$A = \frac{m_i - m_f}{m_i} \cdot 100 \quad [\%] \qquad U_g = \frac{g_i - g_f}{g_i} \cdot 100 \quad [\%] \qquad (3)$$

Within Eq. 3 we have the following:
mI – initial mass of the test samples, in g;
mf – final mass of the test samples after immersion, in g;
gi – initial thickness of test samples, in mm;
gf – the final thickness of the test samples after water immersion, in mm.

RESULTS AND DISCUSSION

Density

Density of the two types of wood composites was different (Fig. 6). Determination was done on 10 samples, of which the extreme values of the experiments as removed (Table 1).

Table 1

Determination of density of the composite boards

No.	Chipb 12		Chipb 18		Blockb V18		Blockb H18	
	m (g)	ρ (kg/m^3)	m (g)	ρ (kg/m^3)	m (g)	ρ (kg/m^3)	m (g)	ρ (kg/m^3)
1	17.44	569.9	28.1	626.2	20.97	487.6	25.84	587.2
2	17.68	570.3	27.89	648.60	25.52	607.6	24.44	568.3
3	17.41	580.3	27.99	666.46	17.42	395.9	24.57	599.2
4	17.35	598.2	28.05	652.32	18.75	436.0	26.55	632.1
5	17.52	584	28.41	692.98	17.96	427.6	25.33	575.6
6	17.49	603.1	28.43	661.18	17.59	409.0	30.67	681.5
7	17.31	577	28.28	642.73	17.33	393.8	25.8	600
8	17.46	623.5	27.96	650.26	18.11	402.4	25.74	585
9	17.37	579	28.1	638.64	18.16	442.9	25.5	621.9
Med		587.2		653.29		444.7		605.6

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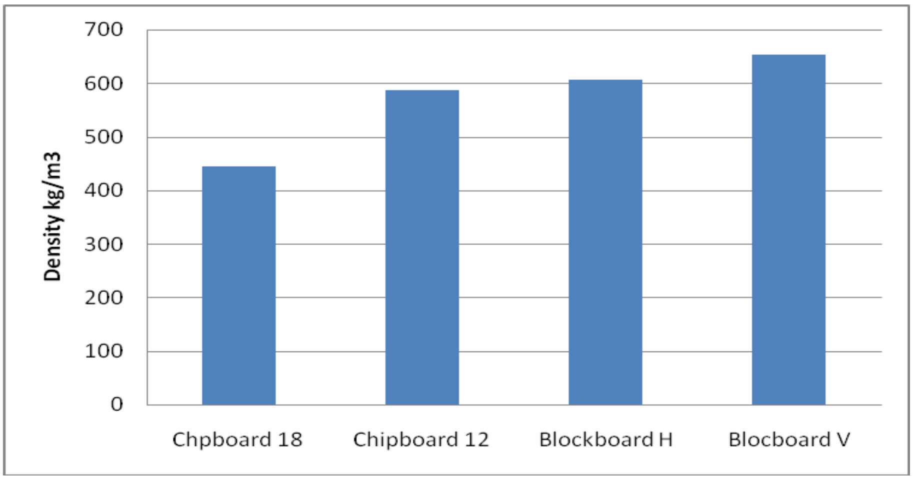

Fig. 6.
Comparative density of composite material.

Static bending strength

Resistance to breaking through static bending of the samples made of PB, panel with veneered faces and panel with HDF faces, results are a shown in Table 2 and Fig. 7.

Table 2

Force and bending strength of veneered hardboard of 12 mm thickness cut longitudinal to core (example of Hardb V 12L)

Nr crt	1	2	3	4	5	6	7	8	9	Mean
Force, daN	149	108.2	173	187	153	182.6	140	117	166	152.8
Bending strength, daN/cm^2	506.1	367.5	587.6	635.1	519.6	620.2	475.5	397.4	563.8	519.2

It can be seen that the higher results were obtained on the test samples made of veneer faced panels longitudinally divided, parallel with the direction of the core strakes.

