WP3 TR3.2.1. Acoustic Analysis

ACOUSTIC ANALYSIS REPORT OF IMIP PANELS, ACTIVITY 3.2.1.

IMIP-SOE3/P3/E0963
Project funded by the Interreg Sudoe programme through the European Regional Development Funds (ERDF)

PROJECT CONTEXT

Project acronym	IMIP
Project title	Innovative Eco-Construction System Based on Interlocking Modular Insulation Wood & Cork-Based Panels
Project code	SOE3/P3/E0963
Coordinator	Universitat Politècnica de València (UPV), Instituto ITACA
Duration	1 May 2020 – 31 January 2023 (33 months)
Working Package (WP)	WP3. 3.2.1
Deliverable	TR5.1.1
Summary	The deliverable includes the structure, responsibilities and procedure of the different management bodies created, both for the correct technical, communication and financial monitoring.
Delivery date	05/2023
WP Leader	FCBA
Activity coordinator	FCBA
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CONTENT

CONTENT I

INTRODUCTION 1

PRINCIPLES 3

OBJETIVES 3

MATERIALS; CHARACTERISTICS AND SPECIFICATIONS. 4

Timber in panels type A, B, C and D: 4
OSB 3 in panels type B: 4
Natural Cork in panels type A, B, C, D: 4

COMPOSITION OF THE PANELS MATERIALS 5

Panels Type A and C 5
Panels Type B 5
Panels Type D 6
Panels Type A, B, C, D 6

BASIS OF TESTS AND CALCULATIONS 7

CALCULATION METHODS 8

BERGER'S MASS LAW 11
ACOUSTIC PERFORMANCES OF THE IMIP PANELS 14
CLT 45mm 14
CLT 60 mm 15
CLT 100 mm 16
Insulation Panels 17
Type A 19
Type B 20
Type C 21
Type D 23

CONCLUSIONS 24

BIBLIOGRAPHY 25

INTRODUCTION

The work is contemplated in the IMIP project of the INTERREG SUDOE Program, within Working Group 3: GT3 Prototype testing. Activity 3.2 Acoustic isolation analysis.

These works focus on the acoustic design of the panels and interconnected modules.
This report studies the IMIP systems and the materials that use natural cork and wood as raw materials in the panels.

The purpose of this report is to describe acoustic performances of the parts and the interlocking panels for private and public buildings, and its description.

The study is carried out within the scope of the Interreg Sudoe territories and we will focus more specifically on Portugal, France and Spain.

Table 1: Programme and Project objectives and results.

Programme specific objective	To improve energy efficiency policies in public buildings and homes through the implementation of networks and joint experimentation.
Project main objective	To support the change towards a low carbon economy using bioproducts (wood and cork) for smart, sustainable, and inclusive growth with a special focus on the public construction sector.
Project specific objectives	To design, validate and implement a new ecological construction system to improve energy efficiency in public buildings. Related activities are: - To design an ecological construction system based on innovative wood and cork products supporting a low carbon economy, - To test prototypes, - To develop an Information and Communication Technology for design, modelling, and evaluation of potential construction solutions, - To compare the modular and interconnected insulating panels designed with currently used insulating panels, - To disseminate results and to train prescribers.
Programme result indicator	Percentage of actors in the energy efficiency sector participating in transnational cooperation projects.
Project results	An interconnected modular system of insulating panels made of wood and cork to improve energy efficiency of buildings, including their entire life cycle. A BIM plug-in to analyse the environmental benefits of bioproducts used in construction (carbon storage and substitute effect).

PRINCIPLES

One of the principal intentions of the IMIP project was, to design an innovative eco-construction system based on interlocking modular insulation wood & cork-based panels, and verify the feasibility of the proposals both in interventions on public and private buildings and in new construction works like so rehabilitation or expansion of buildings.

This project focuses on advancing in solutions that help make a transition towards sustainability in a sector with as much environmental impact as the construction one, generating technical, environmental and socio-economic benefits for smart, sustainable and inclusive growth, through the implementation of networks and experimentation joint.

OBJETIVES

The acoustic isolation report will give the performance of different levels of modules tested and will predict performance of new or rehabilitated buildings.
The aim of the present technical report is to validate the load capacity for four different panels due to acoustic performances.

WP3 2.2.1 is an acoustic analysis of IMIP PANELS, describing the materials, the characteristics of the panels and the acoustic capacity of the panels.

MATERIALS; CHARACTERISTICS AND SPECIFICATIONS.

The materials used for the construction of the beams and the 60mm CLT Cross Laminated Timber, which form the type A and C panels, are "Pinus uncinata" usually known as “black pine". In type B and D panels, the "Pinus Pinaster" usually known as "maritim pine" has been used. The density of this type of timber has been determined in 470 Kg/m3.
Usually the "Pinus Pinaster" used for panels D and B is a lower quality pine and is usually classified as C16 and the "Pinus uncinata" has a better quality and can be compared to a C18 or C20. The panels finally constructed, with the data obtained from the visual classification and the tests, have been determined in both cases to have a C18 classification and 500 Kg/m3 of density.

Timber in panels type A, B, C and D:

The type of wood used to validate the tests is a coniferous wood C18. Its most relevant characteristics, which have been considered in the calculation, are the following:
Definition and characteristics of coniferous sawn wood defined in the UNE-EN 338:2016.

OSB 3 in panels type B:

The main characteristics of the OSB 3 panel, density 650 kg/m3. UNE-EN 300:2007.

Natural Cork in panels type A, B, C, D:

The main characteristics of the natural cork, is the insulation with a medium Density: of 150 kg/m3 and a thermal conductivity of 0,13 W/mK. UNE 56-906-74; UNE 92-202-89.

COMPOSITION OF THE PANELS MATERIALS

Panels Type A and C

CLT 60
pinus uncinata C18, C20

3 layers:	e=60 mm 3x20mm
Board dimension:	6000mm x 120mm
Density:	520 kg/m3
Bending modulus:	9000 N/mm2
Transversal module:	560 N/mm2
Moisture content:	10% a 12%
Thermal conductivity:	0,13 W/mK
Sound propagation velocity in clt:	1500 m/2

OSB 3

1 layer:	e=9 mm
Board dimension:	2500mm x 1000mm
Density:	600 kg/m3
Bending modulus:	5600 N/mm2
Transversal module:	2700 N/mm2
Moisture content:	2% to 12%
Thermal conductivity OSB:	0,13 W/mK
Reaction to fire OSB board:	Euroclass D

(Without fire retardant treatment, their standardized reaction to fire Euroclass values without the need for testing are standardized varying from: D-s2, d0 a D-s2, d2 y Dfl-s1 a E; Efl)

Panels Type B

CLT 45mm
pinus pinaster C16, C18
OSB 3

2 layers; pinus glued boards	e=18 mm
1 layers: OSB 3 board	e=9mm
Board dimension:	2500mm x 1000mm
Density:	470 kg/m3
Bending modulus:	9000 N/mm2
Transversal module:	560 N/mm2
Moisture content:	10% a 12%
Thermal conductivity:	0,13 W/mK
Sound propagation velocity in clt:	1500 m/2

