TEST REPORT WITH ELECTRONIC

FIRE RESISTANCE OF PARTITION WALL ACCORDING TO

Dividing or perimeter

idiem

Investigación, Desarrollo e Innovación de Estructuras y Materiales

INN - CHILE SISTEMA NACIONAL DE ACREDITACION

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Construction Technology Division		
Fire Laboratory		
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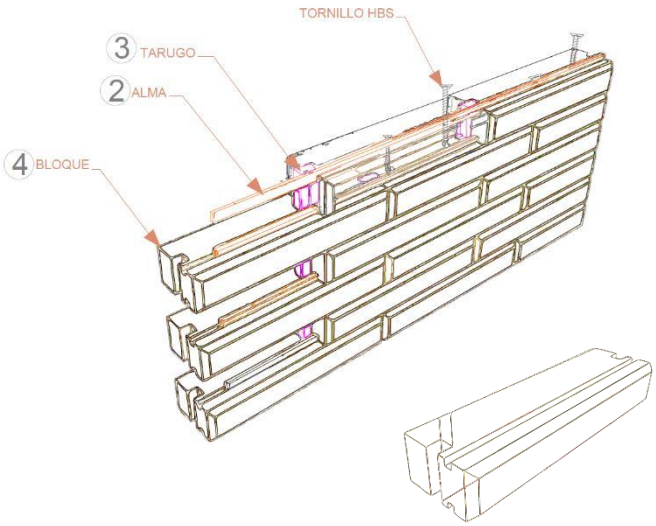
Validated by:	Paula Araneda G.	14/01/2020
Approved by:	Miguel Pérez A.	
Recipient:	Rodrigo Espinoza. University of Bio Bio.	

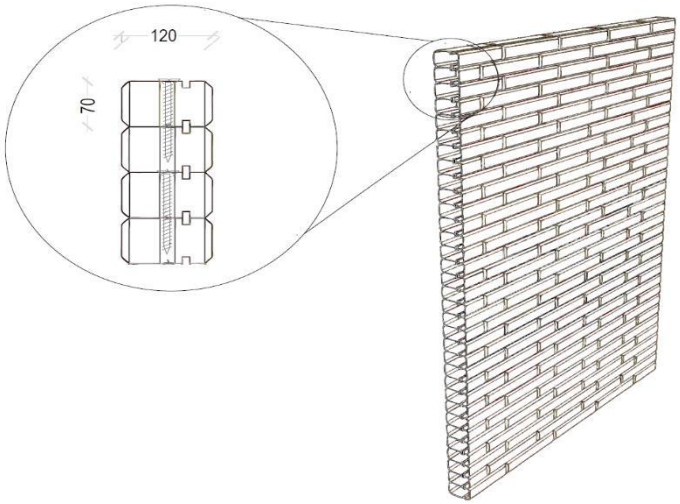
CONTENTS

Summary

Fire-resistance test according to NCh935/1.Of97

Requesting	University of Bio Bio.		Address:	Collao Ave. 1202, Concepción.	
Requested by:	Rodrigo Espinoza.	Element:	Dividing or perimeter partition	Built in:	Factory / ~~Laboratory~~
Test facility:	Fire Laboratory, Salomón Sack 840, Cerrillos.		Report No.: 1.374.751 /2021	Test date: 18-02-2021	





			e "BME" system (Interlocked Wooden Block) is a system joined by the interlocking of wooden elements, namely: blocks, core and dowel. The horizontal joint of the wooden bricks is made by means of dowels interlocked at their ends and with aligning the blocks on their lower and upper faces, while the vertical joint is made by means of screws "Rothoblaas HBS 6120" (uno by bloque).
			20 [mm] high, 10 [mm] wide and of variable length depending on the wall.
			70 [mm] high, 20 [mm] wide and 40 [mm] long.
			70 [mm] high, 120 [mm] wide and 400 [mm] long.
			Joint treatment with "Quilosa profesional N25®" silicone.
			Two coats of varnish during pre-assembly, initially only on the blocks.
			er the specimen was assembled, one coat of varnish was applied to the wall on both faces using a brush

Element width	2,2	[m]
Element height	2,4	[m]
Total	120	[mm]
Total mass	380	[kg]

Note: According to standard NCh935/1.Of97, the result obtained is valid only for the element tested and under the conditions stipulated in the Test Report, since the fire-resistance value may vary if the construction details are changed.

Note: This summary does not replace the **Issue date: January 14, 2020**

1. SCOPE

This test report was requested from IDIEM of the University of Chile by Rodrigo Espinoza, on behalf of Universidad del Bio Bio.

This report establishes the Fire-Resistance Classification of a construction system or element (dividing or perimeter partition wall), tested under standard NCh935/1.Of97 and according to the internal DTC-PT-506, at the IDIEM Fire Laboratory located at Salomón Sack 840, Cerrillos.

2. EQUIPMENT AND

The following equipment and instruments were used to perform the test:

2.1 Test furnace

The Laboratory has a test furnace equipped with a modulating gas burner with a nominal thermal power of 1700 [kW]. The furnace opening measures 2.2 [m] wide by 2.4 [m] high.

2.2 Mechanical overload system

The Laboratory has a mechanical loading system that allows the application of 120 [kg] per linear meter or on the test element.

2.3 Measuring instruments

- Thermocoupl : Chromel-Alumel type, used for monitoring the temperature inside the furnace.
- Infrared sensor : Gun-type infrared thermometer used to measure the average and maximum point temperature of the unexposed face of element.
- Manometer : Differential water-column manometer used to measure the overpressure inside the furnace.

3 CONDITIONING AND ASSEMBLY

The specimen was provided by the requester and kept in the Laboratory for 1 day before the test.

It was placed over the furnace opening, mechanically fixing it at each end. The seal was made with glass wool plus gypsum-based paste.

On the day of the test, the initial temperature conditions were as follows:

- Initial average furnace temperature : 24 [°C]
- Initial temperature of the unexposed : 24 [°C]

4 DESCRIPTION OF THE SAMPLE

The sample tested and received by the laboratory was 2.20 [m] wide and 2.40 [m] high, with construction characteristics as described in Table 4.1 below.

Table 4.1 Description of the tested sample.

Summary					
Fire-resistance test according to NCh935/1.Of97					
Requesting	University of Bio Bio.		Address:	Collao Ave. 1202, Concepción.	
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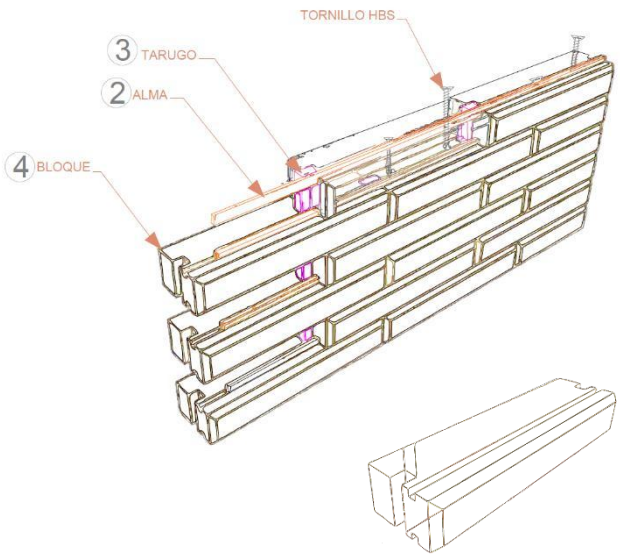

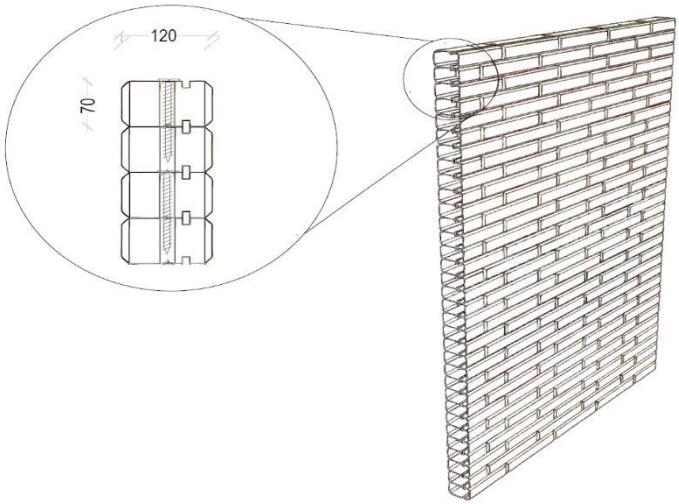

			he “BME” system (Interlocked Wooden Block) is a system joined by the interlocking of wooden elements, namely: blocks, core and dowel. The horizontal joint of the wooden bricks is made by means of dowels interlocked at their ends and with aligning the blocks on their lower and upper faces, while the vertical joint is made by means of screws “Rothoblaas HBS 6120” (uno by bloque).
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			er the specimen was assembled, one coat of varnish was applied to the wall on both faces using a brush

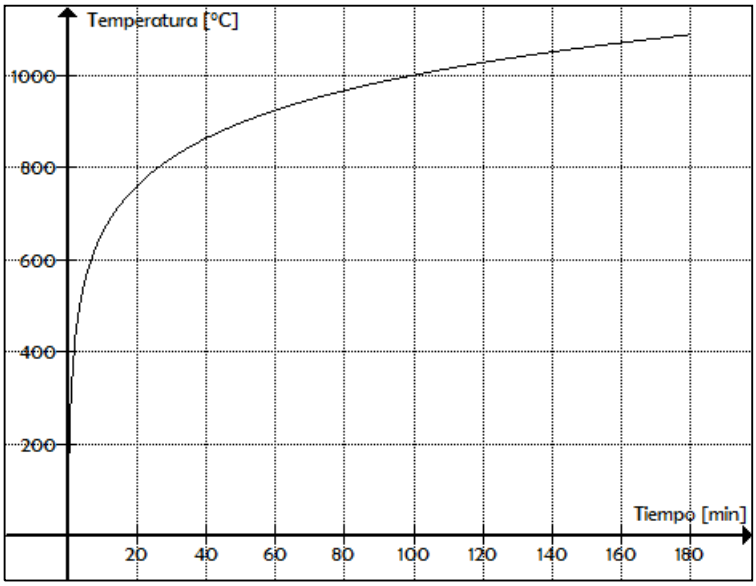
5 TEST PROCEDURE

5.1 Genera

The test consists of exposing one face of the element to the heat of a furnace in order to impose on it a temperature according to the standardized time-temperature curve indicated in NCh935/1.Of97, the following

$$T(t) - T_0 = 345 \log_1 (8t + 1),$$

where T is the furnace temperature [°C], T_0 the ambient temperature at the start of the test t the time elapsed during the test [min]. The graph of this equation and a table of curve values are presented in Figure 4.1.



t	[min]	0	5	15	30	60	90	120	150	180
$T(t) - T_0$	[°C]	0	556	719	822	925	986	1029	1062	1090

Figure 5.1 Standard fire curve

During the test, the furnace temperature, the temperature of the unexposed face and the observations regarding the behavior of the specimen in terms of the fire-resistance criteria specified in 5.3

5.2 Fire resistance

According to standard NCh935/1.Of97, the fire resistance of an element is expressed as the time in minutes, from the start of the test until the conditions relating to load-bearing capacity, insulation, tightness and non-emission of flammable gases cease to be met.

5.3 Fire-resistance criteria

The criteria for determining the fire resistance of the element under test are the following:

- Load-bearing capacity. The moment at which the element can no longer continue fulfilling the load-bearing function for which it was

- Thermal insulation. The moment at which the temperature of the unexposed face reaches 180 point value or 140 [ºC] average above the ambient temperature recorded at the start of the test, or it exceeds 220 [°C], regardless of the initial temperature.

  - ✓ Perimeter elements. As indicated in article 9.2.2.2 of NCh935/1.Of97, for perimeter, vertical or horizontal separation elements that do not involve potential combustible loads on the exterior side, their exterior temperatures may be any value and fire resistance is determined by the failure of the element without into account the surface temperature of the unexposed face.

- Tightness. The moment at which a flame (or high-temperature gases) passes through the joints or cracks or fissures formed during the test and is sustained for 10 or more seconds. In the case of gas leakage, there is loss of tightness if, when a cotton pad is placed at the leakage point, it ignites.