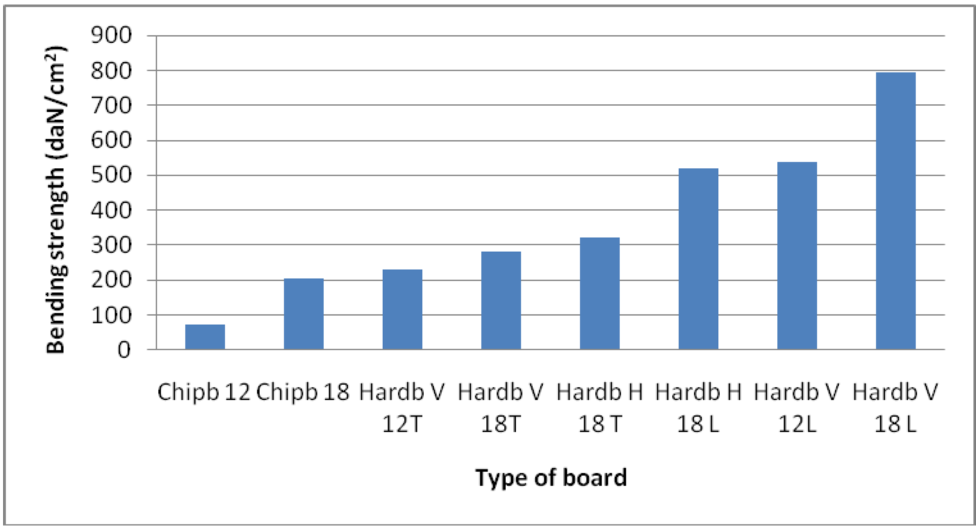

Fig. 7.
Resistance to static bending.

The net higher results were obtained on samples made of veneered faced panels longitudinally divided, followed by the test samples made of HDF faced panels, and in last place were the chipboards test samples. The superiority of both the veneer faced panels, and the HDF faced ones can be seen as regards resistance to breaking through static bending compared to other lignocellulosic composite materials with similar use, in our case chipboards.

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In Table 3 we can see the results obtained following the determination of the resistance to penetration of different composite boards. It can be seen that the higher results were obtained on test samples made of HDF faced panels, followed by test samples made of veneer faced panels, and in last place the test samples made of chipboards.

Table 3

Resistance to impact

	Chipb 18		Chipb 12			Blockb V12			Blockb V18			Blockb H18		
	daN	kgm/cm	daN	kgm	kgm/cm	daN	kgm	Kgm/cm	daN	kgm	Kgm/cm	daN	kgm	Kgm/cm
1	70	59.4	78	79.4	44.1	90	91.7	50.9	100	101.9	56. 6	150	152.8	84.9
2	69	58.5	75	76.4	42.4	75	76.4	42.4	86	87.6	48.66	130	132.4	73.5
3	70	59.4	70	71.3	39.6	77	78.4	43.5	80	81.5	45.2	120	122.2	67.9
4	70	59.4	70	71.3	39.6	80	81.5	45.2	103	104.9	58.34	110	112.0	62.2
5	70	59.4	70	71.3	39.6	90	91.7	50.9	80	81.5	45.2	130	132.4	73.5
6	70	59.4	77	78.4	43.5	80	81.5	45.2	90	91.7	50.95	120	122.2	67.9
7	70	59.4	77	78.4	43.5	95	96.8	53.7	110	112.0	62.2	140	142.6	79.2
8	69	58.5	78	79.4	41.1	90	91.7	50.9	110	112.0	62.2	135	137.5	76.4
9	70	59.4	80	81.5	45.2	80	81.5	45.2	100	101.9	56.6	140	142.6	79.2
Mean	69.	59.2	75	76.4	42.4	84.1	85.7	47.6	95.	97.2	54.0	130.	133.0	73.9

Transversal internal cohesion

Table 4 shows the results obtained following determination of internal bond strength of the board. It can be seen that these tests highlight the internal bond of the component layers of the composite material and show the superiority of the veneer faced panels. The results obtained confirm good internal cohesion between the layers of the panel, both between the core strakes and the veneer faces, and HDF.