Panels Type D

CLT 100:	
pinus pinaster C16, C18	
5 layers;	e=100 mm
Board dimension:	6000mm x 1200mm
Density:	500 kg/m3
Bending modulus:	9000 N/mm2
Transversal module:	560 N/mm2
Moisture content:	10% a 12%
Thermal conductivity:	0,13 W/mK
Sound propagation velocity in clt:	1500 m/2

Panels Type A, B, C, D

Natural Cork	
2, 3 layers; e=2x50 mm	Total e =100 mm; 150mm
2, layers; e=2X30 mm	Total e =120mm
Board dimension:	100 mm x 50mm
Density:	150 kg/m3 (100 to 200 Kg/m3) (UNE 56-906-74)
Bending modulus:	9000 N/mm2
Transversal module:	560 N/mm2
Humidity content:	2% to 12%
Thermal conductivity:	0.04 W/(m·K) 0,035 kcal/ h·m·ºC (UNE 92-202-89)
Sspecific heat capacity:	1852 J/(kg·K)
Water vapor resistance:	5-10 μ
Fire reaction:	Euroclasse E (UN EN 13501-1)
Breaking stress:	4 -2,0 Kg/cm2
Acoustic absorption:	e =50mm; 40% in 400 Hz/50% a 3500 Hz
Sound absorption coefficient:	500 CPS: 0.33/0.35
Reducing percussion sounds:	28 db (e= 30 mm)
water vapor permeability:	0.002 – 0.006 g/m.h.mmHg
Sound propagation speed in cork:	500 m/2

BASIS OF TESTS AND CALCULATIONS

DESIGN CODE

Prototype testing Sound insulation analysis: FCBA BWR5
Sound insulation: EN ISO 10140-1 to 5
Airborne noise: EN ISO 717-1

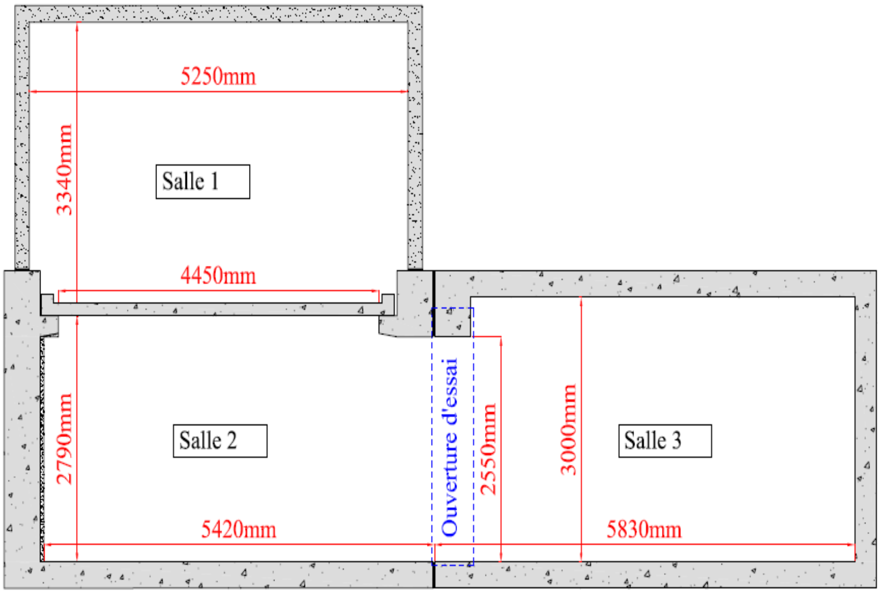


Fig.1 Prototype testing Sound insulation analysis.

CALCULATION METHODS

Regulations for the calculation and evaluation of acoustic insulation

For the calculation and evaluation of acoustic insulation in buildings and construction elements we have the following regulations:

• Evaluation of acoustic insulation in buildings and construction elements. Airborne noise insulation, UNE-EN ISO 717-1 Standard.
• Evaluation of acoustic insulation in buildings and construction elements. Impact noise insulation, UNE-EN-ISO 717-2 Standard.
In both cases, the objective of the regulation is to have a method by which the frequency characteristic of the acoustic insulation can be converted into a single number that characterizes the acoustic properties.

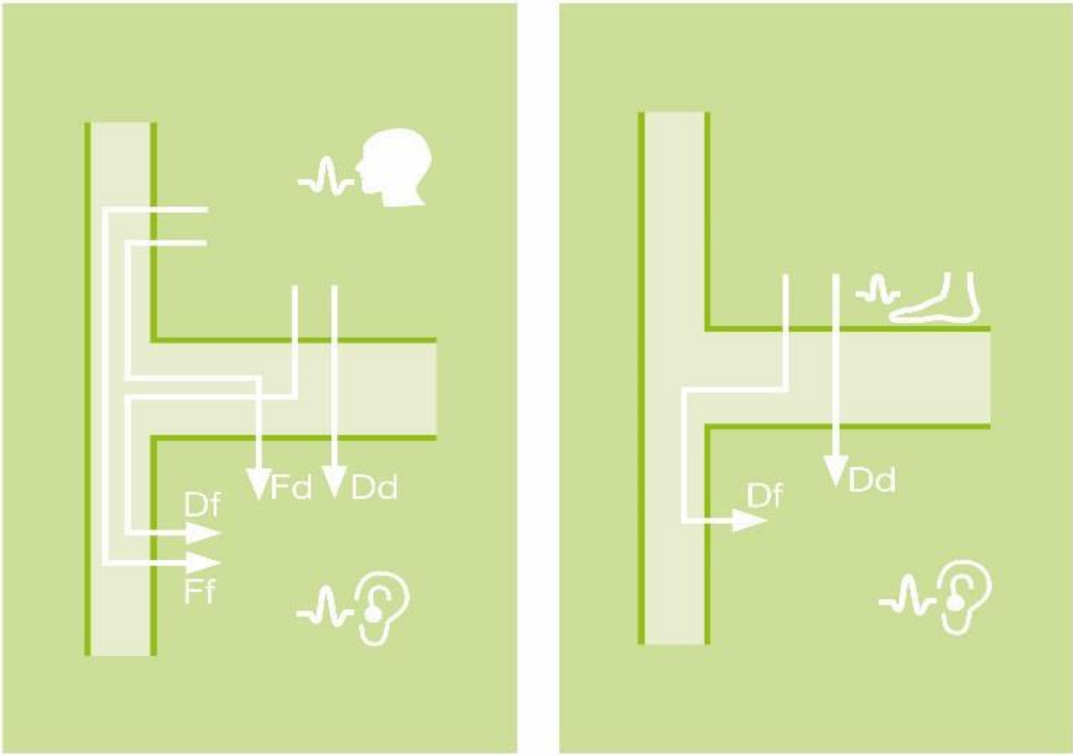
Theoretical noise insulation calculation according to the construction characteristics of the premises or location, UNE-EN 12354 Standard.