- Emission of flammable gases. The moment at which gases emitted by the unexposed face ignite any flame is brought close and continue burning spontaneously for at least 20 [s] after the flame is

5.4 Fire-resistance classification

The element must be classified as follows, according to its fire resistance:

Class F0	< 15 minutes			
Class F15	≥	15 minutes	<	30 minutes
Class F30	≥	30 minutes	<	60 minutes
Class F60	≥	60 minutes	<	90 minutes
Class F90	≥	90 minutes	<	120 minutes
Class F120	≥	120 minutes	<	150 minutes
Class F150	≥	150 minutes	<	180 minutes
Class F180	≥	180 minutes	<	240 minutes
Class F240	≥	240 minutes.		

6 RESULTS

The test results are described below.

6.1 Load-bearing capacity

The element was subjected to a mechanical overload of 240 [kg] per linear meter and maintained its until the end of the test.

6.2 Thermal insulation

At the end of the test, the average temperature of the face unexposed to fire was 34 [°C] and the maximum point temperature era of 46 [°C].

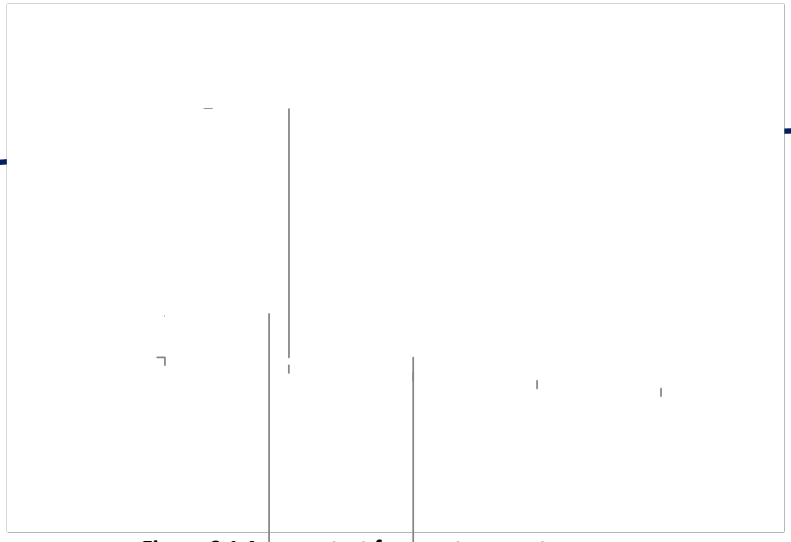


Figure 6.1 Average test furnace temperature

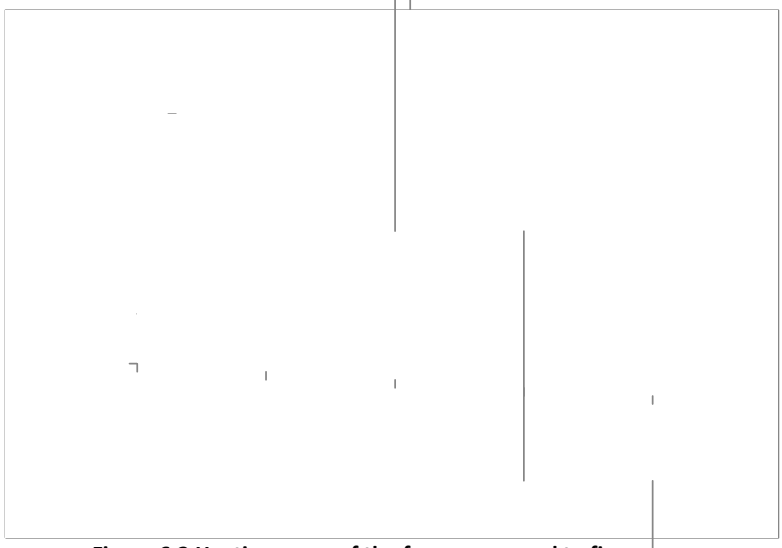


Figure 6.2 Heating curve of the face unexposed to fire

6.3 Tightness

The element remained flame-tight until the end of the test.

6.4 Emission of flammable gases

The element did not emit flammable gases throughout the test.

6.5 Other observations

- The test was terminated at 70 minutes.

7 CONCLUSION

According to the provisions of 6.5, the fire resistance of the tested "perimeter or dividing partition wall" described in section 4 of this report was 70 minutes, reaching, according to 5.4, the
F60

According to standard NCh935/1.Of97, the result obtained is valid only for the sample tested and under the conditions stipulated in this Test Report, since the fire-resistance value may vary if the construction details are changed.

DOCUMENTO CON FIRMA ELECTRONICA AVANZADA
Idiem
UNIVERSIDAD DE CHILE
LEY 19799

VALIDATED BY:	APPROVED BY:
Paula Araneda G. Division Head	**Miguel Pérez A.** Senior Engineer

Santiago, January 14, 2020

APPENDI

A.1 Test images

A.1.1 At the start of the

A.1.2 25 minutes after the start of the test

A.1.4 70 minutes after the start of the test

A.1.4 At the end of the test

CITECUBB CENTRO DE INVESTIGACIÓN EN TECNOLOGÍAS DE LA CONSTRUCCIÓN UNIVERSIDAD DEL BÍO-BÍO	**TEST REPORT** **SOUND REDUCTION INDEX APPARENT**	**REPORT No.**	**3479**
		ISSUE DATE	07.08.2020
		PAGE No.	1/6

PERFORMER **CONSTRUCTION TECHNOLOGY RESEARCH CENTER, CITEC UNIVERSIDAD DEL BÍO-BÍO**
COLLAO AVENUE 1202, CONCEPCIÓN - CHILE

CLIENT

NAME : **BME CHILE SPA.**
ADDRESS : Lynch 0587, Temuco.

I. BACKGROUND

This reports on the test of the Apparent Sound Reduction Index of a wall based on wooden bricks. Trabajo solicitado from the Construction Sciences Laboratory, Environmental Conditioning Area, by Mr. Juan Escobar B., on behalf of the company BME Chile

The sample was assembled by the client in the Acoustic Area Room of the Construction Technologies Research Center CITEC UBB.

II. TEST OBJECTIVE

To determine the sound transmission loss of a wall based on wooden bricks. The test method used corresponds to that specified in Standard NCh 2785, which provides frequency-dependent airborne sound insulation values. By applying Standard ISO 717-1, these values can be converted into a single number that characterizes the acoustic performance tested wall.

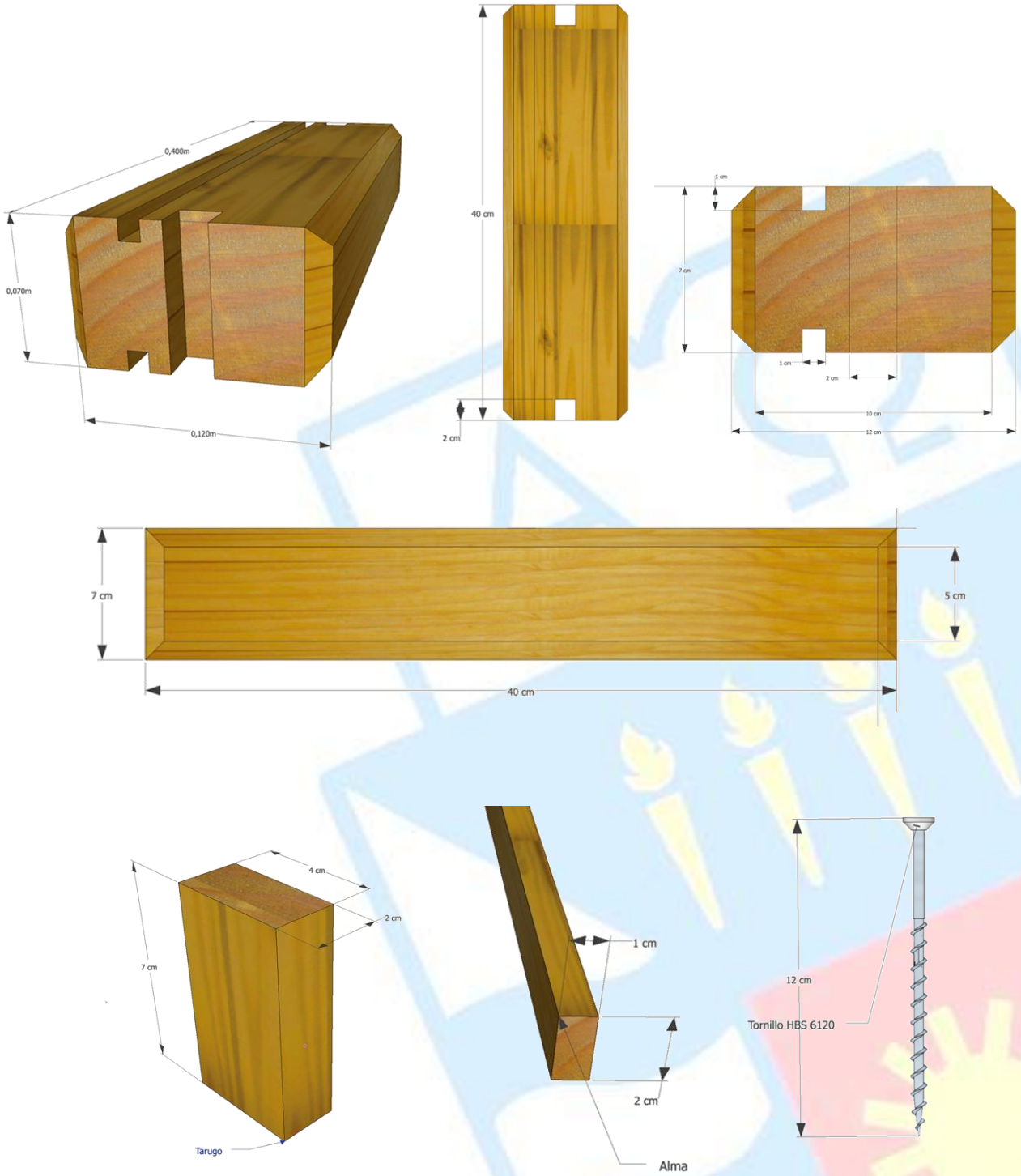
III. IDENTIFICATION OF THE PRODUCT SUBMITTED FOR

The sample of the wall system based on wooden bricks submitted for testing is the following:

Description	:	Wall element composed of wooden blocks or “bricks” (stabilized and treated radiata pine) in the form of a rectangular parallelepiped with longitudinal and short visible edges beveled, with grooves along their bearing faces at their horizontal joint. Ranuras intended to securely connect the blocks arranged in the upper course in an interlocking pattern. At the joint with the lateral block, it has a vertical groove for joining with a dowel of the material, resolving the horizontal and vertical joints with these interlocks. Wall thickness, e=0,120m.
Technical specifications	:	According to the attached plan and section, an integral part of
Sample dimensions	:	Width 3.95 m; Height 2.55

Note: Assembly specifications provided by the client.

PLAN AND CONSTRUCTION



IV. METHODS AND

Sound transmission loss is defined as 10 times the logarithm of the reciprocal of the ratio of the energy transmitted through a surface to the energy incident upon it. Generally, the frequency range of interest is composed of bands of 1/3 octave centered between 100 Hz and 3,150 Hz.

The test method used is that described by NCh 2785 "Acoustics – Measurement of Sound Insulation in Buildings and Building Elements – Field Measurements of Airborne Sound Insulation between Rooms". The measurement of the transmission loss in the sample is based on:

- The difference in the temporal and spatial average of the sound pressure level between the source chamber and the
- The area of the
- The total absorption of the receiving chamber. (The total absorption of the chamber is determined from the reverberation time of the receiving
- The measurement is based on the assumption that the sound fields of the source and receiving chambers are

The mathematical

$$TL = Lp_{(source)} - Lp_{(receiving)} + 10Log\left(\frac{S}{A}\right)$$

Where:

$L_{(source)}$: Sound pressure level in the source chamber. (dB re 2x10-5 Pa)

$L_{(receiving)}$: Sound pressure level in the receiving chamber. (dB re 2x10-5 Pa)

S: Sample surface area. (m ^{2})

A: Total absorption of the receiving chamber with the sample installed. (metros Sabine ^{2})

The test was performed following the procedure of the cited standard. Two source positions were configured of the omnidirectional source for six microphone positions. The sound signal used for the test was white noise and it was 1/3 octave bands, recording the center frequencies between 100 and 3,150 Hz.