Table 4

Tensile strength perpendicular to the plane of the board

No	Chipboard		Venered blockboard		HDF blockboard	
	daN	kgf/cm2	daN	kgf/cm2	daN	Kgf/cm2
1	112	45.612	200	81.52	180	73.768
2	120	48.912	325	132.47	190	77.444
3	96	39.1296	270	110.052	187	76.2212
4	110	44.836	310	126.356	165	67.254
5	85	34.646	290	118.204	187	76.2212
6	118	48.0968	302	123.0952	176	71.7376
7	105	42.798	289	117.7964	158	64.4008
8	110	44.836	305	124.318	167	68.0692
9	92	37.4992	287	116.9812	174	70.9224
Media	105.333	42.933	286.444	116.754	176	71.7376

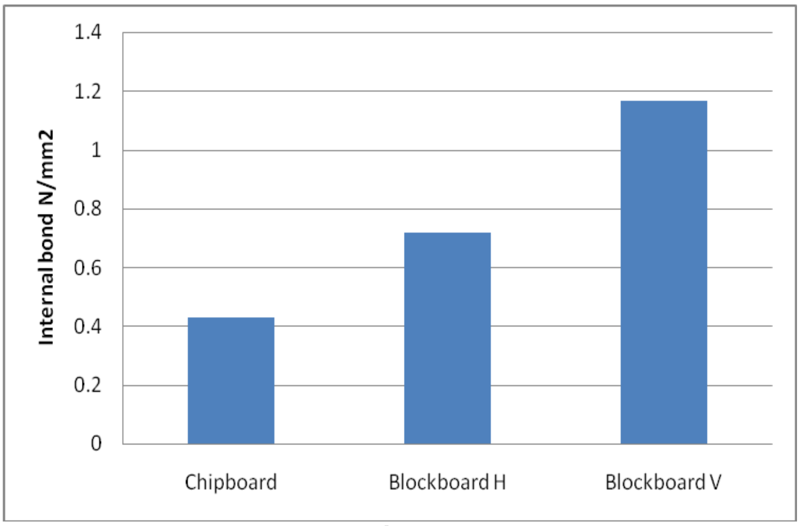

Fig. 8
Comparative values of the tensile strength perpendicular to the plane of the board.

Water absorption and thickness swelling

As regards dimensional stability that depends on density and humidity, the results obtained are shown in Table 5. It can be seen that after a period of immersion of the test samples in water, they changed their volume, weight and density changed. The highest dimensional stability was found with the test samples made of HDF faced panels, followed by those with veneered faces and finally, the PB. These experimental results confirm that both the HDF faced panels, as well as the veneer faced panels have a better performance in a humid environment, compared to the traditional PB boards.