In practice it is desirable to express the transmission loss of an element by a single-number value in order to improve the comparison of data. To determine this value, the measured curves are weighted with reference curves, defined in ISO 717, part1 for airborne sound and part 2 for impact sound.

When performing this evaluation in accordance with EN ISO 717, the reference curve is shifted towards the measured curve until the sum of the unfavourable deviations is as large as possible, however not more than 32 dB (on average no more than 2 dB per one- third octave band). Favourable deviations are not taken into account. The single-number value is now the reference curve value at 500 Hz.

The additional “w”, which stands for “weighted” (e.g. Rw or DnT,w), indicates that this single-number rating is evaluated according to EN ISO 717.

Sound transmission pathways between two rooms



The figure 2. shows the different sound effect.

- Airborne sound

- Impact sound

F flanking transmission (indirect)
D direct transmission
D direct radiation

Airborne sound

	Residencial Building between different uses		Exterior attenuation
France	DnT,w+Ctr	≥ 53 dB	≥ 53 dB
Portugal	DnT,w	≥ 50 dB	≥ 50 dB
Spain	DnT,A=DnT,w	≥ 50 dB	≥ 50 dB

Requirement for partitions depending on the type of partition, the acoustic reduction index, RA, required in this table is greater than 33 dBA. These values are consistent with the sound insulation values obtained in the laboratory for these Requirement for enclosures:
The values guarantee compliance with the requirements for acoustic insulation against airborne noise between enclosures of different use units, which must be:
− DnT,A ≥ 50 dBA (between protected rooms or between any room of another unit of use and a protected room);
− DnT,A ≥ 45 dBA (between habitable rooms or between any room of another unit of use and a habitable room).

Impact sound

	Residencial Building between different uses		Exterior attenuation
France	L′nT,w	≤ 58 dB	≤ 58dB
Portugal	L′n,w	≤ 58 dB	≤ 53 dB
Spain	L′n,w	≤ 65 dB	≤ 65 dB

BERGER'S MASS LAW

Airborne sound

The sound insulation of single-layer solid components is primarily determined by the mass of the components. “Acoustic single-layer” components are those that have points of mass that do not change in relation to each other when the component vibrates (they vibrate as a whole unit). The sound reduction index of such structures can be approximately calculated using Berger’s mass law:

$$R = 20 \cdot \log\left(\frac{M \pi f}{Z}\right) \quad (dB)$$

The law of masses tells us, then, that the insulation in dB is proportional to the square of the mass per unit area of the partition (M) and also to the square of the frequency (f). That is, the insulation increases with the surface density of the partition and if the sound frequency is higher. According to the equation, if we double the mass of the wall, the insulation will increase by 6 dB and in the same way, given a panel of mass M, its insulation will increase by 6 dB when doubling the frequency. High-pitched sounds are attenuated more effectively than low-pitched sounds, therefore, a noise which penetrates a component will sound duller than the source of noise itself.

where M is the mass per unit area, f is the frequency of the incident wave, and Z is the acoustic impedance of the medium surrounding the wall. If this medium is air, Z = 415 rayls, and the equation can be expressed in the form:

$$R = 20 \cdot \log(M f) - 43 \, dB$$

It must be added that this relationship is fulfilled as long as the frequency of the incident wave is much higher than that of the proper modes of vibration of the wall and the incidence of sound is perpendicular to the wall. Under normal conditions (reverberant field) and when evaluating the insulation in thirds of an octave, the equation that best fits is:

$$R = 20 \cdot \log(M f) - 47 \, dB$$

In principle, soundproofing can be verified either mathematical, based on the calculation method in EN 12354, or through metrological measurements, based on construction site measurements. Despite active research and a few early publications, no sufficiently accurate values for the relatively new product, cross-laminated timber, exist as yet to enable a calculation to be performed in line with EN 12354. Simplified calculation approaches for sound transmission in solid wood construction can be found, for example, in the publications of the Informationsdienst Holz, or the Holzforschung Austria.

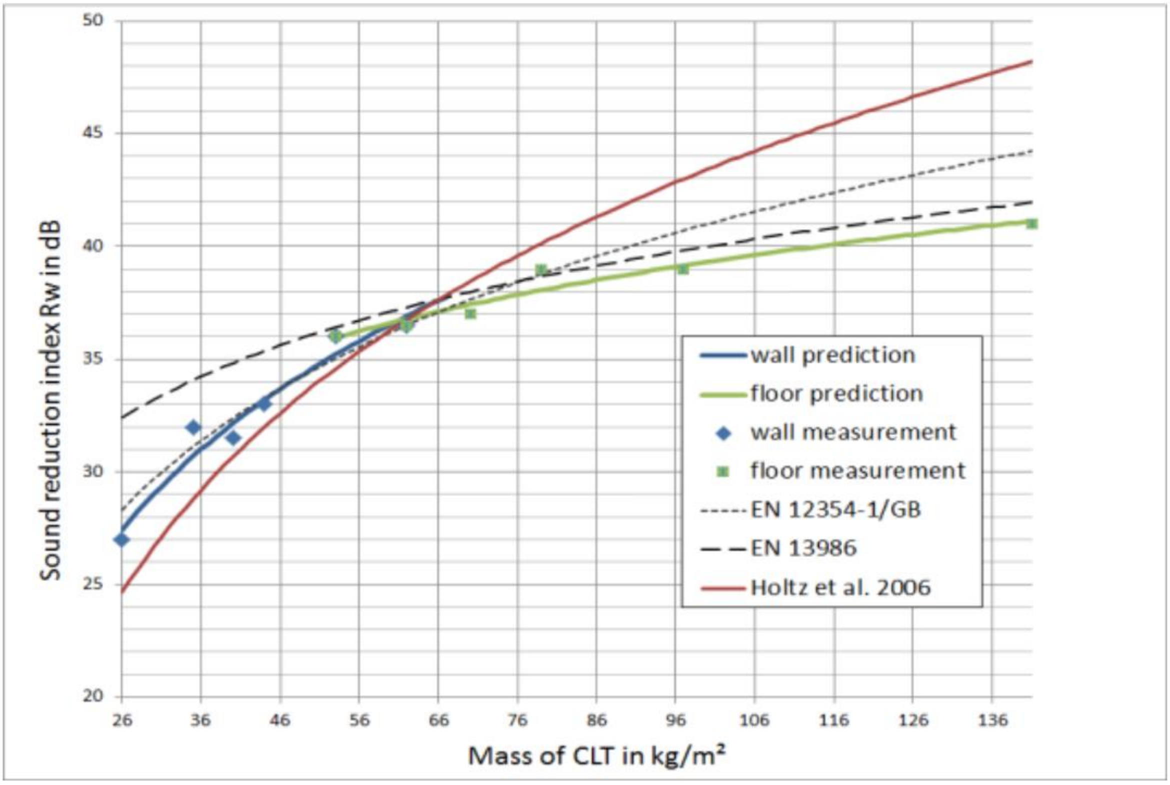
As a reference in this test the variant of Berger's formula as follow:

$$\boldsymbol{R_{w,CLT,wall} = 25\,\lg(m'_{CLT}) - 8\ in\ dB}$$

applicable for CLT Walls from 60 to 150 mm

$$\boldsymbol{R_{w,CLT,floor} = 12{,}2\,\lg(m'_{CLT}) + 15\ in\ dB}$$

applicable for CLT Floors from 120 to 320 mm



The fig. 3 Shows the different behaviour of isotropic and orthotropic materials. (by Stora Enso studies)

