CHARACTERIZATION OF INSULATION CORKBOARD OBTAINED FROM DEMOLITIONS

L. GIL*, P. SILVA

Laboratório Nacional de Energia e Geologia I.P., Unidade de Engenharia de Produto,
Edifício C, 1649-038 Lisboa, Portugal
* luis.gil@lneg.pt

ABSTRACT: This work shows details from the demolition of the cold chambers of DOCAPESCA (one of the biggest European companies working in the fishing industry) near Lisbon, in Portugal, namely related with the insulation corkboard (ICB). ICB is a product made of granules of cork which are expanded (steam-backed) in autoclaves and agglomerated together by pressure and temperature (>300ºC) without any exogenous glue. Samples were collected and tests were carried out with ICB obtained from this demolition (after 41 years in use) to verify some characteristics in order to compare these with ICB specifications. The conclusion is that, after several decades of intensive use, ICB shows a thermal behavior better than the specified limit for ICB in relevant standards.

Keywords: Insulation corkboard; demolition; recycling; thermal behavior

RESUMO: Neste trabalho são apresentados aspectos da demolição das câmaras frigoríficas da DOCAPESCA (uma das maiores empresas europeias da indústria das pescas), próximo de Lisboa, em Portugal, nomeadamente aspectos relacionados com o aglomerado expandido de cortiça (ICB, da sigla em inglês). O ICB é um produto produzido a partir de grânulos de cortiça que são expandidos (vapor sobreaquecido) em autoclaves e aglomerados en«m conjunto através da acção da pressão e da temperatura (>300ºC) sem qualquer cola externa. As amostras foram recolhidas e foram realizados testes com ICB obtido desta demolição (após 41 anos de utilização) para verificar algumas características de modo a compará-las com as especificadas para o ICB. A conclusão é a de que o ICB apresenta um comportamento térmico melhor do que o especificado para este material em normas relevantes.

Palavras-chave: Aglomerado expandido de cortiça; demolição; reciclagem; comportamento térmico

1. INTRODUCTION

The insulation corkboard (ICB) is an agglomerated material exclusively made of cork granules (mainly from winter virgin cork) of a larger size (usually 5-20 mm) than those used in composition cork. The granules are bonded by their own resins in molds defined by the autoclave walls. The granules are placed into an autoclave that also functions like a mold, undergo light compression and then steaming occurs at more than 300ºC, usually between 17 to 30 minutes. The superheated steam passes through the granule mass resulting in the secretion of the cork resins to the granules' surfaces and in an increase in its volume, which by being confined to an autoclave, determines their agglutination. The granules are compressed against each other and in the boundaries the cells collapse and bind. The blocks formed are then cut into planks which are then finished (usually by sanding) as required. ICB is a completely natural product since its agglomeration process is due to the cork natural resins and to the granules expansion, without using any glues or additives or other materials than cork [1].

The characteristics of ICB, according to the NP EN 13170:2001 standard are:

Apparent density	≤ 130 kg.m^{-3}
Thermal conductivity coefficient	≤ 0.045 W.m^{-1}.K^{-1};
Compression to 10% deformation	≥ 100 kPa
Bending strength	≥ 130 kPa
Tensile strength	≥ 50 kPa

DOCAPESCA [2] is one of the biggest European companies working in the fishing industry and it is a state-owned company that manages fishing port facilities and first sale fish markets all over Portugal. They have local headquarters in all the major ports and in the Lisbon area (Pedrouços) where is the demolition site. The cold stores (overall capacity of 62 000 m^3, prepared for hundreds of tons of fish daily) for frozen fish products, include a big chamber for common storage and 16 smaller chambers for private storage. These buildings were initially built in the end of the 50's and rebuilt in 1970, so the collected ICB was used for 41 years. The demolition work (carried out by the company Demotri S.A.) started in March 2011, and ICB samples were obtained in the end of March. The area is going to be re-qualified by Administração do Porto de Lisboa S.A. for the event Volvo Ocean Race in 2012.

Fig. 1. Aerial view of the demolition site with buildings for demolition in white (left corner of the dock).

Fig. 2. Detail of two of the small cold chambers before demolition (the first with ICB protected by wood; the second with painted ICB).

Fig. 3. Detail of ICB behind the wood paneling protection (wall insulation).