Table 5

The parameters of the test samples before water immersion

PAL 12				PAL 18			PAF 18			PAH 18		
Sample	V (m^3)	m (g)	ρ kg/m^3	V (m^3)	m (g)	ρ kg/m^3	V (m^3)	m (g)	ρ kg/m^3	V (m^3)	G (g)	ρ kg/m^3
1	0.0000306	17.44	569.9	0.000045	28.18	626.2	0.000043	20.97	487.6	0.000044	25.8	587.2
2	0.000031	17.68	570.3	0.000043	27.89	648.6	0.000042	25.52	607.6	0.000043	24.4	568.3
3	0.00003	17.41	580.3	0.000042	27.99	666.4	0.000044	17.42	395.9	0.000041	24.5	599.2
4	0.000029	17.35	598.2	0.000043	28.05	652.3	0.000043	18.75	436.0	0.000042	26.5	632.1
5	0.00003	17.52	584	0.000041	28.41	692.9	0.000042	17.96	427.6	0.000044	25.3	575.6
6	0.000029	17.4	603.1	0.000043	28.4	661.1	0.000043	17.59	409.0	0.000045	30.67	681.5
7	0.00003	17.3	577	0.000044	28.2	642.7	0.00044	17.33	393.8	0.000043	25.8	600
8	0.000028	17.4	623.5	0.000043	27.9	650.2	0.000045	18.11	402.4	0.000044	25.74	585
9	0.00003	17.3	579	0.000044	28.1	638.6	0.000041	18.16	442.9	0.000041	25.5	621.9
Mean		17.4	587.2		28.1	653.2	0.000043	19.09	444.7	0.000043	26.04889	605.6

Table 6

The parameters of the test samples after water immersion

Chipboard 12				Chipboard 18			Veneered blockboard 18			HDF blockboard		
Sample	V (m3)	G (g)	P kg/m^3	V (m^3)	G (g)	P (kg/m^3)	V (m^3)	G (g)	P (kg/m^3)	V (m^3)	G (g)	P (kg/m^3)
1	0.000036	31.2	866.6	0.000052	39.6	762.5	0.000048	28.07	584.7	0.000049	30.2	617.9
2	0.000033	32.12	973.3	0.000051	38.7	758.8	0.000044	28.6	650	0.00005	31.2	624.2
3	0.000035	33.2	948.5	0.000049	39.4	804.6	0.000043	27.9	648.8	0.000048	39.9	832.9
4	0.000036	33.1	919.4	0.000048	38.4	800.8	0.000049	28.54	582.4	0.000047	30.7	654.4
5	0.000034	32.5	555.8	0.000051	39.4	772.7	0.000039	28.30	725.6	0.000049	29.7	607.1
6	0.000035	32.75	935.7	0.000054	38.2	708.3	0.000042	27.91	664.5	0.000045	30.6	681.1
7	0.000033	33.21	1006.3	0.00005	37.9	759.6	0.000044	28.71	652.5	0.000048	28.9	660.2
8	0.000035	32.75	935.7	0.000048	39.4	821.2	0.000045	28.43	631.7	0.000047	29.7	633.1
9	0.000034	33.76	992.9	0.000051	38.2	749.4	0.000041	38.21	684.0	0.000048	30.4	633.9
Mean		32.732	948.2		38.8	770.9		28.2	647.6		31.6	659.9

Resistance to screw withdrawal

The experimental data on screw withdrawal is showed in Table 7 and Fig. 9. It can be seen that the higher resistance is obtained by the test samples made of HDF faced panels, followed by the one with veneered faces, and in the last place, the PB.

Table 7

Resistance to screw withdrawal

	Chipboard		Veneered Bolockboard		Blockboard with HDF faces	
Sample	Force, daN	Strength,kgf/cm	Force, daN	Strength, Kgf/cm	Force, daN	Strength, Kgf/cm
1	116	65.66889	171	96.805	195	110.3917
2	135	76.425	205	116.0528	165	93.40833
3	180	101.9	166	93.97444	170	96.23889
4	125	70.76389	153	86.615	195	110.3917
5	152	86.04889	172	97.37111	210	118.8833
6	143	80.95389	186	105.2967	204	115.4867
7	137	77.55722	192	108.6933	193	109.2594
8	164	92.84222	175	99.06944	187	105.8628
9	128	72.46222	189	106.995	206	116.6189
Mean	142.222	80.513	178.777	101.208	191.666	108.504

Fig. 9 shows a graphical representation of the resistance to screw withdrawal of different test samples, namely chipboards, HDF faced panels and veneer faced panels, to compare the two categories of wood composites.