Global space acoustic insulation

Global isolation of the premises
It is calculated using the expression:

$$a_g = 10\log\frac{\sum S_i}{\sum \frac{S_i}{10^{\frac{a_i}{10}}}}$$

Si = Area of each element in m2.
ai = Insulation of each element.
As the estimated noise of the activity according to regulations is 70 dB (A), the globally transmitted noise is: 70 – ag = dBA
Value less than 30 dB (A) allowed by Noise Pollution regulations in residential areas during daytime. These hours correspond to the hours of operation of the premises.

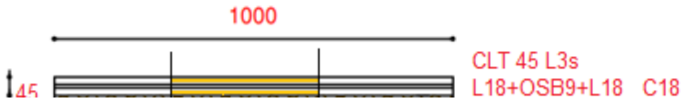
The sound study of the premises and the supporting documents express: the airborne noise insulation values of the vertical construction elements, the global airborne noise insulation values of the façade, **the airborne noise insulation values and the impact noise** level in the underlying space of the horizontal construction elements.
ag = Global insulation of the room in dB A.

ACOUSTIC PERFORMANCES OF THE IMIP PANELS

CLT 45mm

- pinus pinaster C16, C18
- OSB 3

2 layers; pinus glued boards	e=18 mm
1 layers: OSB 3 board	e=9mm
Board dimension:	2500mm x 1000mm
Density:	470 kg/m3
Bending modulus:	9000 N/mm2
Transversal module:	560 N/mm2
Moisture content:	10% a 12%
Thermal conductivity:	0,13 W/mK
Sound propagation velocity in clt:	1500 m/2



e 45 mm

Fig. 4: Panel B test section

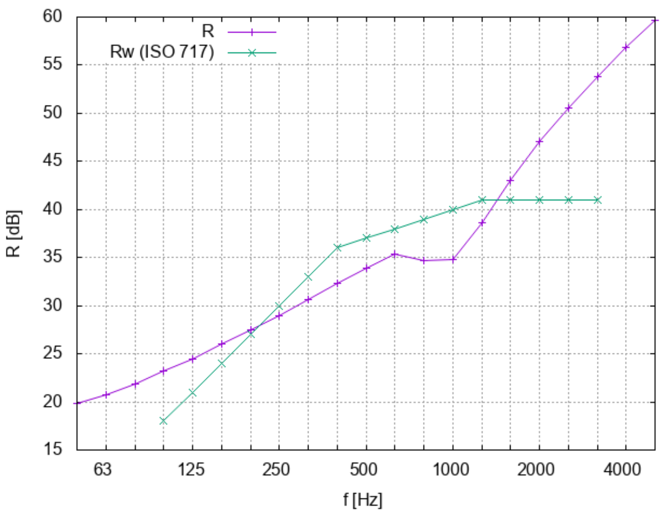
Parameters used:

Density [kg/m³]	500
Thickness [m]	0.045
Surface density [kg/m²]	22.5
Damping coefficient	0.85
Longitudinal propagation speed [m/s]	1500
Wall surface [m²]	2 x 2

Coefficients:

Weighted sound reduction index (Rw) = 37
Pink noise spectrum adaptation term (C) = 0
Traffic noise spectrum adaptation term (Ctr) = -3

Frequency [Hz]	R [dB]
50	19.8
63	20.7
80	21.9
100	23.2
125	24.5
160	26.0
200	27.5
250	29.0
315	30.6
400	32.3
500	33.9
630	35.4
800	34.7
1000	34.8
1250	38.6
1600	43.0
2000	47.1
2500	50.5
3150	53.8
4000	56.8
5000	59.7



R: Sound reduction index.

CLT 60 mm

pinus uncinata C18, C20

3 layers:	e=60 mm 3x20mm
Board dimension:	6000mm x 120mm
Density:	520 kg/m3
Bending modulus:	9000 N/mm2
Transversal module:	560 N/mm2
Moisture content:	10% a 12%
Thermal conductivity:	0,13 W/mK
Sound propagation velocity in clt:	1500 m/2

e 60 mm

Fig. 5: CLT 60 mm test section

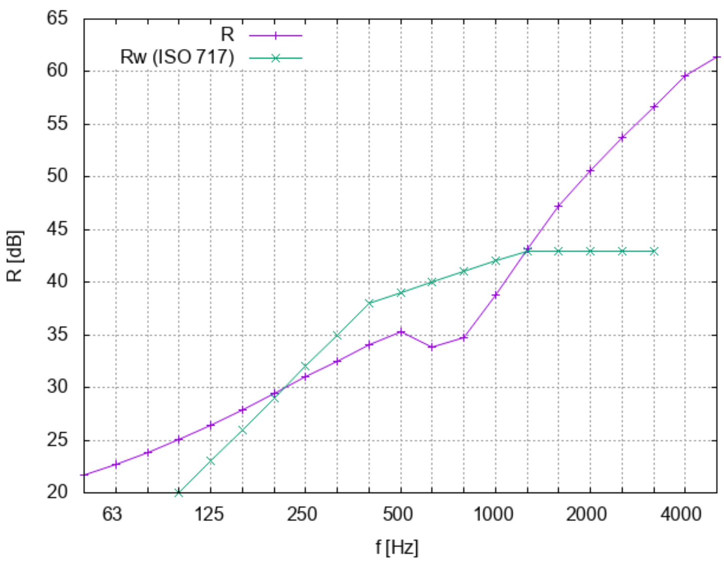
Parameters used:

Density [kg/m³]	470
Thickness [m]	0.06
Surface density [kg/m²]	28.2
Damping coefficient	0.8
Longitudinal propagation speed [m/s]	1500
Wall surface [m²]	2 x 2

Coefficients:

Weighted sound reduction index (Rw) = 39
Pink noise spectrum adaptation term (C) = -1
Traffic noise spectrum adaptation term (Ctr) = -4

Frequency [Hz]	R [dB]
50	21.7
63	22.7
80	23.8
100	25.1
125	26.4
160	27.9
200	29.4
250	31.0
315	32.5
400	34.1
500	35.3
630	33.8
800	34.7
1000	38.8
1250	43.2
1600	47.2
2000	50.6
2500	53.7
3150	56.7
4000	59.6
5000	61.4



R: Sound reduction index.