Fig. 4. Cooling pipes with ICB insulation before demolition.

The total amount of ICB obtained by demolition is going to be quantified, collected by an integrated waste management company and sent to ICB production companies where, after separation of impurities and grinding, it is going to be used to produce re-granulated expanded cork e.g. for light weight concrete.

Fig. 5. Detail of the wall of one of the big cold chambers (reinforced concrete, asphalt sheet, two ICB layers (15+10 cm) and covering).

Fig. 6. Operation for the removal of ICB from the cold chambers walls.

2. MATERIALS AND METHODS

Two samples were selected and collected, the sample A from the insulation of an interior cold corridor (for product transportation), 1 layer with a thickness of 15 cm and the sample B from cold storage chamber, two layers of 15 cm + 10 cm.

Fig. 7. Sample A for ICB testing.

Fig. 8. Sample B for ICB testing.

Before testing all the samples were conditioned to 23±2ºC and 50±5% of relative humidity for at least 48 hours. Five tests specimens were used for each test.

The thermal conductivity coefficient (λ) was measured using the fluximeter method using an ANACON TCA 8 equipment – hot plate (37.7ºC), cold plate (10ºC) (θ_m = 23.8ºC). The equipment was initially calibrated. The mechanical tests were carried out in an INSTRON equipment, model 4467, with a load cell of 5 kN and a precision of 0.1 N. All the mechanical tests were carried out at a room temperature of 23ºC.

The several tests were carried out accordingly to the relevant standards as follows:

Apparent density – NP EN 1602: 1998
Thermal conductivity – ISO 8301:1991 (150×150 mm)
Bending strength – NP EN 12089:1997 (175×150×25 mm) (10 mm/min)
Compression behavior (10% deformation) – NP EN 826:1996 (100×100×50 mm) (5 mm/min)
Tensile strength – NP EN 1607:1998 (50×50×50 mm) (10 mm/min)

3. RESULTS

The results of the different physico-mechanical tests of ICB demolition samples are shown in the following Tables and graphics.

Table 1. Apparent density of sample A.

Nº	Reference	($kg.m^{-3}$)	
1	A1	105.28	
2	A2	94.45	
3	A3	100.57	
4	A4	110.31	
5	A5	99.37	
		Average	102.00
		Standard Deviation	4.63

Table 2. Apparent density of sample B.

Nº	Reference	($kg.m^{-3}$)	
1	B1	139.14	
2	B2	133.68	
3	B3	127.70	
4	B4	130.11	
5	B5	125.17	
		Average	131.16
		Standard Deviation	4.20

Table 3. Thermal conductivity coefficient of sample A.

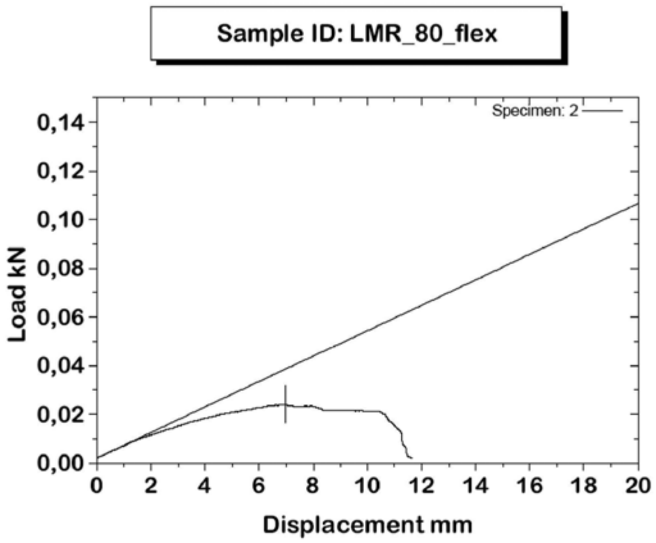
Nº	Reference	λ (W.m^{-1}.K^{-1})	
1	A1	0.0402	
2	A2	0.0375	
3	A3	0.0386	
4	A4	0.0395	
5	A5	0.0382	
		Average	0.0388
		Standard Deviation	0.0008

Table 4. Thermal conductivity coefficient of sample B.