The reverberation time was measured following the procedure of ISO 354 "Acoustic – Measurement of Sound Absortion in a Reverberation Room".

The entire system was duly calibrated.

To obtain the single number that characterizes the acoustic performance of the sample, the ISO 717-1 algorithm was used "Acoustics – Rating of sounds isolation in building and building element. Part 1: Airborne sound isolation".

The equipment used is detailed below:

Equip	Brand	Model	Seria
2	Brüel & Kjaer	4942	2330460 / 2330462
Soundbook (Acquisition Hardware)	Panasonic	CF-19	9CKCA57761
Noise & Vibration Software	SINUS Messtechnik GmbH	SAMURAI	#6444
Power Amplifier	Brüel & Kjaer	2716C	2401241
Omnidirectional Source	Brüel & Kjaer	4295	2368616
Acoustic Calibrator	Brüel & Kjaer	4231	2422540

The experimental setup used to determine the apparent sound reduction index is shown in Figure No. 1.

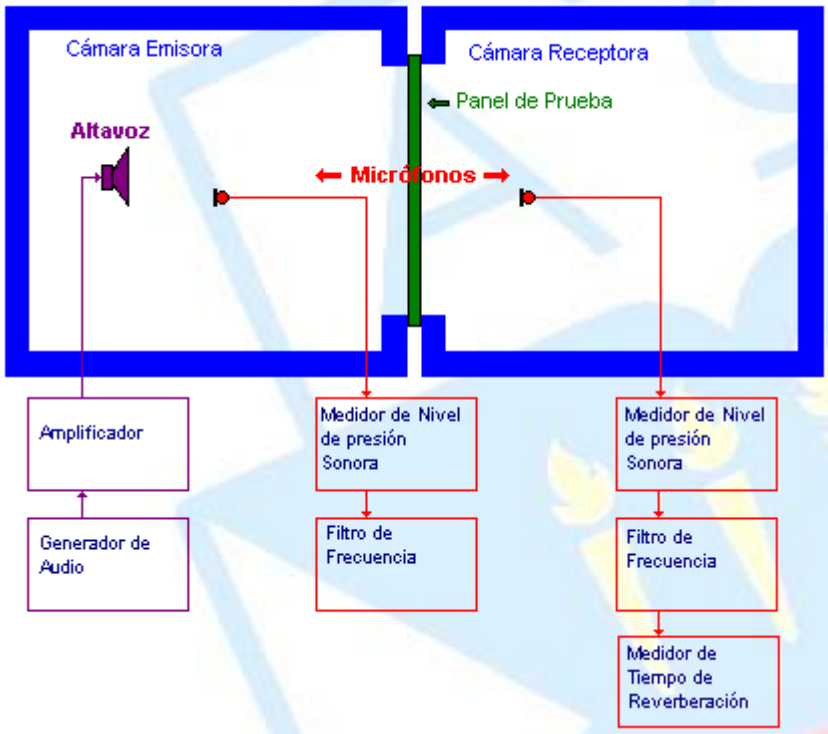


Fig. No. 1: Experimental setup diagram.

V. TEST CONDITIONS

Test date : March 10, 2020

Test specimen area : 10 ^{2}

Temperature in the test room : 21 °C

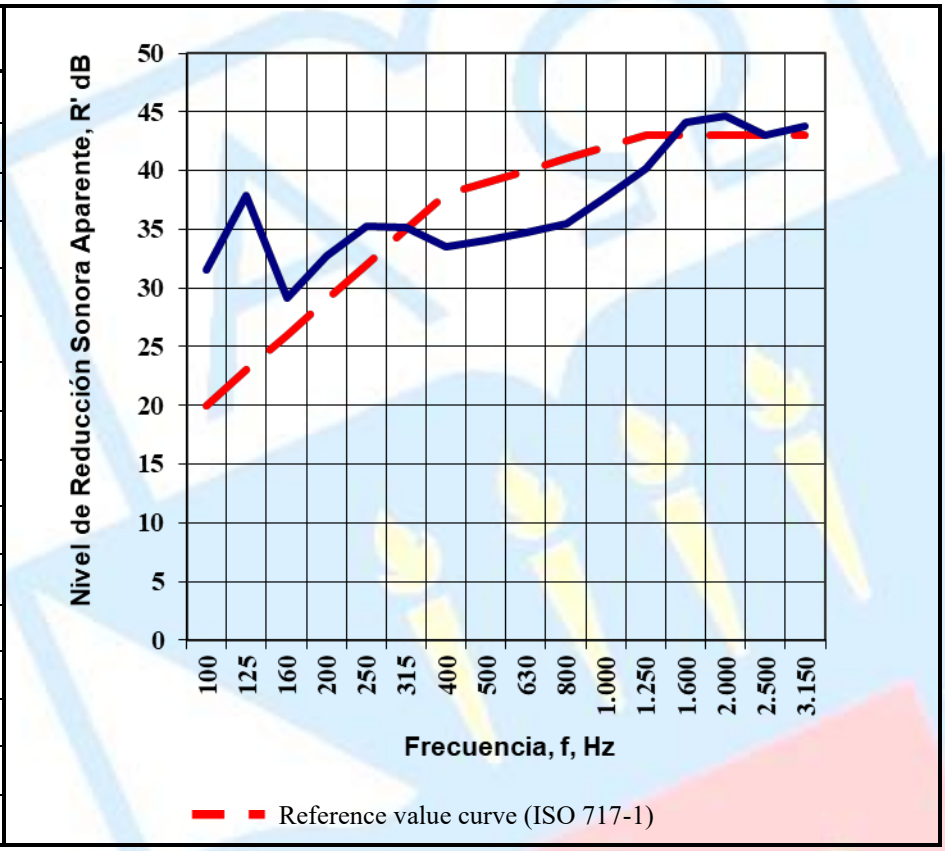
Humidity in the test room : 57 %

Volume of the emission room : 50 ^{3}

Volume of the receiving room : 58 ^{3}

VI. RESULTS

Frequency f, Hz	R', dB
100	31,5
125	37,9
160	29,1
200	32,7
250	35,3
315	35,1
400	33,5
500	34,1
630	34,7
800	35,5
1.000	37,8
1.250	40,2
1.600	44,1
2.000	44,6
2.500	43,0
3.150	43,8



VII. CONCLUSIONS AND OBSERVATIONS

Classification according to ISO 717-1: **$R (C ; {}_{tr}) = 39(-1; -2)$ dB**

Apparent Sound Reduction Index of the element submitted for testing: 38 dB(A)

Minimum Sound Reduction Index required by the General Ordinance of Urban Planning and Construction: 45 (Article 4.1.6, Supreme Decree No.

According to the results obtained, the element submitted for testing does not comply with the minimum requirements by the Ordinance.

The results obtained do not endorse past, present or future productions (production lots or inspection lots) and are applicable only to the tested element.

FREDDY GUZMAN GARCÉS
Acoustic Engineer
Acoustics Area CITEC

Dr. ARIEL BOBADILLA MORENO
Director of the Research Center in
Construction Technologies
CITEC UBB

PERFORM : **CONSTRUCTION TECHNOLOGY RESEARCH CENTER, CITEC UBB**
COLLAO AVENUE 1202, CONCEPCIÓN
CLIENT
NAME : **BME CHILE SPA.**
ADDRESS : Lynch 0587, Temuco

1. IDENTIFICATION OF THE TEST PANEL

1.1 Brand and
The panel corresponds to a representative wall of the BME construction system, composed of wooden blocks or "bricks" connected to each other through battens, dowels and screws. According to standard NCh806Of1971 it corresponds to type VI (mixed), class C (wood).

1.2 Date of manufacture: 26.05.2020

1.3 Geometry:
Symmetrical with respect to its coverings.

1.4 Dimensions:
Height: 2.40
Length: 2.40
Thickness: 0.12

1.5 Materials and construction
Rectangular-geometry panel (2400x2400mm) of the wooden block or "brick" wall type, with a total thickness of 120mm. It is formed by stabilized and treated radiata pine wooden blocks or "bricks" (400mm length, 120mm width, 70mm height) without additional coverings. The blocks or "bricks" are connected to each other through battens wooden dowels, reinforced by means of self-drilling screws type HBS6120.

2. TEST CHARACTERISTICS

2.1 Load holding time:

In the 3 tests, equal load increments were applied, with a tolerance of 10% of the load. The number of number of load increments was equal to or greater than 5 and, after the application of each load increment, the load level as constant as possible for an appropriate period. The average loading rate was 45 (kN/min)

2.2 Standard used:

This test was performed according to the provisions of Chilean Official Standard NCh 802.Of2017 "Building elements-Wall segments-Horizontal load test". Since this particular test sought to evaluate the behavior of the panel under conditions close to actual construction conditions, the test was performed in its mode without rotational rotation. The effective lateral displacements were calculated as the upper lateral displacement, minus uplift and minus the lower lateral displacement (panel aspect ratio equal to 1). Figure 1 shows the setup of the test in the laboratory.

Figure No. 1: Horizontal load test setup, according to NCh 802.

3. GRAPHS

The summarized results of this test are shown graphically in Figures No. 2 to No. 3 and Table No. 1. In both, only the values associated with the complete loading-unloading cycles, which were common to all tests, are shown. The panel that had the lowest resistance of the 3 tested was that corresponding to specimen #3, so this is considered the representative maximum load of the system. In all Figures, the applied load was divided by the panel length

Table 1: Numerical values for constructing horizontal load vs. horizontal displacement curves in Figure

		desplazamientos bajo carga (mm)			desplazamientos residuales (mm)			promedios (mm)	
carga (kN/m)	carga (T)	ensayo 1	ensayo 2	ensayo 3	ensayo 1	ensayo 2	ensayo 3	dprom	rprom
0.82	0.20	0.74	0.74	-0.01	0.05	0.04	-0.44	0.49	-0.12
1.63	0.40	1.91	1.62	1.11	0.42	0.35	-0.16	1.55	0.20
2.45	0.60	4.26	4.09	1.92	1.75	1.44	0.44	3.42	1.21
3.27	0.80	7.80	7.17	5.47	4.04	3.78	2.09	6.81	3.30
4.09	1.00	11.90	10.89	8.85	6.94	6.77	3.94	10.55	5.88
4.90	1.20	19.80	16.60	14.07	11.96	10.52	6.41	16.82	9.63
5.72	1.40	26.66	23.89	17.95	16.48	15.76	8.88	22.83	13.71
6.54	1.60	36.59	32.93	22.77	22.70	21.61	12.05	30.76	18.79
7.36	1.80	49.57	41.89	29.89	34.64	28.31	16.60	40.45	26.52
8.17	2.00	--	51.88	39.01	--	35.16	21.11	--	--
8.99	2.20	--	--	47.58	--	--	23.85	--	--