CLT 100 mm

pinus pinaster C16, C18

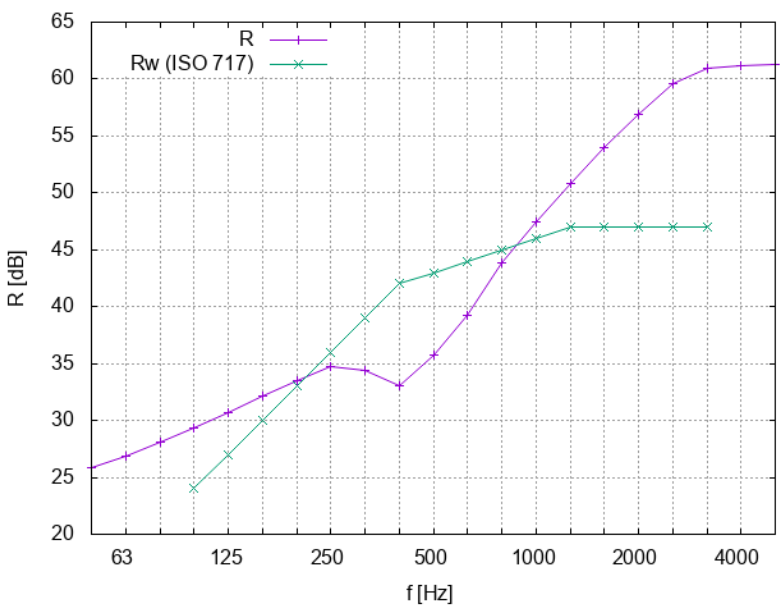
5 layers;	e=100 mm
Board dimension:	6000mm x 1200mm
Density:	500 kg/m3
Bending modulus:	9000 N/mm2
Transversal module:	560 N/mm2
Moisture content:	10% a 12%
Thermal conductivity:	0,13 W/mK
Sound propagation velocity in clt:	1500 m/2

e 100 mm

Fig. 6: CLT 100 test section

Coefficients:
Weighted sound reduction index (Rw) = 43
Pink noise spectrum adaptation term (C) = -1
Traffic noise spectrum adaptation term (Ctr) = -4

Frequency [Hz]	R [dB]
50	25.9
63	26.9
80	28.1
100	29.3
125	30.7
160	32.1
200	33.5
250	34.7
315	34.4
400	33.0
500	35.7
630	39.2
800	43.8
1000	47.5
1250	50.8
1600	54.0
2000	56.9
2500	59.6
3150	61.0
4000	61.2
5000	61.3



R: Sound reduction index.

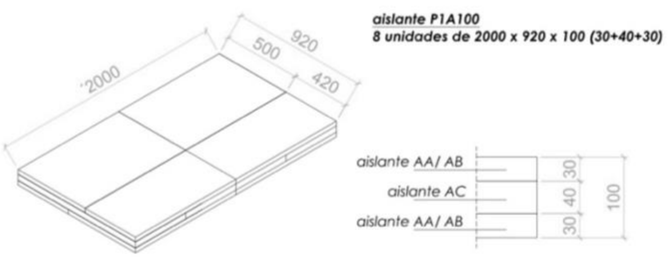
Insulation Panels

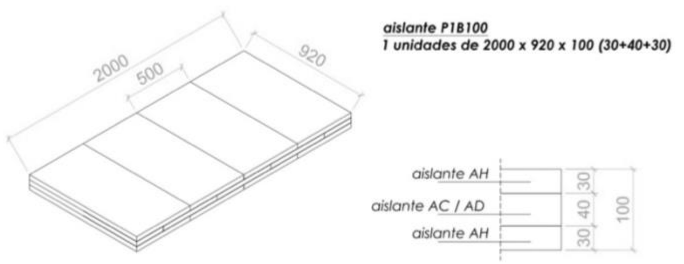
Natural Cork

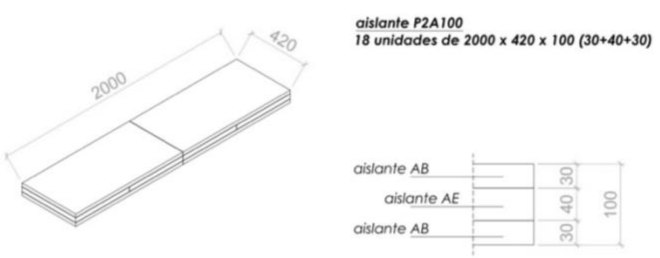
2, 3 layers; e=2x50 mm	Total e =100 mm; 150mm
2, layers; e=4X30 mm	Total e =120mm
Board dimension:	100 mm x 50mm
Density:	150 kg/m3 (100 to 200 Kg/m3) (UNE 56-906-74)
Bending modulus:	9000 N/mm2
Transversal module:	560 N/mm2
Humidity content:	2% to 12%
Thermal conductivity:	0.04 W/(m·K) 0,035 kcal/ h·m·ºC (UNE 92-202-89)
Sspecific heat capacity:	1852 J/(kg·K)
Water vapor resistance:	5-10 µ
Fire reaction:	Euroclasse E (UN EN 13501-1)
Breaking stress:	4 -2,0 Kg/cm2
Acoustic absorption:	e =50mm; 40% in 400 Hz/50% a 3500 Hz
Sound absorption coefficient:	500 CPS: 0.33/0.35
Reducing percussion sounds:	28 db (e= 30 mm)
water vapor permeability:	0.002 – 0.006 g/m.h.mmHg
Sound propagation speed in cork:	500 m/2

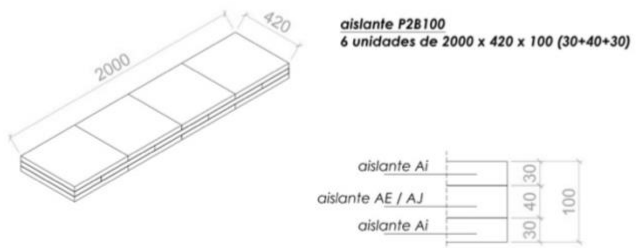
Fig. 7: Cork insulation test section

e 150mm









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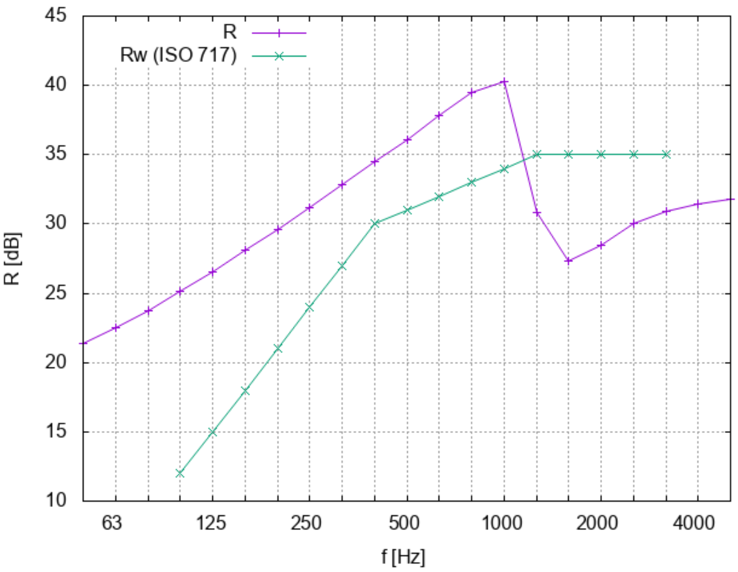
Parameters used:

