CHARACTERIZATION TESTS FOR INSULATION BOARDS MADE FROM CORN COB AND NATURAL GLUES

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Materials: Boards of corn cob and natural glues with different compositions (type of glue, particle size of corn cob and features of the pressing process)

Boards id.	Type of glue	Particle size (mm)	Type of pressing	Time of pressing	Fibers
C8_c8	Casein	2,38 - 4,76	Cold	8 h	-
C8_c4				4 h	
C4_c8		4,76 - 9,52		8 h	
C4_c4				4 h	
C4_c4_f1/2					1/2 thickness
C4_c4_f1/3					1/3 thickness
Cmg_c4_f1/2		4,76 - 19,1			1/2 thickness
Cmf_c4_f1/2		0 - 4,76			
F8_h0.5	Wheat flour	2,38 - 4,76	Hot	7,5 min (increasing 10°C/min) + 30 min to 105°C + 7 min to 60°C	-
FH_38_c4	Wheat flour + sodium hydroxide		Cold	4 h	
FH_34_c4		4,76 - 9,52			
FH_38_c4_f1/2		2,38 - 4,76			1/2 thickness
FH_34_c4_f1/2		4,76 - 9,52			
FH_3mg_c4_f1/2		4,76 - 19,1			
FH_3mf_c4_f1/2		0 - 4,76			
FEV8_h0.5	Wheat flour + egg white + vinegar	2,38 - 4,76	Hot	7,5 min (increasing 10°C/min) + 30 min to 105°C + 7 min to 60°C	-
FEV8_c4			Cold	4 h	
$FEVH_68$_c4	Wheat flour + egg white + vinegar + sodium hydroxide				
$FEVH_38$_c4			Cold		
$FEVH_34$_c4		4,76 - 9,52			
$FEVH_34$_c4_f1/2					1/2 thickness
$FEVH_34$_c4_f1/3					1/3 thickness
$FEVH_3$mg_c4_f1/2		4,76 - 19,1			1/2 thickness
$FEVH_3$mf_c4_f1/2		0 - 4,76			

Physical and mechanical characterization: thermal conductivity (λ) with a ISOMET 2104 and a 60 mm diameter contact probe (Fig. 1), density (ρ) based on EN 1602:2013, surface hardness (SH) with a PCE Shore A durometer (Fig. 2), surface resistance (SR) with a PROCEQ PT pendular sclerometer (Fig. 3), dynamic modulus of elasticity (E_d) with a Zeus Resonance Meter equipment (Fig. 4) based on NP EN 14146:2006, bending (σ) based on EN 12089:2013, compression strength (σ_{10}) based on EN 826:2013 and resilience (R) based on EN 1094-1:2008, with a Zwick Rowell bending equipment with 2 kN and 50 kN load cells (Fig. 5), and water vapour permeability (δ) based on EN 12086:2013


Figure 1


Figure 2


Figure 3


Figure 4

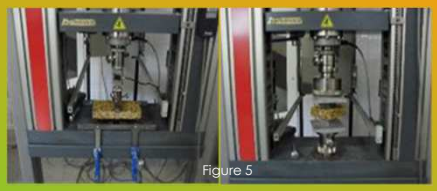
Figure 5

C8_c8, C8_c4, F8_h0.5, FEV8_h0.5 and $FEVH_68$_c4 showed the best results (table 1).

The board with the best characteristics is made with wheat flour glue, egg white and sodium hydroxide, particle size 2,38-4,76 mm and cold pressing for 4 hours

Table 1: Characteristics of best boards

Boards id.	λ [W/m.°C]	ρ [kg/m³]	SH [Shore A]	SR [graus Vickers]	σ [kPa]	σ_{10} [kPa]	R [%]	E_d [MPa]	δ [mg/m.h.Pa]
C8_c8	0,115	484	49	70	591	1521	80	252	0,07
C8_c4	0,108	486	62	70	566	1504	81	308	0,08
F8_h0.5	0,122	557	75	70	757	933	74	430	0,09
FEV8_h0.5	0,115	520	72	73	697	1044	87	527	0,11
$FEVH_68$_c4	**0,114**	**502**	**49**	**65**	**1043**	**1690**	**68**	**453**	**0,09**

Table 2: Comparison between the board with corn cob and natural glue that presented better results and traditional insulation materials

Insulation boards	$FEVH_68$_c4	ICB	XPS	EPS	Rockwool
Thickness (mm)	31	10 a 300	30 e 40	20 a 100	30 a 100
ρ (kg/m³)	502	110 a 120	30	20	145
λ (W/m.°C)	0,114	0,037 a 0,040	0,035	0,036	0,038
δ (mg/m.h.Pa)	0,09	0,015 a 0,045	0,004 a 0,009	0,009 a 0,020	0,400
σ (kPa)	1043	≥ 130	-	150	-
σ_{10} (kPa)	1690	≥ 110	200	100	≥ 45
Technical details	-	Sofalca	Wallmate / Floormate - Dow	CIN	CIN

$FEVH_68$_c4 *versus* traditional insulation materials (table 2)

- Density and thermal conductivity is higher but the product is still under study, non-industrialized, so those characteristics can be further improved (eg. reducing the amount of glue)
- Water vapor permeability is higher (essential for the quality of indoor air and to avoid condensation)
- Bending and compression behavior is higher (great benefit when applied, for example, on floors soundproofing and reinforcing layer, in addition to thermal)
- Reduced environmental impact as the corn cob is an agricultural residue and the glue is natural

Conclusions: These boards have potential as a thermal and, eventually, acoustic insulation material, to use as coating or intermediate layer on walls, floors or false ceilings. The integrity of these boards seems to be maintained even in higher humidity environments. However, due to biological susceptibility and sensitivity to water, they would be more adequate for application in dry indoor conditions. When compared with traditional insulation materials the use of these boards in building permits to incorporate low embodied energy, contributing for the eco-efficiency of construction