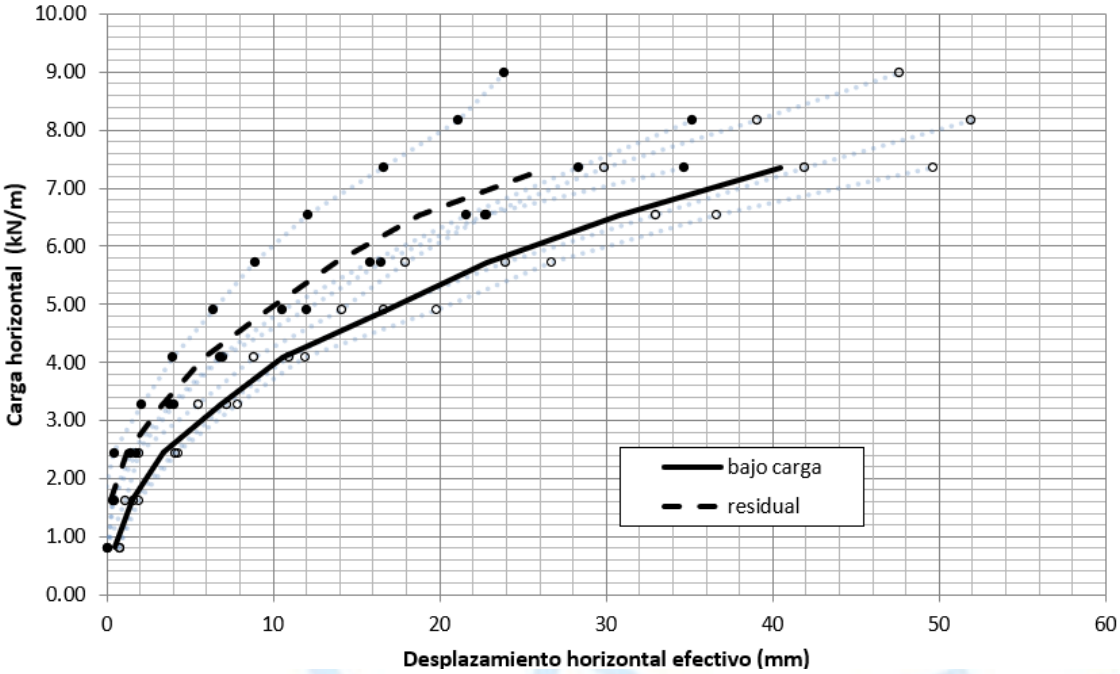
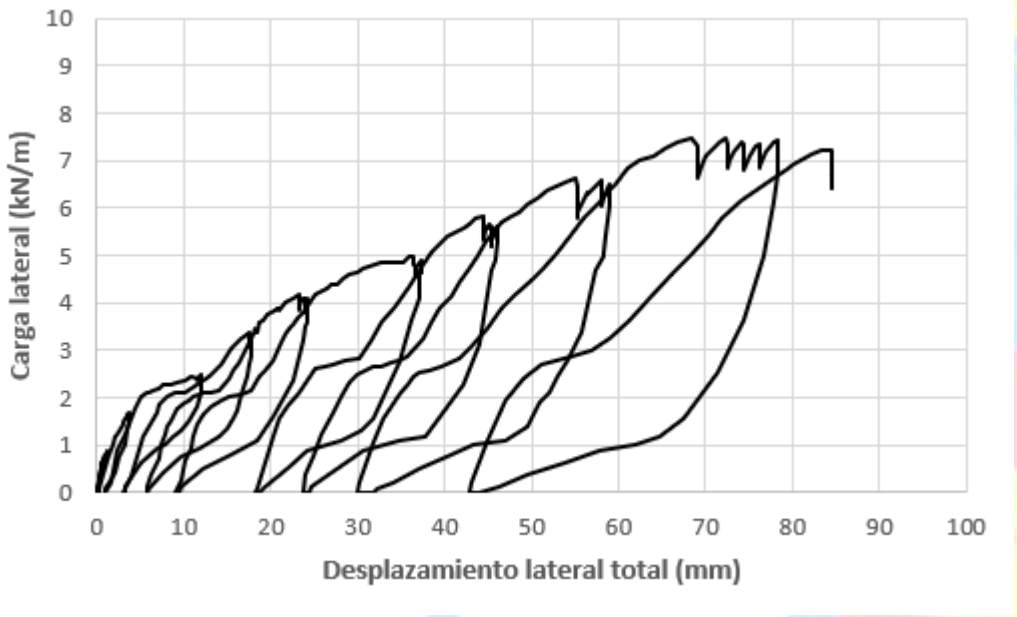
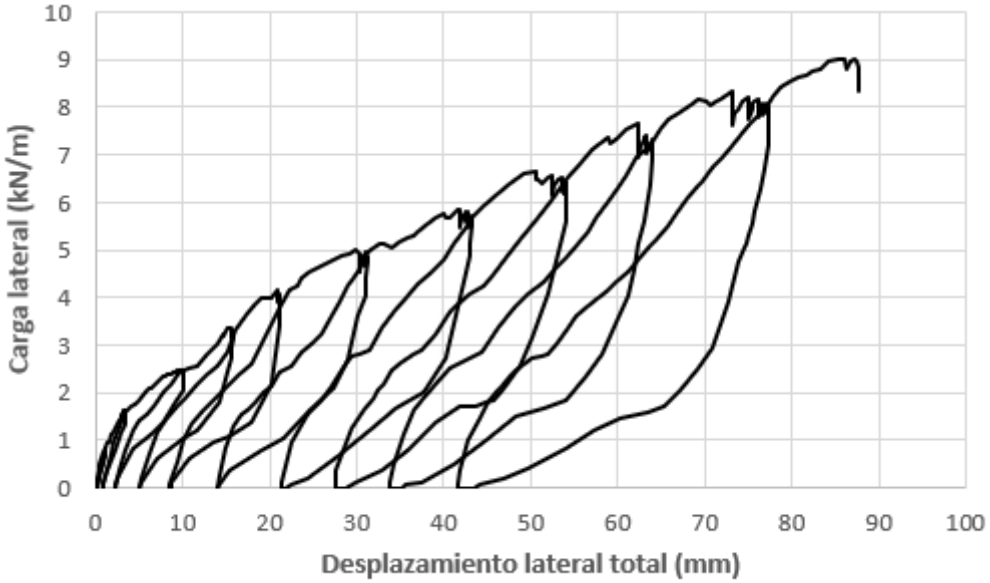


Figure No. 2: Graph of horizontal load test results, according to NCh 802. (Note: The continuous black line corresponds to a piecewise linear fit to the average of the displacements associated with each load level).



(a)



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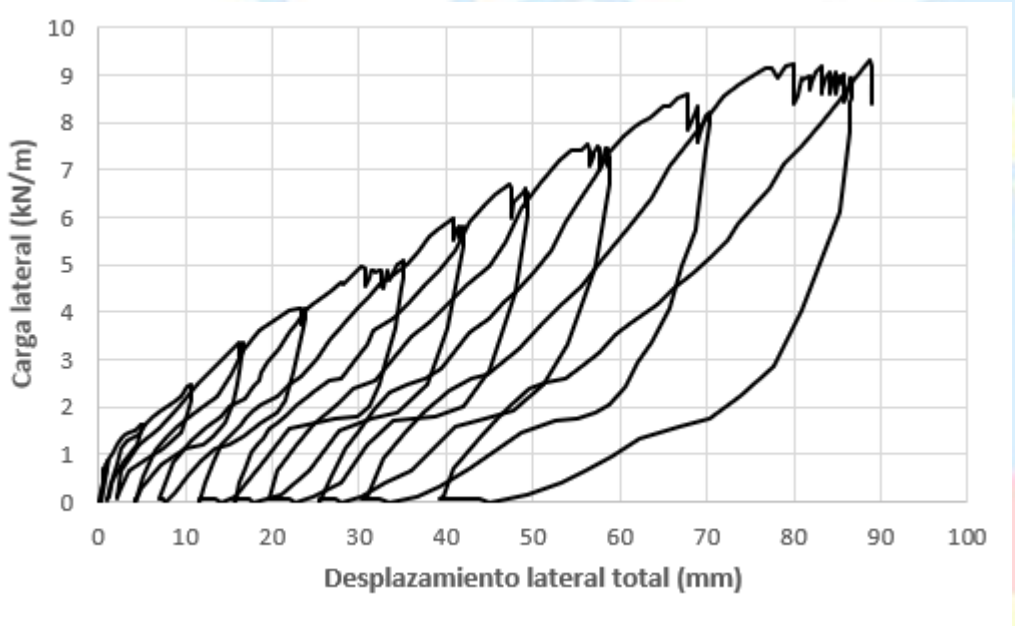

(c)

Figure No. 3: Lateral loading-unloading curves versus total lateral displacement for: (a) specimen #1, (b) specimen

4. LOADS

The representative maximum load of the system corresponds to the lowest maximum load value reached by any of the specimens, in this case 7.36 (kN/m) for specimen # 1. For that load level, total horizontal deformations were obtained of 69.08 mm, while the effective deformations were 49.57mm (subtracting uplifts and slips). Based on the average of the tests, the load at the proportionality limit is estimated to correspond to 4.09 (kN/m). The horizontal deformation effective for that load level was 10.55 mm.

5. FAILURES, WARPING AND DETACHMENTS

In the 3 panels, failures associated with excessive lateral displacements of the system were evidenced, due to its low lateral lateral. The damage was observed mainly at the edge experiencing the greatest uplift in the wall, through dislocations of the wooden “brick” blocks. The 3 tests were stopped before the maximum resistance of the system was developed, since it was on track to reach excessive total lateral displacements of put the stability of the system and damage to the sensors and equipment at risk. The foregoing is shown in Figure No. 4 mentioned.

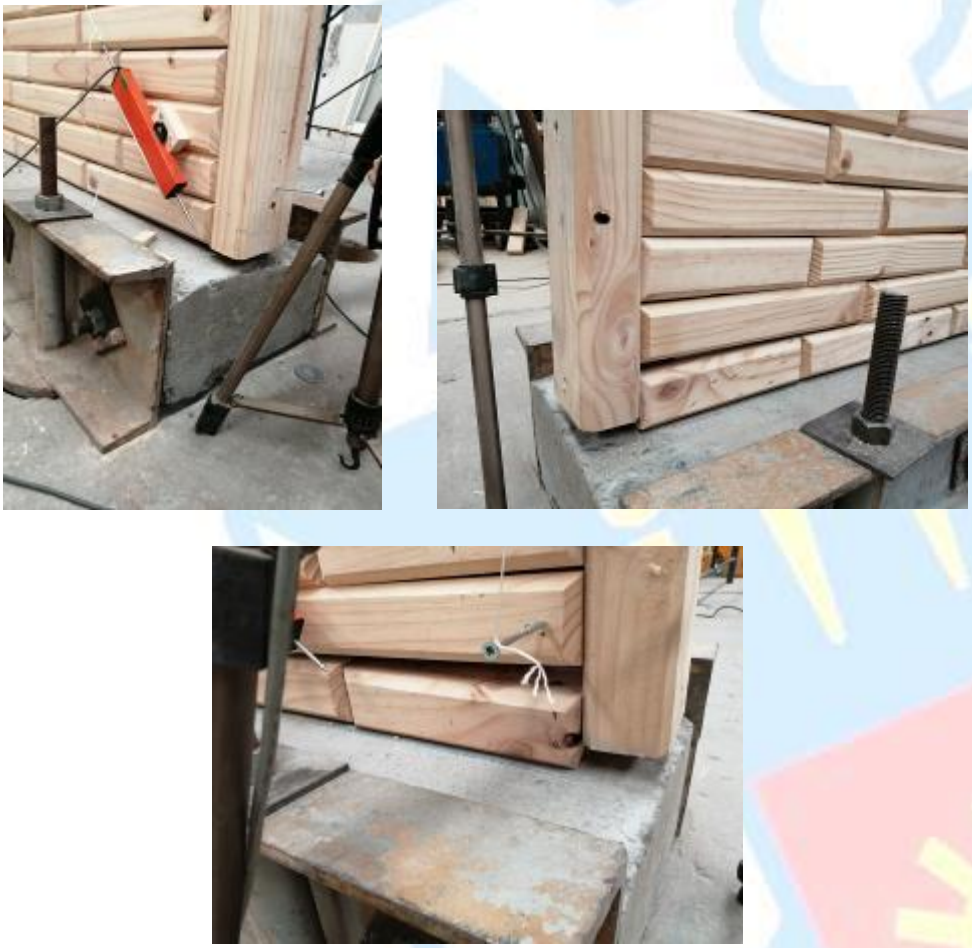

Figure No. 4: Horizontal-load failure modes for tested panels.

6. COMPLIANCE WITH REQUIREMENTS

According to the format of Chilean Standard NCh806EOf71, on average the tested panels have the following characteristics:

- Breaking load: 750.51 (kgf/m). (The breaking load was divided by the panel length, 2.40m)
- Load at proportionality limit: 417.06 (kgf/m) (The limit load was divided by the panel length, 2.40m)
- Allowable deformation at proportionality limit: 10.55 (mm).

Therefore, from the point of view of horizontal load resistance, the panel is classified in category RH1c, indicated in standard NCh806EOf71.