Density [kg/m³]	150
Thickness [m]	0.1
Surface density [kg/m²]	15
Damping coefficient	0.2
Longitudinal propagation speed [m/s]	500
Wall surface [m²]	3.2 x 2

Coefficients:

Weighted sound reduction index (Rw) = 31
Pink noise spectrum adaptation term (C) = 0
Traffic noise spectrum adaptation term (Ctr) = 1

Frequency [Hz]	R [dB]
50	21.4
63	22.5
80	23.7
100	25.1
125	26.5
160	28.1
200	29.6
250	31.2
315	32.8
400	34.5
500	36.1
630	37.8
800	39.5
1000	40.3
1250	30.8
1600	27.3
2000	28.5
2500	30.0
3150	30.9
4000	31.4
5000	31.8

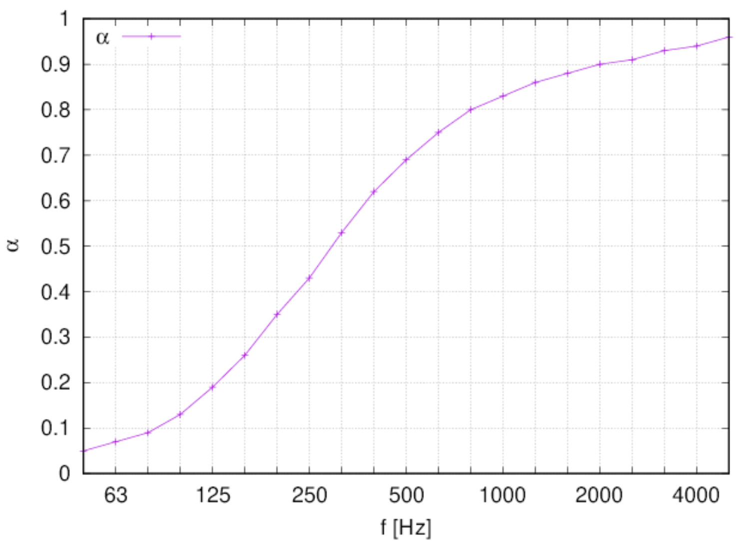


R: Sound reduction index.

Weighted absorption coefficient:

α_w = 0.70 (H)

Frequency [Hz]	α
50	0.05
63	0.07
80	0.09
100	0.13
125	0.19
160	0.26
200	0.35
250	0.43
315	0.53
400	0.62
500	0.69
630	0.75
800	0.80
1000	0.83
1250	0.86
1600	0.88
2000	0.90
2500	0.91
3150	0.93
4000	0.94
5000	0.96



α: Absorption coefficient

Type A

- Type A: CLT of 60mm (3 layers of 20mm) + ribs of 80x200mm Total thickness of 260mm + 18mm Osb 3 board
- Material "Pinus uncinata" C18.
- The definition had an OSB 3 panel and an internal cork insulation.

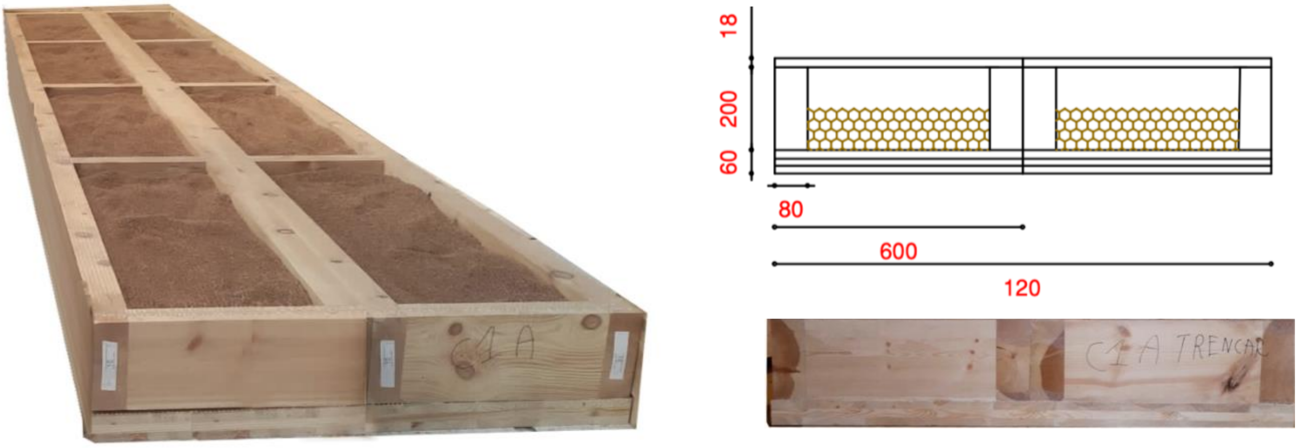
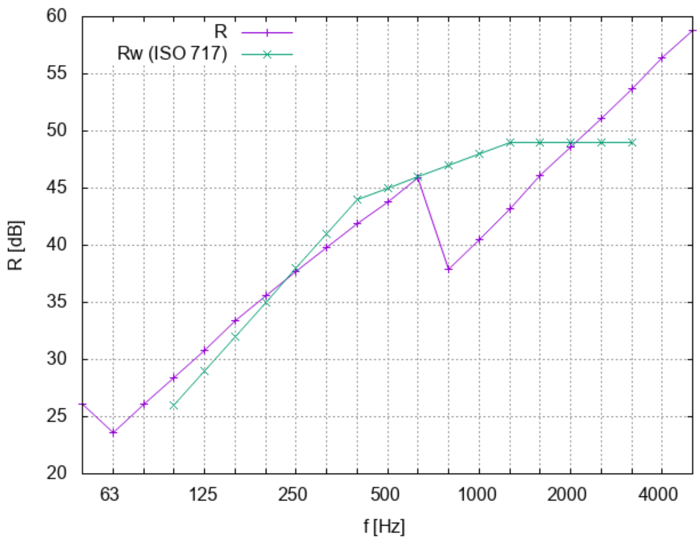


Fig. 8: Panel A section

Wall 1		**Absorbent material**		**Wall 2**	
Number of layers	1	Flow resistivity [Ns/m⁴]	35400	Number of layers	1
Density [kg/m³]	691.03	Thickness [m]	0.2	Density [kg/m³]	470
Thickness [m]	0.018			Thickness [m]	0.06
Longit. propagation speed [m/s]	2098.25			Longit. propagation speed [m/s]	1500
Loss factor	0.031			Loss factor	0.8