Nº	Reference	λ (W.m^{-1}.K^{-1})	
1	B1	0.0411	
2	B2	0.0404	
3	B3	0.0408	
4	B4	0.0407	
5	B5	0.0405	
		Average	0.0407
		Standard Deviation	0.0002

Table 5. Bending strength (sample A)

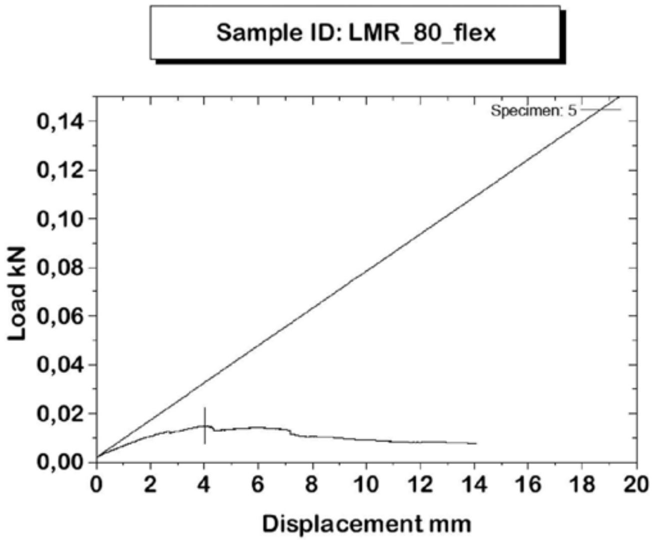
Nº	Reference	Dimensions (mm)		L - length	Fm	σm
		b - width	d - thickness	(mm)	(N)	(kPa)
1	A1	46	23	115	26.31	186.51
2	A2	46	22	110	25.51	189.06
3	A3	46	22	110	24.03	178.09
4	A4	46	22	110	22.96	170.16
5	A5	46	22	110	29.13	215.88
				Average		**187.94**
				Standard Deviation		**17.30**



Graphic 1. Bending behavior of one of the test specimens (Nº 2) of sample A.

Table 6. Bending strength (sample B)

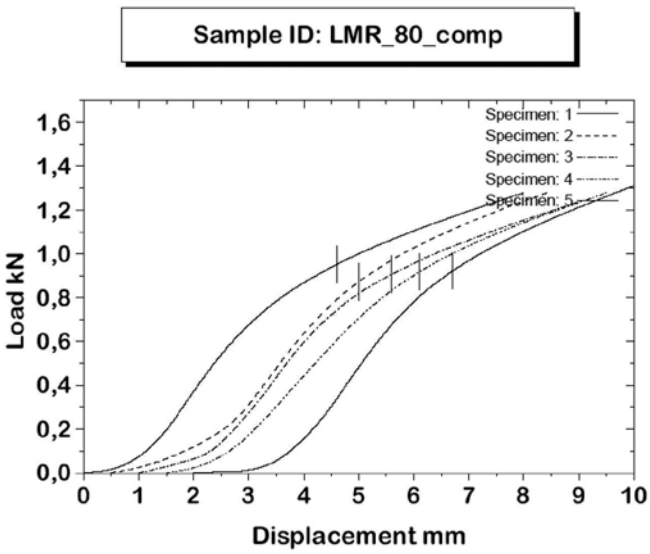
Nº	Reference	Dimensions (mm)		L - length	Fm	σm
		b - width	d - thickness	(mm)	(N)	(kPa)
1	B1	46	23	110	14.90	110.42
2	B2	49	22	110	16.11	112.08
3	B3	47	21	105	16.52	125.53
4	B4	47	22	110	15.98	115.91
5	B5	46	21	105	13.16	102.17
				Average		**113.22**
				Standard Deviation		**8.51**



Graphic 2. Bending behavior of one of the test specimens (Nº 2) of sample B.