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Head of Structural Engineering Area
University of Bío-Bío

Dr. ARIEL BOBADILLA MORENO
CITEC Director
University of Bío-Bío

PERFORM : **CONSTRUCTION TECHNOLOGY RESEARCH CENTER, CITEC UBB**
COLLAO AVENUE 1202, CONCEPCIÓN
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NAME : **BME CHILE SPA.**
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1. IDENTIFICATION OF THE TEST PANEL

1.1 Brand and
The panel corresponds to a representative wall of the BME construction system, composed of wooden blocks or "bricks" connected to each other through battens, dowels and screws. According to standard NCh806Of1971 it corresponds to type VI (mixed), class C (wood).

1.2 Date of manufacture: 26.05.2020

1.3 Geometry:
Symmetrical with respect to its coverings.

1.4 Dimensions:
Length: 2.40
Width: 1.20 (m)
Thickness: 0.12

1.5 Materials and construction
Rectangular-geometry panel (1200x2400mm) of the wooden block or "brick" wall type, with a total thickness of 120mm. It is formed by stabilized and treated radiata pine wooden blocks or "bricks" (400mm length, 120mm width, 70mm height) without additional coverings. The blocks or "bricks" are connected to each other through battens wooden dowels, reinforced by means of self-drilling screws type HBS6120.

2. TEST CHARACTERISTICS

2.1 Test panel position:
The panel was tested in the horizontal

2.2 Span between
A span between supports of 2.20 m was

2.3 Load holding time:

In the 3 tests, equal load increments were applied, with a tolerance of 10% of the load. The number of number of load increments was equal to or greater than 5 and, after the application of each load increment, the load level as constant as possible for an appropriate period.

2.4 Standard used:

This test was performed according to the provisions of Chilean Official Standard NCh 803.Of2016 "Building elements-Wall segments-Flexure test". Figure 1 shows the setup of the test in the laboratory.

Figure No. 1: Flexure test setup, according to NCh 803.

3. GRAPHS

The results of this test are shown graphically in Figures No. 2 to No. 3. In all these graphs the load was calculated vertical as the applied force divided by the panel width (1.20m). In both figures, only the levels of load that were common to all tests are shown.
To generate the graph in Figure No. 2, the vertical deformation of the panel was calculated as the average at 2 edges located at the midpoint of the support span. In turn, Figure No. 3 shows the complete loading-unloading curve vertical versus vertical deformation. The panel with the lowest resistance of the 3 tested was specimen #2. In Table 1 the data associated with generating Figure No. 2 are shown

Table 1: Numerical values for constructing vertical load vs. vertical deformation

		desplazamientos bajo carga (mm)			desplazamientos residuales (mm)			promedios (mm)	
carga (kN/m)	carga (T)	ensayo 1	ensayo 2	ensayo 3	ensayo 1	ensayo 2	ensayo 3	dprom	rprom
4.09	0.50	4.65	4.02	4.20	0.32	0.44	0.91	4.29	0.55
8.17	1.00	9.31	7.86	8.09	0.67	0.62	1.76	8.42	1.01
12.26	1.50	11.89	11.45	11.55	0.74	0.72	2.11	11.63	1.19
16.35	2.00	14.54	15.77	14.68	0.81	0.85	2.30	14.99	1.32
20.43	2.50	18.65	19.59	18.01	1.26	0.91	2.49	18.75	1.55
24.52	3.00	22.90	23.61	21.26	1.07	0.55	2.70	22.59	1.44
28.60	3.50	26.75	27.61	24.45	1.12	1.29	2.82	26.27	1.74
32.69	4.00	30.06	--	28.54	1.31	--	3.14	--	--
36.78	4.50	--	--	31.95	--	--	3.39	--	--
40.86	5.00	--	--	36.23	--	--	3.72	--	--

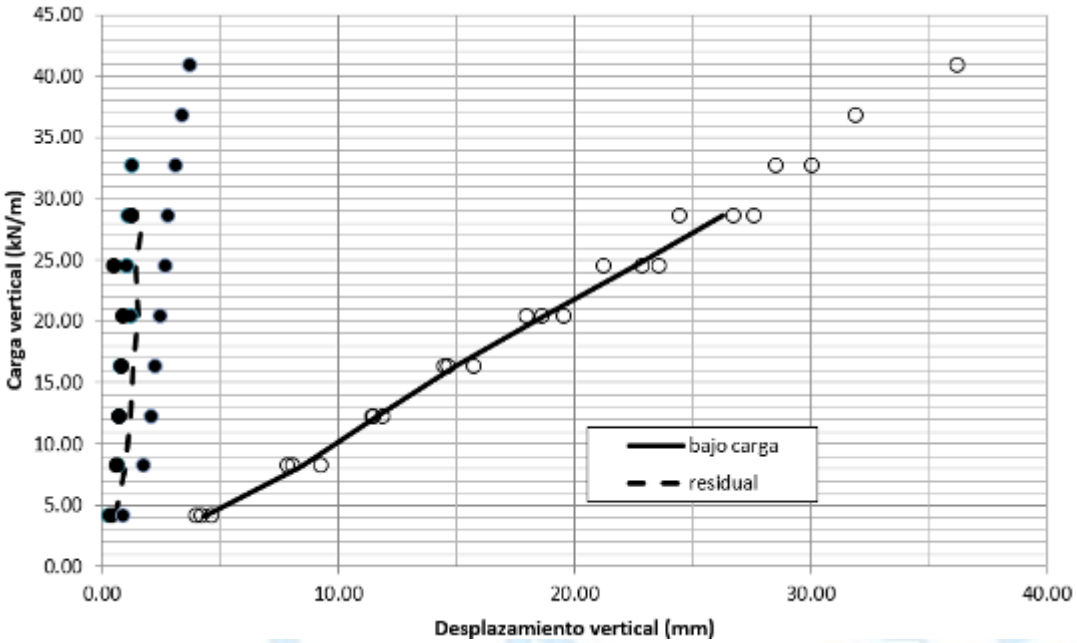

Figure No. 2: Graph of flexure test results, according to NCh 803. (Note: The continuous black line a piecewise linear fit to the average of the displacements associated with each load level)

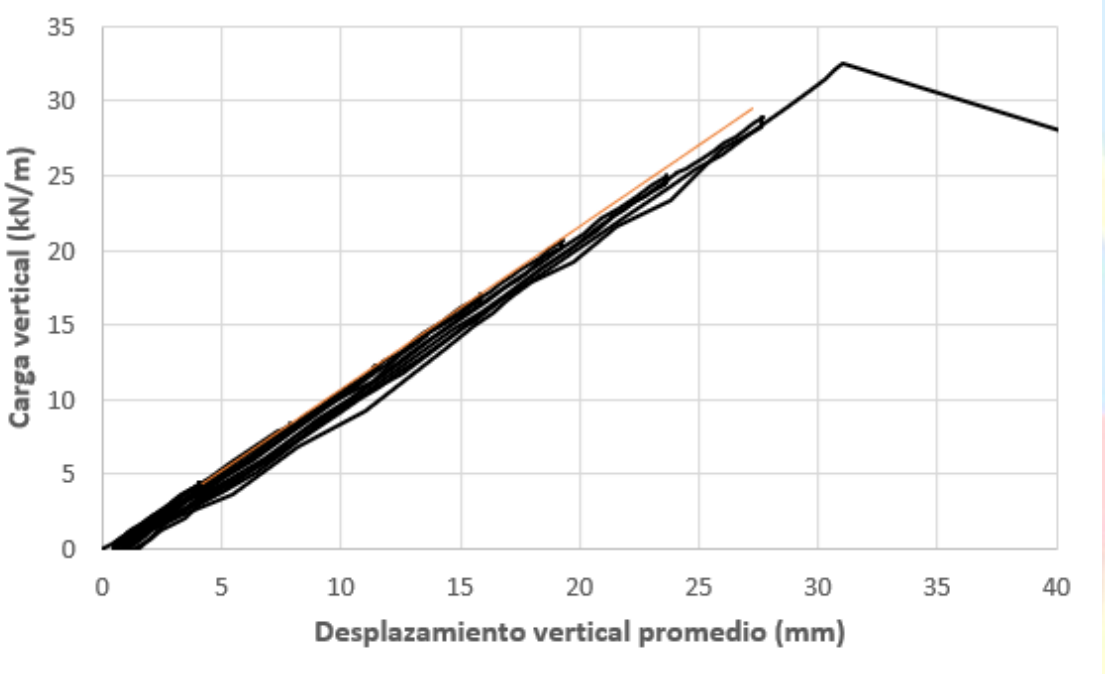

Figure No. 3: Vertical loading-unloading graph versus vertical deformation for specimen #2 (least

4. LOADS

The representative maximum load of the system corresponds to the lowest maximum load value reached by any of the specimens, in this case 28.60 (kN/m). For that load level, vertical deformations of 27.61mm were obtained.
Based on the average of the tests, the load at the proportionality limit is estimated to correspond to 20.43 (kN/m). La vertical deformation para ese nivel de load fue de 18.75mm.

5. FAILURES, WARPING AND DETACHMENTS

In the 3 tested panels, flexural failures were evidenced at the flexural-tension edge, accompanied by excessive vertical displacements, and fracture of wooden posts at the panel edges. A graphic summary is shown in Figure of the foregoing.

Figure No. 4: Flexure failure modes for loaded panels.

6. COMPLIANCE WITH REQUIREMENTS

According to the format of Chilean Standard NCh806EOf71, on average the tested panels have the following characteristics:

- Breaking load: 2916.39 (kgf/m). (The breaking load was divided by the panel width, 1.20m)
- Load at proportionality limit: 2083.28 (kgf/m) (The limit load was divided by the panel width, 1.20m)
- Allowable deformation at proportionality limit: 18.75 (mm).

Therefore, from the point of view of flexural resistance, the panel is classified in category RT3c, indicated in the standard NCh806EOf71.

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PERFORM : **CONSTRUCTION TECHNOLOGY RESEARCH CENTER, CITEC UBB**
COLLAO AVENUE 1202, CONCEPCIÓN

CLIENT
NAME : **BME CHILE SPA.**
ADDRESS : Lynch 0587, Temuco

1. IDENTIFICATION OF THE TEST PANEL

1.1 Brand and
The panel corresponds to a representative wall of the BME construction system, composed of wooden blocks or "bricks" connected to each other through battens, dowels and screws. According to standard NCh806Of1971, it corresponds to the tipo VI (mixed), class C (wood).

1.2 Date of manufacture: 26.05.2020.

1.3 Geometry:
Symmetrical with respect to its coverings.

1.4 Dimensions:
Height: 2.40
Length: 1.20
Thickness: 0.12

1.5 Materials and construction
Rectangular-geometry panel (2400x2400mm) of the wooden block or "brick" wall type, with a total thickness of 120mm. It is formed by stabilized and treated radiata pine wooden blocks or "bricks" (400mm length, 120mm width, 70mm height) without additional coverings. The blocks or "bricks" are connected to each other through battens wooden dowels, reinforced by means of self-drilling screws type HBS6120.

1.6 Selection method:
To select the panels to be tested, 3 panels were randomly taken from a total of 12, specially manufactured for the tests.

2. TEST CHARACTERISTICS

2.1 Test panel position:

The panel was tested in the vertical

2.2 Span between

A span between supports of 2.2 m was

2.3 Total mass of the impact bag.

The total mass of the impact bag was 30.0 kg and it struck the typical covering of the panel

2.4 Standard used:

This test was performed according to the provisions of Chilean Official Standard NCh 804.Of2017 "Building elements-Wall segments-Impact test". A total of 3 panels were impact-tested. Figure No. 1 shows the test setup.

Figure No. 1: Impact test setup

3. GRAPHS AND

Figure No. 2 shows the instantaneous horizontal displacements measured in the panel for different impact loads impact (impact energies for different drop heights). The impact energy was calculated as the product of the mass of the impact bag, the drop height relative to the center and the acceleration of gravity.

Table No. 1 shows the results of the impact tests from which the graphs were generated.

4. DROP HEIGHT

Following the requirements of Standard NCh804, the test began with a drop height of 150 mm (with respect to the mid-height of the panel), and then this height was increased every 150 mm.