Coefficients:
Weighted sound reduction index (Rw) = 45
Pink noise spectrum adaptation term (C) = -2
Traffic noise spectrum adaptation term (Ctr) = -5

Frequency [Hz]	R [dB]
50	26.1
63	23.6
80	26.1
100	28.4
125	30.8
160	33.4
200	35.6
250	37.7
315	39.8
400	41.9
500	43.8
630	45.9
800	37.9
1000	40.5
1250	43.2
1600	46.1
2000	48.6
2500	51.1
3150	53.7
4000	56.4
5000	58.8



R:Sound reduction index

Type B

- Type B: CLT of 45mm (2 layers of 18mm + oriented strand board layer of 9mm) + 100 and 150mm cork insulation + CLT of 45mm. Total thickness of 190 to 240mm.
- Material "Pinus Pinaster" C18, Cork (E=5MPa) and OSB
- Test section

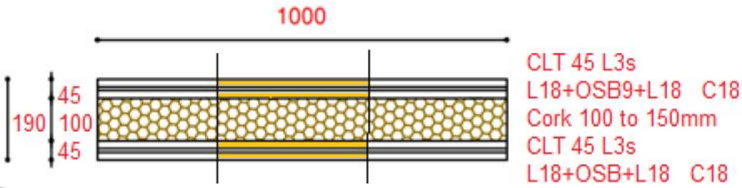
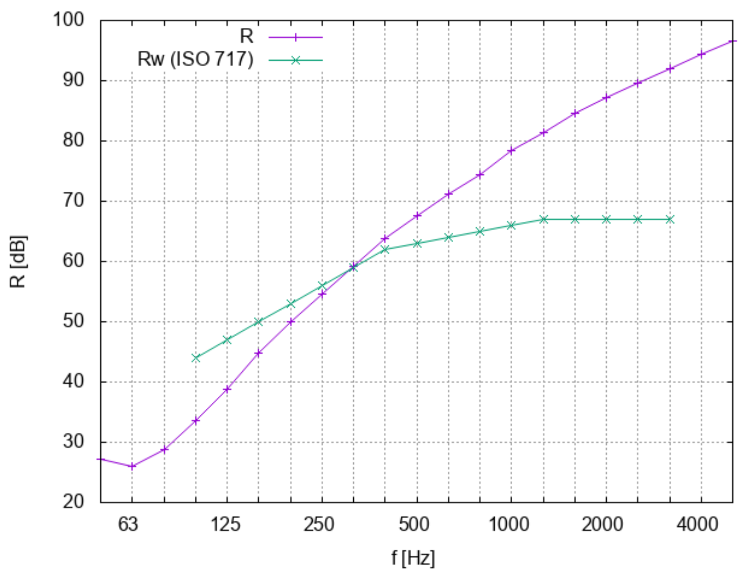


Fig. 9: Panel B test section

Wall 1		**Absorbent material**		**Wall 2**	
Number of layers	1	Flow resistivity [Ns/m⁴]	35400	Number of layers	1
Density [kg/m³]	500	Thickness [m]	0.1	Density [kg/m³]	500
Thickness [m]	0.045			Thickness [m]	0.045
Longit. propagation speed [m/s]	1500			Longit. propagation speed [m/s]	1500
Loss factor	0.85			Loss factor	0.85

Coefficients:
Weighted sound reduction index (Rw) = 63
Pink noise spectrum adaptation term (C) = -4
Traffic noise spectrum adaptation term (Ctr) = -11

Frequency [Hz]	R [dB]
50	27.1
63	26.0
80	28.7
100	33.6
125	38.7
160	44.8
200	49.9
250	54.6
315	59.2
400	63.7
500	67.5
630	71.2
800	74.3
1000	78.4
1250	81.4
1600	84.5
2000	87.1
2500	89.5
3150	92.0
4000	94.4
5000	96.6



R:Sound reduction index

Type C

- Type C: CLT of 60mm (3 layers of 20mm) + ribs of 80x200mm + CLT of 60mm. Total thickness of 320mm.
- Material “Pinus uncinata” C18
- Test section

The cork layer is not considered structural.

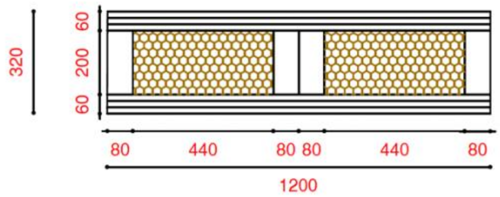


Fig. 10: Panel C test section

Description:
IMIP type C 320mm impact noice

Parameters:
Slab

Dimensions [m²]	2 x 2
Thickness [m]	0.06
Density [kg/m³]	470
Longit. propagation speed [m/s]	1500
Loss factor	0.01
Speed of sound [m/s]	340

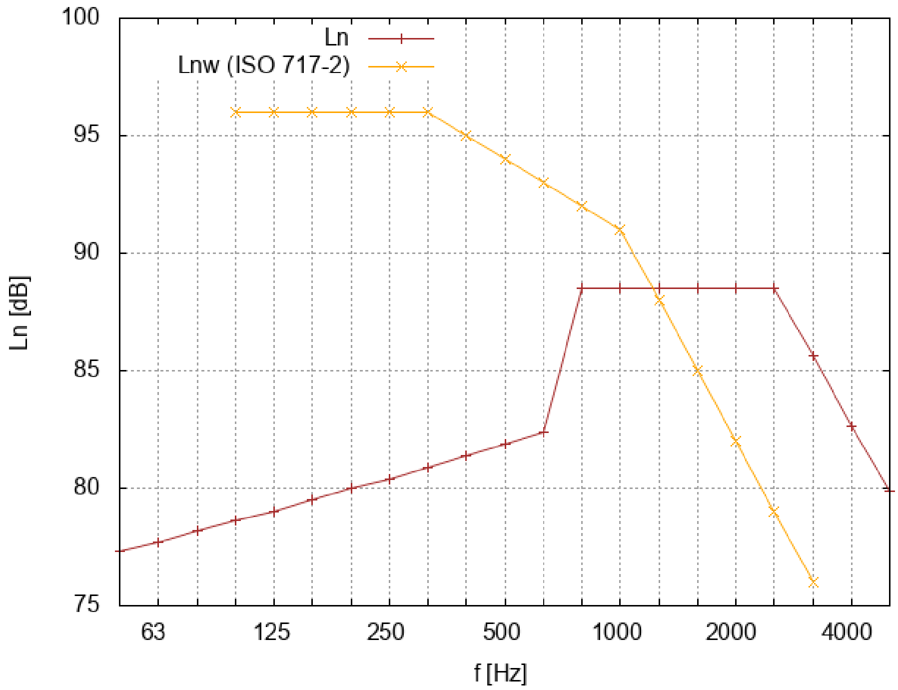
Ceiling

Distance ceiling-slab [m]	0.2
Coupling type between walls	Wood
Distance between couplings	0.6
Number of layers	1
Thickness [m]	0.06
Density [kg/m³]	470
Longit. propagation speed [m/s]	1500
Loss factor	0.8
Flow resistivity [Ns/m⁴]	35400
Thickness abs. material [m]	0.2