Table 7. Compression behavior (10% deformation) (sample A)

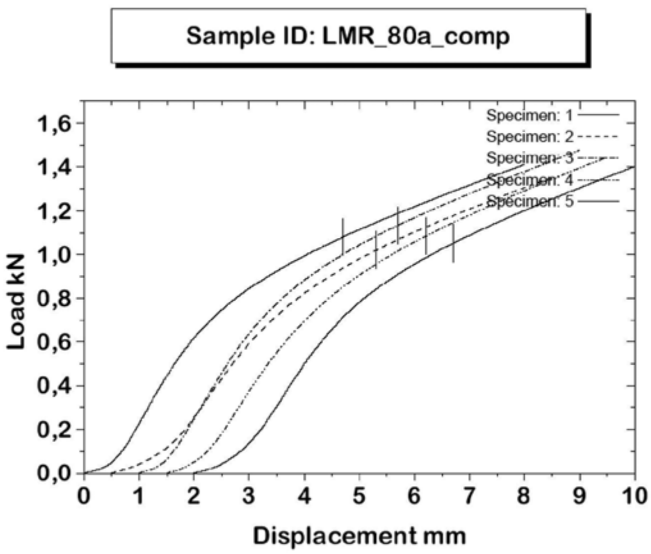
Nº	Reference	Dimensions (mm)			A_0 (mm^2)	σ_{10} (kPa)
		c - length	l - width	d - thickness		
1	A1	100	100	46	10000	95.25
2	A2	105	96	46	10080	86.56
3	A3	100	97	46	9700	93.56
4	A4	104	100	46	10400	88.31
5	A5	105	100	47	10500	87.80
				Average		**90.30**
				Standard Deviation		**3.85**



Graphic 3. Compression behavior of sample A.

Table 8. Compression behavior (10% deformation) (sample B)

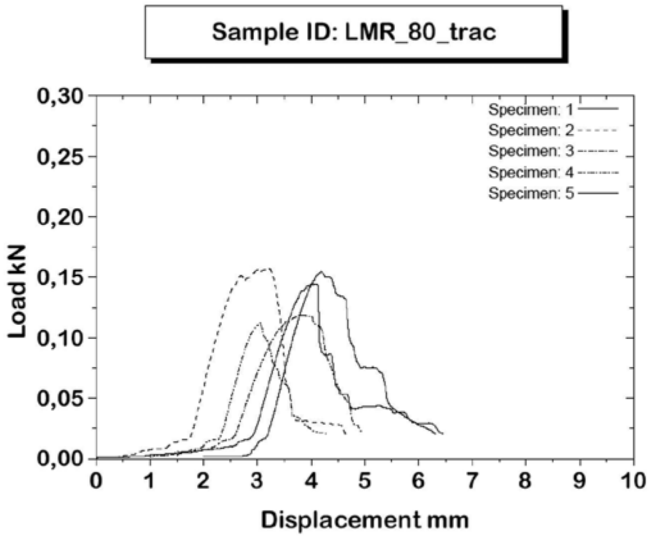
Nº	Reference	Dimensions (mm)			A_0	σ_{10}
		c - length	l - width	d - thickness	(mm²)	(kPa)
1	B1	100	98	47	9800	110.20
2	B2	100	100	48	10000	102.03
3	B3	100	99	47	9900	114.56
4	B4	100	99	47	9900	109.58
5	B5	100	99	47	9900	106.25
				Average		**108.52**
				Standard Deviation		**4.68**



Graphic 4. Compression behavior of sample B.

Table 9. Tensile strength (sample A)

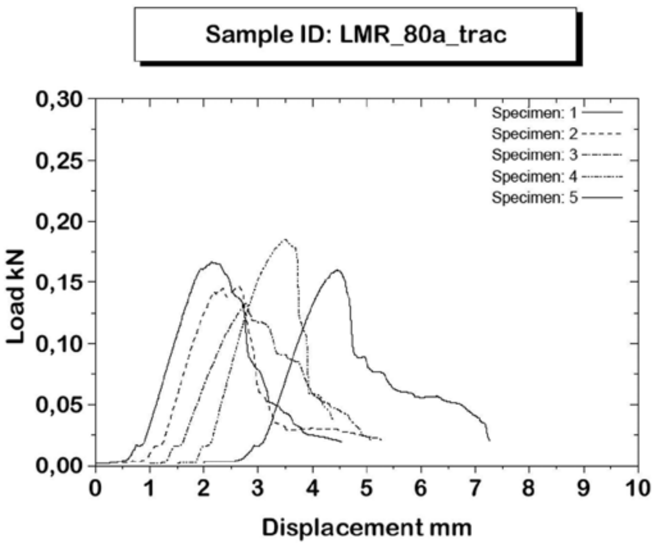
Nº	Reference	Dimensions (mm)		A	F_m	σ_{mt}
		l - length	b - width	(mm²)	(N)	(kPa)
1	A1	49	54	2646	167.10	63.15
2	A2	48	45	2160	146.60	67.87
3	A3	51	44	2244	132.60	59.09
4	A4	49	45	2205	185.60	84.17
5	A5	50	45	2250	160.70	71.42
				Average		**69.14**
				Standard Deviation		**9.61**



Graphic 5. Tensile behavior of sample A.