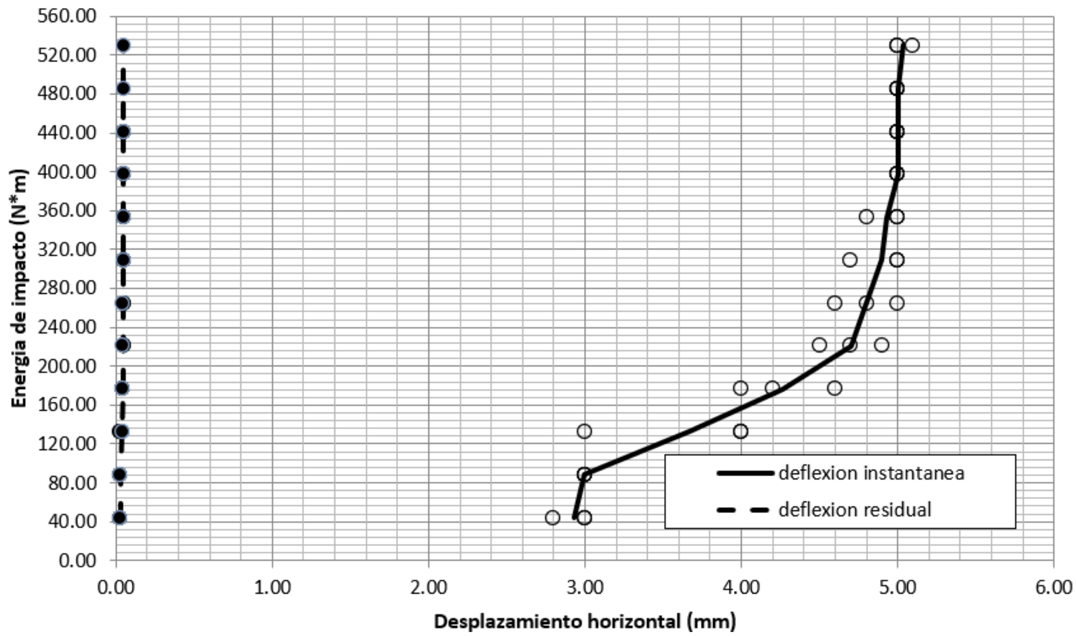

Figure No. 2: Graph of impact test results

Table No. 1: Impact test results.

		desplazamientos bajo carga (mm)			desplazamientos residuales (mm)			promedios (mm)	
energia (N*m)	altura (m)	ensayo 1	ensayo 2	ensayo 3	ensayo 1	ensayo 2	ensayo 3	dprom	rprom
44.15	1.35	2.80	3.00	3.00	0.03	0.03	0.03	2.93	0.03
88.29	1.50	3.00	3.00	3.00	0.03	0.03	0.03	3.00	0.03
132.44	1.65	4.00	3.00	4.00	0.04	0.03	0.04	3.67	0.04
176.58	1.80	4.60	4.00	4.20	0.05	0.04	0.04	4.27	0.04
220.73	1.95	4.90	4.70	4.50	0.05	0.05	0.05	4.70	0.05
264.87	2.10	5.00	4.80	4.60	0.05	0.05	0.05	4.80	0.05
309.02	2.25	5.00	5.00	4.70	0.05	0.05	0.05	4.90	0.05
353.16	2.40	5.00	5.00	4.80	0.05	0.05	0.05	4.93	0.05
397.31	2.55	5.00	5.00	5.00	0.05	0.05	0.05	5.00	0.05
441.45	2.70	5.00	5.00	5.00	0.05	0.05	0.05	5.00	0.05
485.60	2.85	5.00	5.00	5.00	0.05	0.05	0.05	5.00	0.05
529.74	3.00	5.10	5.00	5.00	0.05	0.05	0.05	5.03	0.05

5. FAILURE MECHANISMS, CRACKS AND DETACHMENTS

The panels suffered no deterioration during the test.

6. COMPLIANCE WITH REQUIREMENTS.

According to the format of Chilean Standard NCh806.EOf71, on average the tested panels have the following characteristics:

- Impact load for which there is no apparent deterioration: 353.16 (J)
- Impact load for which the panel does not break: 529.74 (J)
- Maximum residual deformation-instantaneous deformation ratio in the elastic zone: less

From the aforementioned results, it is concluded that the panels have satisfactory behavior under impact loads impact.

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CLIENT
NAME : **BME CHILE SPA.**
ADDRESS : Lynch 0587, Temuco

1. IDENTIFICATION OF THE TEST PANEL

1.1 Brand and
The panel corresponds to a representative wall of the BME construction system, composed of wooden blocks or "bricks" connected to each other through battens, dowels and screws. According to standard NCh806Of1971, it corresponds to the tipo VI (mixed), class C (wood).

1.2 Date of manufacture: 26.05.2020

1.3 Geometry:
Symmetrical with respect to its coverings.

1.4 Dimensions:
Height: 2.40
Length: 1.20 (m)
Thickness: 0.12

1.5 Materials and construction
Rectangular-geometry panel (1200x2400mm) of the wooden block or "brick" wall type, with a total thickness of 120mm. It is formed by stabilized and treated radiata pine wooden blocks or "bricks" (400mm length, 120mm width, 70mm height) without additional coverings. The blocks or "bricks" are connected to each other through battens wooden dowels, reinforced by means of self-drilling screws type HBS6120.

2. TEST CHARACTERISTICS

2.1: Reference length:
To measure vertical deflections, a reference length of 2.2 m was used in the displacement transducers

2.2 Load holding time:
In the 3 tests, equal load increments were applied, with a tolerance of 10% of the load. The number of number of load increments was greater than 5 and, after the application of each load increment, the load level was maintained constant as possible for a period of 5 minutes. The loading rate was 1 (mm/min).

2.3 Standard used:
This test was performed according to the provisions of Chilean Official Standard NCh 801.Of2016 "Building elements-Wall segments-Compression test". A total of 3 panels were compression-tested. Figure No. 1 shows the test setup in the laboratory.

Figure No. 1: Compression test setup, according to NCh 801.

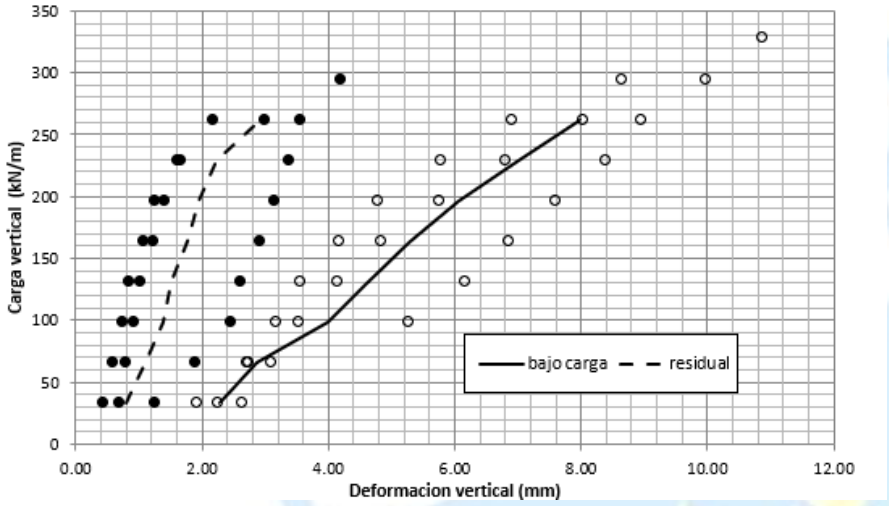
3. GRAPHS

The results of this test are shown graphically in Figures No. 2 and No. 3. The vertical load was calculated as the force applied divided by the panel length (1.20m).
To generate the graph in Figure No. 2, the vertical deformation of the panel was calculated as the average in 4 vertical vertical (both faces, 2 edges), multiplied by the ratio between the panel height and the length of the vertical lines (2.44/2.2=1.1). In the figure, only the load levels that were common to all tests are shown. In Table 1 the data associated with generating Figure No. 2 are shown.

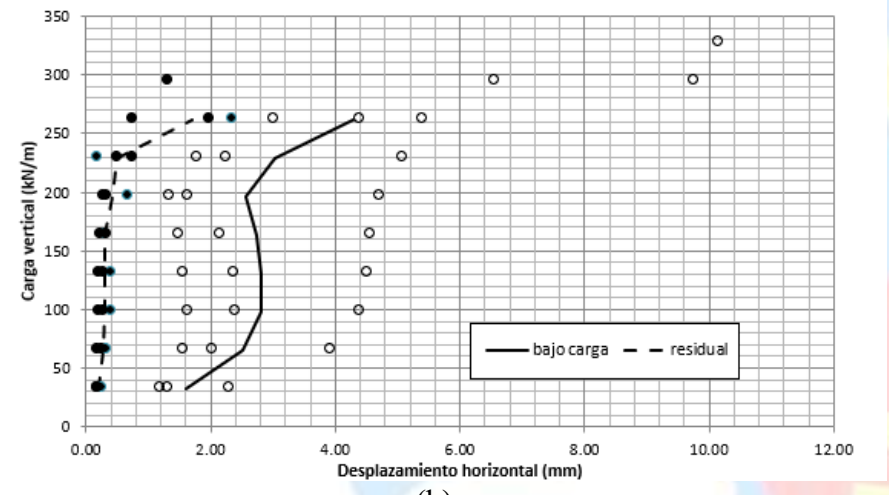
Table 1: Numerical values for constructing vertical load vs. vertical deformation

		Deformaciones verticales							
		bajo carga (mm)			residuales (mm)			promedios (mm)	
Carga (kN/m)	Carga (T)	ensayo 1	ensayo 2	ensayo 3	ensayo 1	ensayo 2	ensayo 3	dprom	rprom
32.70	4.00	1.93	2.27	2.66	0.45	0.71	1.27	2.28	0.81
65.40	8.00	2.73	2.75	3.12	0.59	0.80	1.90	2.87	1.10
98.10	12.00	3.54	3.18	5.28	0.76	0.95	2.47	4.00	1.39
130.80	16.00	4.16	3.58	6.17	0.86	1.04	2.63	4.63	1.51
163.50	20.00	4.85	4.18	6.86	1.10	1.24	2.94	5.30	1.76
196.20	24.00	5.77	4.80	7.60	1.27	1.42	3.16	6.06	1.95
228.90	28.00	6.82	5.79	8.39	1.63	1.67	3.40	7.00	2.23
261.60	32.00	8.05	6.92	8.96	3.01	2.18	3.58	7.98	2.92
294.30	36.00	--	8.67	10.00	--	--	4.21	--	--
327.00	40.00	--	--	10.88	--	--	--	--	--

		Desplazamientos laterales							
		bajo carga (mm)			residuales (mm)			promedios (mm)	
Carga (kN/m)	Carga (T)	ensayo 1	ensayo 2	ensayo 3	ensayo 1	ensayo 2	ensayo 3	dprom	rprom
32.70	4.00	1.21	1.33	2.31	0.27	0.18	0.19	1.62	0.21
65.40	8.00	2.04	1.57	3.92	0.33	0.27	0.20	2.51	0.27
98.10	12.00	2.42	1.64	4.39	0.40	0.30	0.22	2.82	0.31
130.80	16.00	2.37	1.57	4.51	0.41	0.30	0.22	2.82	0.31
163.50	20.00	2.17	1.49	4.57	0.32	0.33	0.25	2.74	0.30
196.20	24.00	1.63	1.35	4.71	0.67	0.28	0.34	2.56	0.43
228.90	28.00	1.78	2.26	5.09	0.20	0.76	0.51	3.04	0.49
261.60	32.00	3.03	4.40	5.41	2.35	1.98	0.75	4.28	1.69
294.30	36.00	--	9.78	6.56	--	--	1.32	--	--
327.00	40.00	--	--	10.17	--	--	--	--	--



(a)



(b)

Figure No. 2: Results graphs: (a) vertical load vs. vertical deformation, (b) vertical load vs. horizontal deformation.
(Note: The continuous black line corresponds to a piecewise linear fit to the average of the displacements associated with each load level).