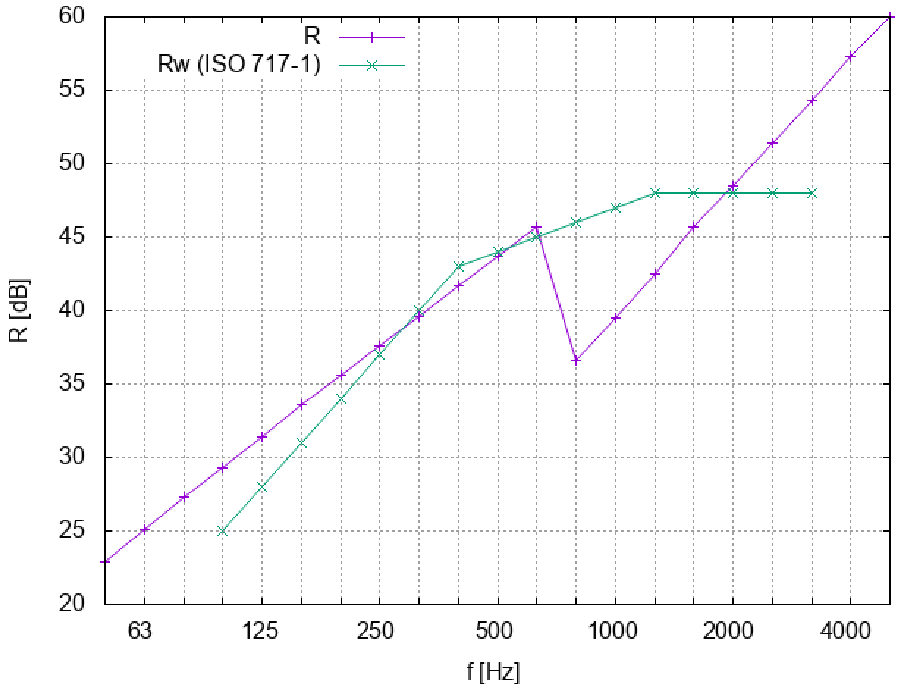
Coefficients:
Sound reduction
Weighted sound reduction index (Rw) = 44
Pink noise spectrum adaptation term (C) = -2
Traffic noise spectrum adaptation term (Ctr) = -4

Impact
Weighted normalized impact SPL (Lnw) = 94
Impact spectrum adaptation term (C1) = -11

f [Hz]	Ln* [dB]
50	77.3
63	77.7
80	78.2
100	78.6
125	79.0
160	79.5
200	80.0
250	80.4
315	80.9
400	81.4
500	81.9
630	82.4
800	88.5
1000	88.5
1250	88.5
1600	88.5
2000	88.5
2500	88.5
3150	85.6
4000	82.6
5000	79.9



f [Hz]	R* [dB]
50	22.9
63	25.1
80	27.3
100	29.3
125	31.4
160	33.6
200	35.6
250	37.6
315	39.6
400	41.7
500	43.7
630	45.7
800	36.6
1000	39.5
1250	42.5
1600	45.7
2000	48.5
2500	51.4
3150	54.3
4000	57.3
5000	60.0



Type D

- Type D: CLT of 100mm (5 layers of 20 mm) + 100mm cork insulation. Total thickness of 200mm.
  Material “Pinus Pinaster” C18
  Test section, (test results are pending)

Variable dimension

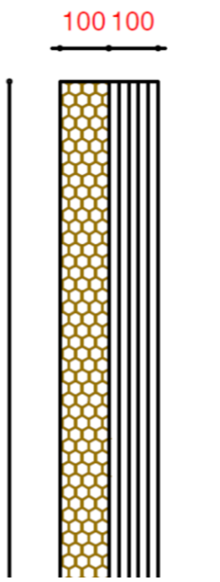


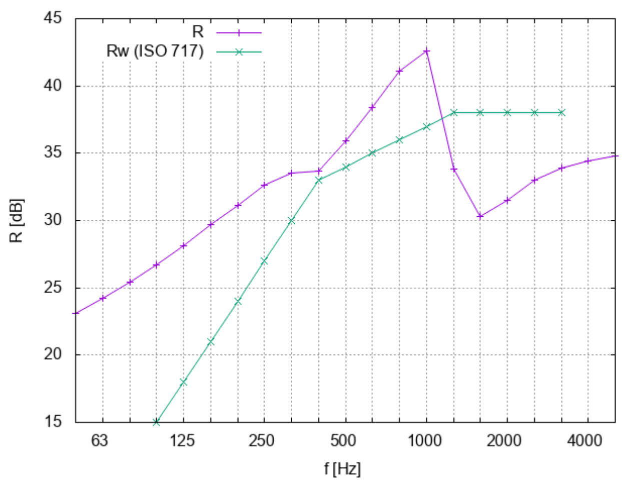
Fig. 11: Panel D test section

Parameters:

#	Surface [m²]	Section name
1	1	R, Single wall IMIP clt 100
2	1	R, Single wall natural cork panel

Coefficients:
Weighted sound reduction index (Rw) = 34
Pink noise spectrum adaptation term (C) = -1
Traffic noise spectrum adaptation term (Ctr) = 0

f [Hz]	R1	R2	R [dB]
50	25.9	21.4	**23.1**
63	26.9	22.5	**24.2**
80	28.1	23.7	**25.4**
100	29.3	25.1	**26.7**
125	30.7	26.5	**28.1**
160	32.1	28.1	**29.7**
200	33.5	29.6	**31.1**
250	34.7	31.2	**32.6**
315	34.4	32.8	**33.5**
400	33.0	34.5	**33.7**
500	35.7	36.1	**35.9**
630	39.2	37.8	**38.4**
800	43.8	39.5	**41.1**
1000	47.5	40.3	**42.6**
1250	50.8	30.8	**33.8**
1600	54.0	27.3	**30.3**
2000	56.9	28.5	**31.5**
2500	59.6	30.0	**33.0**
3150	61.0	30.9	**33.9**
4000	61.2	31.4	**34.4**
5000	61.3	31.8	**34.8**



R: Sound reduction index

CONCLUSIONS

The results of the IMIP panel tests, both in terms, are similar to those established in the previous hypotheses of the WP3.

The results of the acoustic analysis of the IMIP panels meet the initial expectations.
The materials and systems developed and tested comply with international regulations.
The use or combination of the IMIP systems are capable of solving regulatory needs and developing any building system, be it roofs, intermediate slabs, facades or interior partitions.
In this sense, it can solve divisions between rooms of different uses and high acoustic requirements or typical acoustic conditioning.

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