Table 10. Tensile strength (sample B)

Nº	Reference	Dimensions (mm)		A	F_m	σ'_{mt}
		l - length	b - width	(mm²)	(N)	(kPa)
1	B1	48	48	2304	144.20	62.59
2	B2	48	48	2304	158.00	68.58
3	B3	49	50	2450	118.80	48.49
4	B4	48	48	2304	112.60	48.87
5	B5	46	47	2162	155.30	71.83
				Average		**60.07**
				Standard Deviation		**10.92**



Graphic 6. Tensile behavior of sample B.

4. DISCUSSION

To simplify the discussion the summary of the results is shown in the next table.

Table 11. Summary of the results (average and standard deviation of 5 test specimens)

Sample	A	B
Apparent density (kg.m^{-3})	102.00 ± 4.63	131.16 ± 4.20
Thermal conductivity coefficient (W.m^{-1}.K^{-1})	0,0388 ± 0,0008	0.0407 ± 0.0002
Bending strength (kPa)	187.94 ± 17.30	113.22 ± 8.51
Compression behavior (10% deformation) (kPa)	90.30 ± 3.85	108.52 ± 4,68
Tensile strength (kPa)	69.14 ± 9.61	60.07 ± 10.92

These results should be compared with those from NP EN 13170:2001 standard referred above. This comparison shows us that the apparent density of sample A is much lower than the standard value and for sample B is just slightly higher than the maximum specified value. Both thermal conductivity coefficients (samples A and B) are much lower than the standard limit value. Also the tensile strength values for both samples are according to the relevant standard. The bending strength and compression behavior of samples A and B show values which are not conclusive. Nevertheless, for this kind of application of ICB the thermal insulation behavior is the most important parameter and the results are excellent.

Other way of comparison is to use the equation for ICB thermal conductivity [1],[3] defined for the range 120-350 Kg.m^{-3}:

$$\lambda = (220 + 1{,}36\ ) \text{ X } 10^{-4} \text{ W.m}^{-1}.\text{K}^{-1}$$

Using the average values of apparent density and the equation above, we obtain a thermal conductivity coefficient for samples A and B, respectively of 0.0359 W.m^{-1}.K^{-1} and 0.0398 W.m^{-1}.K^{-1} values which are not very far away from the real ones. It must be stressed that sample A is out of the range of apparent density defined for the equation.

The tests were the most representative and the most used for ICB and other similar materials, but as a reference for further work, other tests will be done in the future, such as dimensional stability (e.g. NP EN 1603:1998; NP EN 1604:1998), water absorption (e.g. NP EN 1609:1998), water vapor transmission (e.g. NP EN 12086:1995), shear strength (e.g. NP EN 12090:1997) or even behavior in boiling water (e.g. NP 604:1995).

According to unpublished test results, the ICB carbon content is 64.6% (w/w), and so in 1 kg of ICB, carbon corresponds to 0.646 kg. As previously reported in [4], [5], we know that the mass ratio of CO_2/C is 3.664. Knowing this1 kg of ICB corresponds to 2.367 kg of CO_2.

The estimated quantity of ICB removed from this demolition, according to information of the demolition company is around 700 tons. This material was collected by an integrated waste management company and it is going to be sent to ICB production companies for re-granulation and the production of re-granulated expanded cork, to be used for the production of light concrete, increasing enormously in time the sequestration of the equivalent CO_2. Using the calculations of the last paragraph, this quantity corresponds to more than 1650 tons of CO_2.

5. CONCLUSIONS

It can be concluded that, after several decades of intensive use, ICB shows a thermal behavior better than the specified for ICB in relevant standards. Regarding the characteristics of apparent density, bending strength, compression behavior and tensile strength most of them respect the standard values. The insulation behavior of the demolition samples is in line with previous results with ICB from other demolition sources [6], [7] and it is a proof of ICB durability.

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