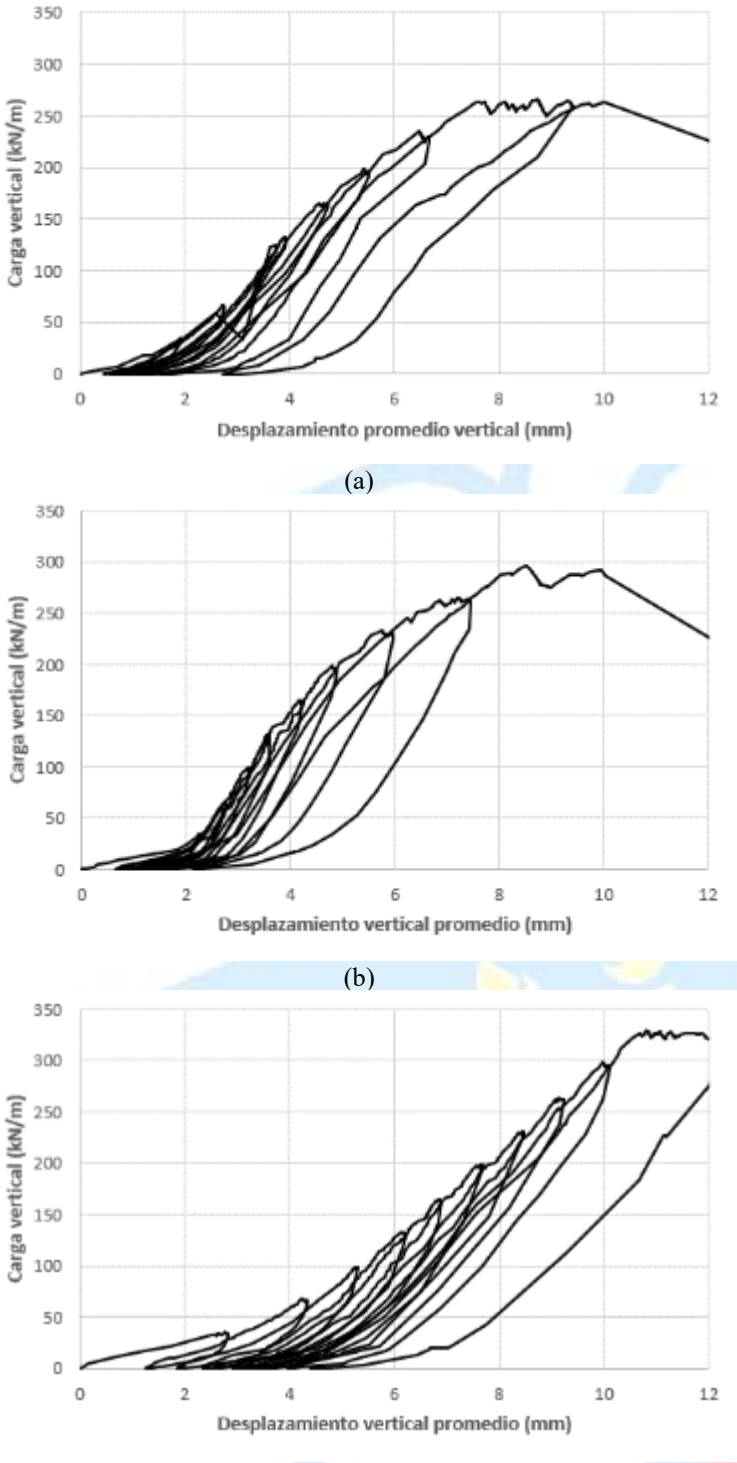


Figure No. 2: Force loading-unloading graphs vs. vertical displacement for: (a) specimen #1, (b) specimen #2, (c)

4. LOADS

The representative maximum load of the system was limited by the worst compression performance of the panels, generated specimen # 1. Thus, the maximum load was 261.60 (kN/m). For that load level, deformations were obtained maximum vertical deformations of 8.05 (mm) and maximum lateral displacements of
Based on the average of the results, it is estimated that the load at the proportionality limit corresponds to 130.80 (kN/m). The vertical deformation and lateral displacement for that load level were 4.63 (mm) and 2.82 (mm), respectively.

5. FAILURES, WARPING AND DETACHMENTS

In the 3 tested panels, failures due to local buckling and fracture of the wall edge posts were evidenced. Figure No. 3 shows a graphic summary of the foregoing.

Figure No. 3: Compression failure modes for loaded panels.

6. COMPLIANCE WITH REQUIREMENTS

According to the format of Chilean standard NCh806.EOf71, the tested panels have the following characteristics:

- Breaking load: 26675.78 (kgf/m)
- Load at proportionality limit: 13337.89 (kgf/m)
- Allowable deformation at the proportionality limit: 4.63 (mm) vertical and 2.82 (mm) lateral

Therefore, from the point of view of compression resistance, the panel is classified in category RC3c.

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CITECUBB — Centro de Investigación en Tecnologías de la Construcción, Universidad del Bío-Bío	**TEST REPORT** **DETERMINATION OF COEFFICIENT OF THERMAL**	**REPORT No.**	**3928**
		ISSUE DATE	01.02.2021
		PAGE No.	1/5

AREA CODE : AA

PERFORM : **CONSTRUCTION TECHNOLOGY RESEARCH CENTER, CITEC UBB. COLLAO AVENUE 1202, CONCEPCIÓN.**

CLIENT
NAME : **BME CHILE SPA**
ADDRESS : Lynch 0587, Temuco

I. BACKGROUND

This reports on the determination of the thermal transmission coefficient of a wall based on wooden bricks. Work requested from the Construction Sciences Laboratory, Environmental Conditioning Area, by Mr. Juan Escobar B., on behalf of the company BME Chile SpA.

II. TEST OBJECTIVE

To determine the thermal transmission coefficient of a full-size sample representative of a window element.

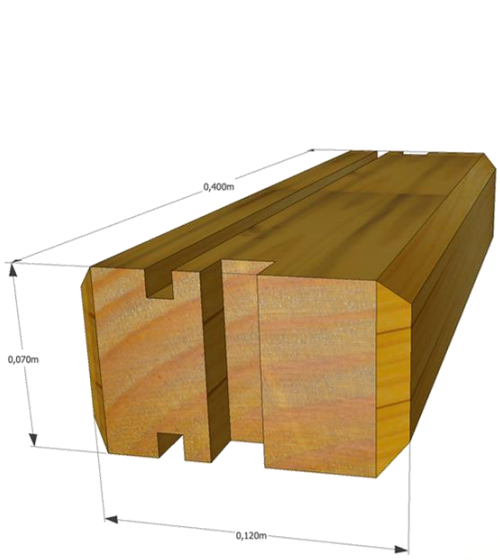
III. IDENTIFICATION OF THE PRODUCT SUBMITTED FOR

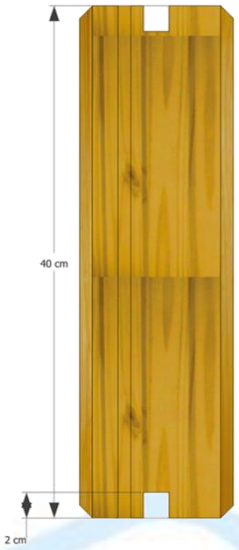
The sample of the wall system based on wooden bricks submitted for testing is the following:

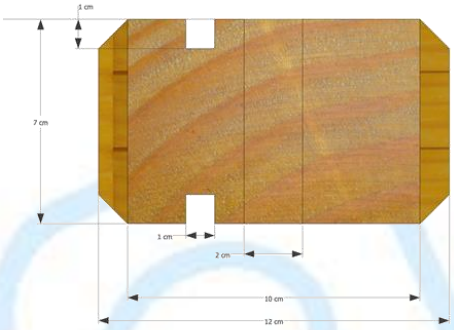
Description	:	Wall element composed of wooden blocks or “bricks” (stabilized and treated radiata pine) in the form of a rectangular parallelepiped with longitudinal and short visible edges beveled, with grooves along their bearing faces at their horizontal joint. Ranuras intended to securely connect the blocks arranged in the upper course in an interlocking pattern. At the joint with the lateral block, it has a vertical groove for joining with a dowel of the material, resolving the horizontal and vertical joints with these interlocks. Wall thickness, e=0,120m.
Technical specifications	:	According to the attached plan and section, an integral part of
Sample dimensions	:	Width 1,36 m; Height 1,54

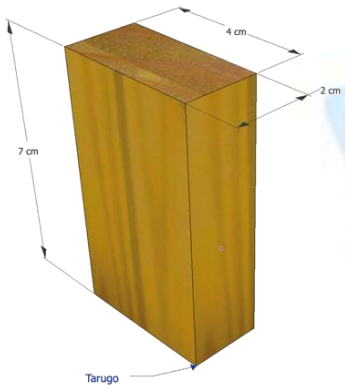
Note: Assembly specifications provided by the client.

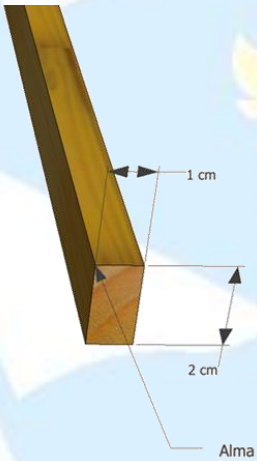
PLAN AND CONSTRUCTION

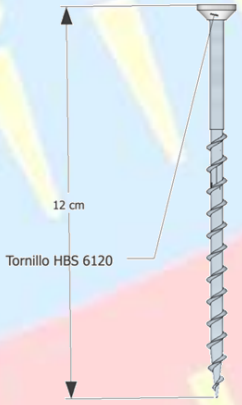












Note: diagram provided by the client.

IV. METHODS AND

The thermal chamber method is used, according to the procedure described in Chilean Standard NCh 851 Of2008 "Thermal Insulation – Determination of steady-state thermal transmission properties and related properties – Chamber Thermal Calibrada and of

The apparatus used to apply the method basically consists of three chambers, which are boxes open on one of their sides: 1) Guard or hot chamber (1.85 x 1.85m); 2) Cold chamber; 3) Measuring or protected chamber (1.0 x 1.0 (m)). See Figure No. 1. The method is reduced to determining, under steady-state conditions, the heat flow passing through a construction element respective temperatures in a measurement area of 1.0 m^2. The 1.39 x 1.55 (m) sample is placed vertically between two special thermal chambers with internal-face emissivity of 0.2; in one of them, a hot environment is simulated using adjustable-power electrical resistances and, in the other opposing chamber, a cold environment based on a conventional cooling unit conventional. In this way, an amount of heat flows through the construction element that is inversely proportional to its thermal

Under these conditions, thermal transmittance (U) is determined as follows:

$$U = \frac{\phi}{A \, \Delta Ta}$$

U	:	Transmitancia thermal, ^{2}K).
ϕ	:	Thermal flow passing through the element,
A	:	Measurement area, ^{2}).
ΔTaa	:	Difference in average temperatures: air-air on both sides of the element (K)

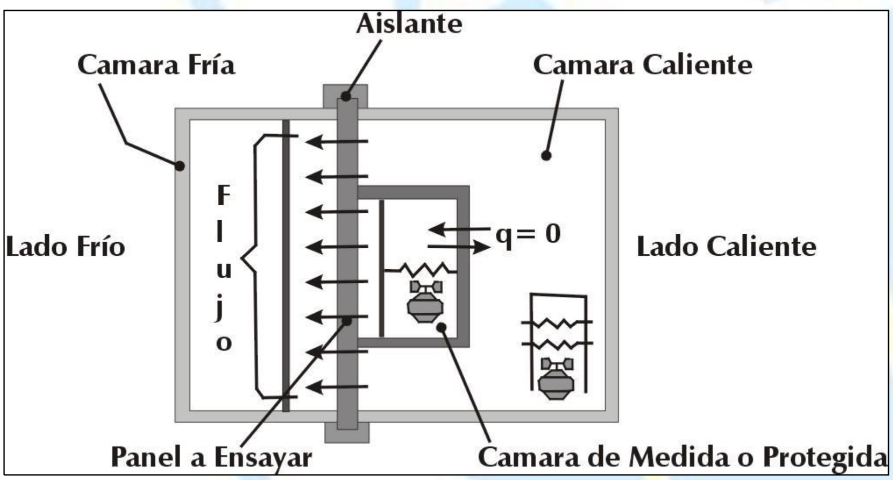
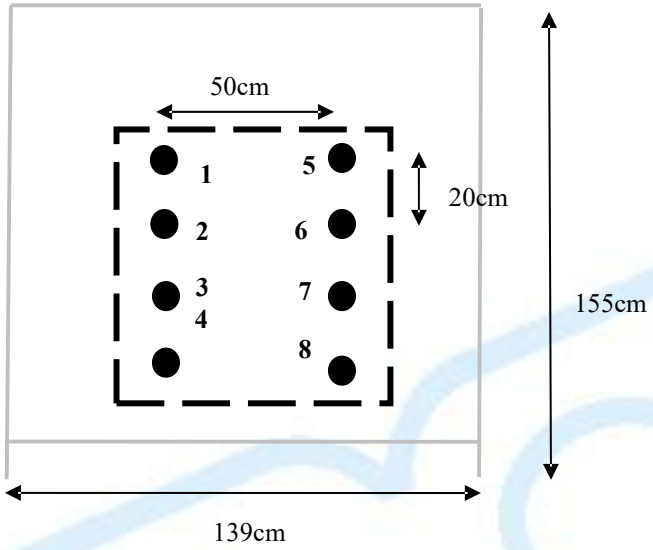


Figure No. 1: Experimental setup diagram.