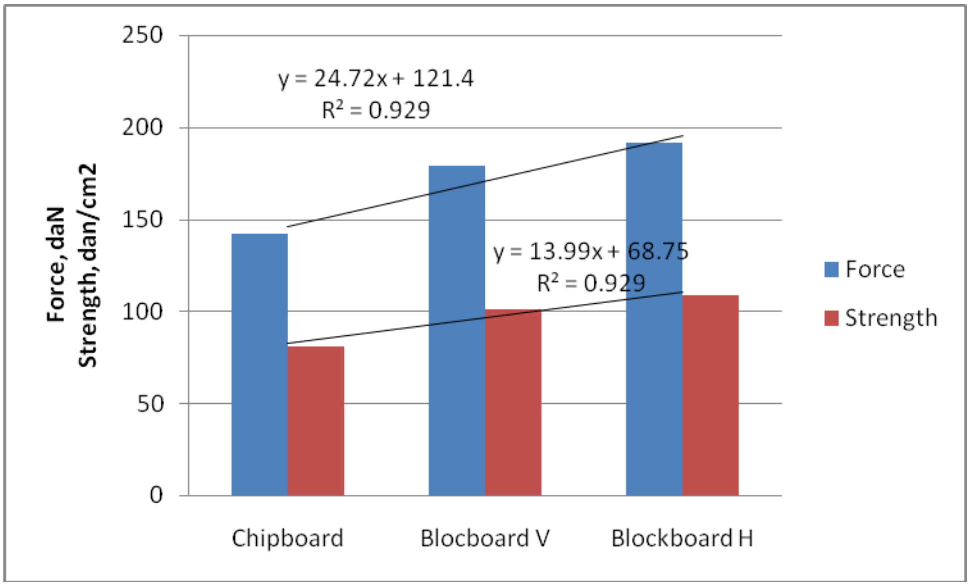

Fig. 9.
Graphical representation of resistance to screw withdrawal.

CONCLUSIONS

Following the experimental tests performed, the following were concluded:

- a good performance of the HDF faced panels to humid environment in comparison with chipboards;
- internal cohesion of the layers forming the veneered panel was superior to the HDF panels and chipboards;
- resistance to penetration of the HDF panel is better than chipboards or veneered blockboard;
- good resistance to breaking through static bending was achieved by test samples when the veneer are longitudinally oriented, parallel with the core strakes;
- good mechanical resistance highlighted by the experimental tests make from blockboard a competitive material for a large range of performance use, this being a successful replacer of many traditional materials existing currently.

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REFERENCES

Belleville B, Segovia C, Pizzi A, Stevanovic T, Cloutier A (2011) Wood Block-boards Fabricated by Rotational Dowel Welding, Journal of Adhesion Science and Technology 25:2745–2753, DOI: 10.1163/016942410X537323.

Bowyer JL, Stokke D (1982) The effect of core block length on strength of face-glued blockboard, Wood and Fiber Science 1:60-69.

ESB, Nantes-France (2016) Testing Panels Products, https://www.ecoledubois.fr/.

Lunguleasa A (2012) Composites obtained by lamination, Transilvania Print House of Brasov

Thoemen H, Irle M, Sernek M (2010) Wood-based panels. An introduction for specialists, Edited by Brunel University Press.

Wulf M (1997) Investigation of the wetting characteristics of MDF by means of contact angle measurements, HolzRoh-Werkst,vol.55:331-33.

Yongquist JA (1987) Wood based composites: The panel and building components of the future. Proceedings of the IUFRO, pp. 5-22.

Yongquist JA, Krzysik AM (1993) Properties of wood and polymer fiber composites, Wood-Fiber/Polymer Composites, pp.79-88.

Youngquist JA (2011) Wood-based Composites and Panel Products, Chapter 10, https://www.drjengineering.org/sites/default/files/uploads/attachments/field_collection/563/fpl_wood_handbook_ch10.pdf.

Zeleniuc O (2016) Materials used in wood industry, Course, Transilvania Print House of Brasov.