For measurement of surface temperatures, 8 type T thermocouples (copper-constantan) are placed on each face of the wall, according to the following setup diagram:

Sensor installation diagram



V. DATE OF SPECIMEN RECEIPT AND TESTING

Date of sample receipt	:	02/04/2020
Date of material receipt	:	Not
Date of sample preparation	:	Not
Test start date	:	02/05/2020
Test end date	:	04/05/2020

VI. SAMPLING PROCEDURE

The specimen was placed in the Laboratory by the client; therefore, the Laboratory is not responsible for the sampling procedure

VII. TEST CONDITIONS

At the time of the test, the laboratory had an ambient temperature of 20ºC and relative humidity of 61%.

VIII. RESULTS

The experimental determination of thermal transmittance (U) of the element with an accuracy of 5% yielded the following results:

▪ **Thermal transmittance (U)**	**:**	**0,89**	**(W ^{2} K)**
▪ Thermal Resistance, (R)	:	1,124	(m^2 K / W)
▪ Thermal Conductance, (C)	:	1,09	(W ^{2} K)

The mean values associated with these determinations are the following:

▪ Average air temperature on hot side (TaLc)	:	28,5	(ºC)
▪ Average air temperature on cold side	:	8,5	(ºC)
▪ Average surface temperature on hot side (TsLc)	:	26,4	(ºC)
▪ Average temperature on cold side	:	10,0	(ºC)
▪ Calculated ambient temperature on hot side (TnsLc)	:	37,0	(ºC)
▪ Calculated ambient temperature on cold side	:	7,0	(ºC)
▪ Average air velocity on hot side (VaLc)	:	0,20	(m/s)
▪ Average air velocity on cold side (VaLf)	:	0,95	(m/s)
▪ Parallel air direction on hot side (DirVaLc)	:	0	(rad)
▪ Parallel air direction on cold side (DirVaLf)	:	0	(rad)
▪ Average power of measuring chamber	:	17,8	(W)
▪ Duration of the test (t)	:	48	(h)

IX. OBSERVATIONS

Note (1): The results obtained do not endorse past, present or future productions (production lots or inspection lots) and are future ones and is applicable only to the tested

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PERFORM : **CONSTRUCTION TECHNOLOGY RESEARCH CENTER, CITEC UBB.**
COLLAO AVENUE 1202, CONCEPCIÓN.

CLIENT
NAME : **BME CHILE SPA.**
ADDRESS : Lynch 0587, Temuco.

I. BACKGROUND

This reports on the facade tightness test of a wall based on wooden bricks. Work requested from the Laboratory of Construction Sciences, Environmental Conditioning Area, by Mr. Juan Escobar B., on behalf of the company BME Chile SpA.

II. TEST OBJECTIVE

To determine the facade water tightness of a wall in the laboratory.

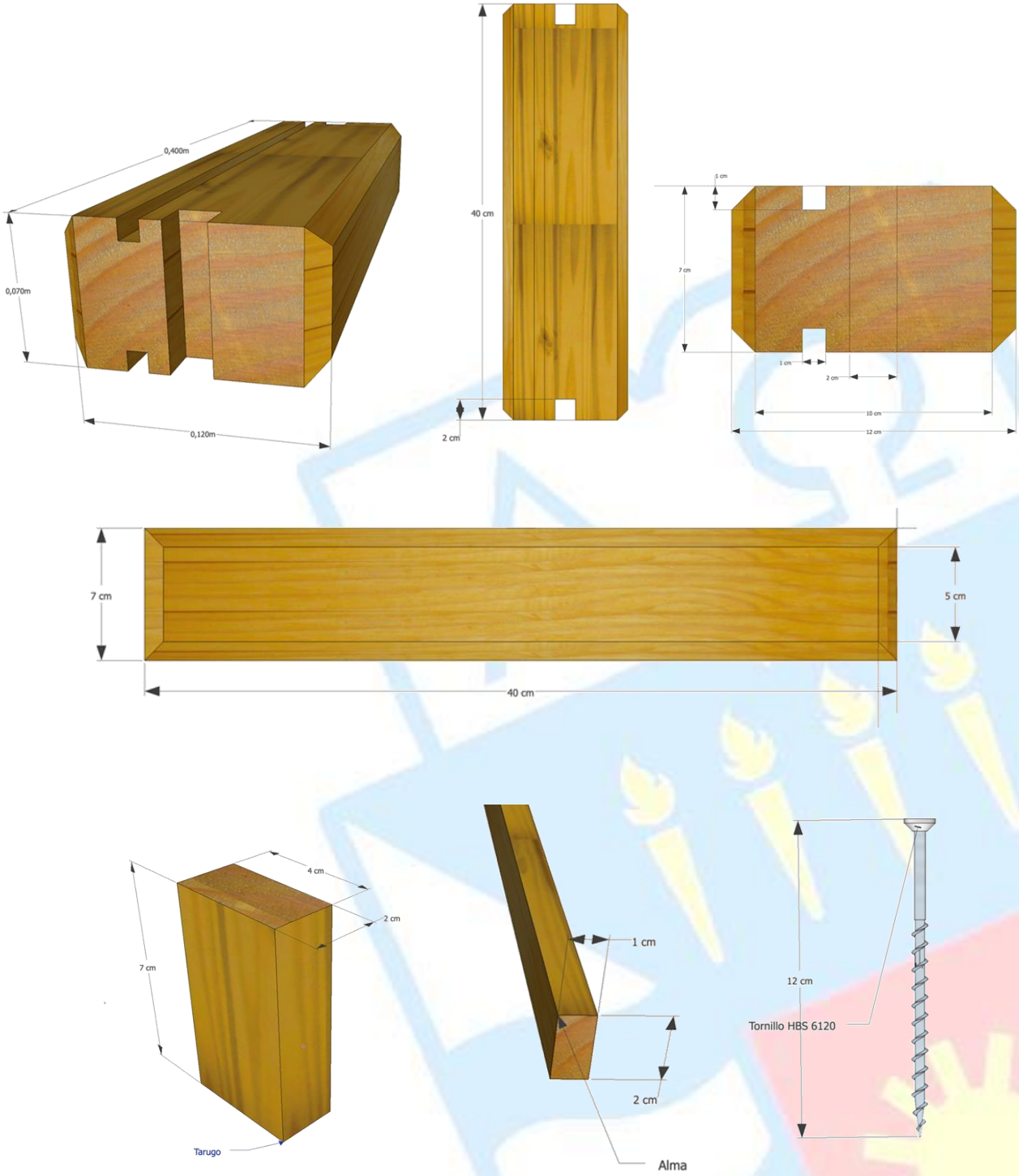
III. IDENTIFICATION OF THE PRODUCT SUBMITTED FOR

The sample of the wall system based on wooden bricks submitted for testing is the following:

Description	:	Wall element composed of wooden blocks or “bricks” (stabilized and treated radiata pine) in the form of a rectangular parallelepiped with longitudinal and short visible edges beveled, with grooves along their bearing faces at their horizontal joint. Ranuras intended to securely connect the blocks arranged in the upper course in an interlocking pattern. At the joint with the lateral block, it has a vertical groove for joining with a dowel of the material, resolving the horizontal and vertical joints with these interlocks. Wall thickness, e=0,120m.
Technical specifications	:	According to the attached plan and section, an integral part of
Sample dimensions	:	Width 1.0 m; Height 1.0

Note: Assembly specifications provided by the client.

PLAN AND CONSTRUCTION



IV. APPLIED

NCh 2821 Of2003 “Facades – Water tightness test method.”

V. TEST METHODOLOGY

The test was performed in the laboratory, using an infiltration chamber according to the methodologies described in the NCh 2821 Of2003 for facade water tightness.

A chamber equipped with pneumatic and hydraulic networks and the necessary control and measurement elements is used to with the requirements established in standard NCh 2821 Of2003. The equipment diagram is shown in Figure No. 2:

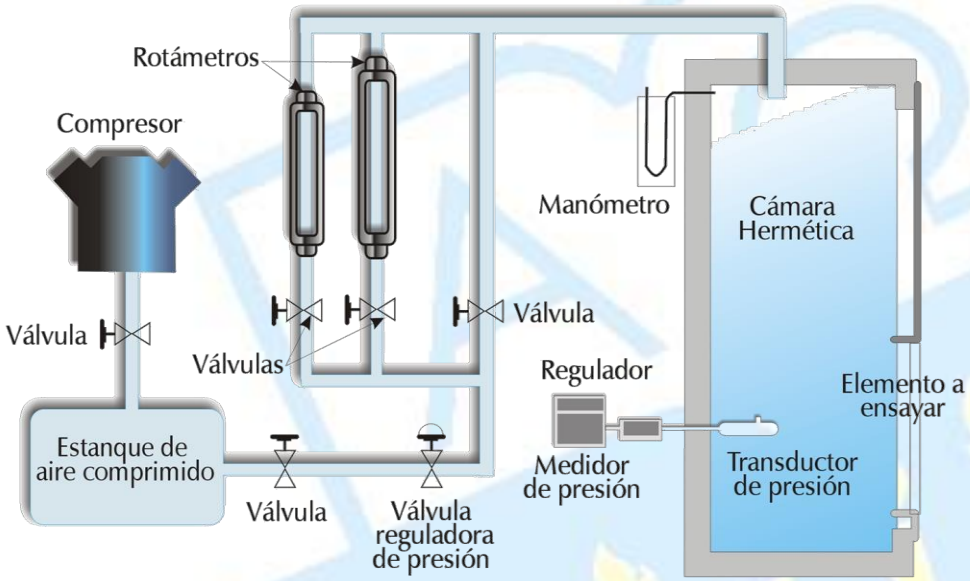


Fig. No. 2: Experimental setup diagram

VI. TEST CONDITIONS

Ambient temperature : 18º C
Chamber : 18º C

VII. TEST DATE.

Test date : 26/06/2020

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VIII. RESULTS

a) Facade tightness

Water flow rate Lts/min/m2	Pressur Pa	Time minutes	Failu		Actual minutes
			Ye	No	
3	0	15		X	15
3	50	5		X	5
3	100	5		X	5
3	150	5		X	5
3	200	5		X	5
3	300	5		X	5
3	400	5		X	5
3	500	5		X	5
3	600	5		X	5
3	700	5		X	5

b) Weights of the test

Specimen No.	Initial weight	Final weight	Increase (kg)
1	19,40	19,60	0,20
2	18,40	18,55	0,15
3	19,45	19,65	0,20

IX. CONCLUSIONS

According to the method described in NCh 2821 Of2003, no water leaks are observed on the interior side of the wall, therefore the solution is classified as L700.

In accordance with the method for establishing facade tightness requirements for walls, developed by CITEC-UBB, in the context of the INNOVA CHILE project "Technical Guide for the Prevention of Pathologies in Social Housing", which is available on the website www.citec.cl, and which considers exposure criteria, climate zone and building height building, the tested solution meets the requirements for all localities in our country.

X. OBSERVATIONS

1.- The results obtained do not endorse past, present or future productions (production lots or inspection lots) and are applicable only to the tested element.
2.- Once the tests were completed, an average increase in specimen weight of 0.18kg was recorded relative to their initial weight.

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