EMMEDUE

Advanced Building System

EMMEDUE BUILDING SYSTEM

TEST CERTIFICATES

This document shows the main tests that characterize the performance of the EMMEDUE building system both from an environmental and mechanical point of view. It should be noted that for each performance it is indicated only a single test, despite the EMMEDUE Company has performed numerous tests not only in Italy but also in many different countries in the world.

INDEX

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❖ SOUNDPROOFING

SINGLE PANEL PSM80 (See test result at annex on page 9)

Evaluation index at 500 Hz in the frequency band between 100 Hz and 3 150 Hz:

R_w= 41 dB

NOTE: the result is in function of the frequency indicated by the Italian regulation which compares all values at one frequency, in fact for higher frequencies some higher **R values** are obtained **up to 65 dB** for a frequency equal to 5 000 Hz.

❖ THERMAL INSULATION

- EPS DENSITY 15 Kg/m^3 (see test results at annex on page 10)

THERMAL CONDUCTIVITY λ = **0.0361 watt/mK (average value)**

THERMAL RESISTANCE R = **1.42 m^{2}K/watt (average value)**

NOTE: The laboratory test is used to evaluate the effective thermal conductivity of EPS so as to be able then to calculate the Thermal Transmittance of the panel assembled on site. In fact, with simple algebraic operations it is possible to calculate, on the basis of the theories of physics, the value of Thermal Transmittance U and the Thermal Resistance R, as a function of thickness and conductivity of the layers. The test was realized on an EPS sample with 5 cm of thickness.

PANEL TYPE	FINISHED WALL THICKNESS (cm) (in brackets values in inch)	THERMAL TRANSMITTANCE U (W/m^2 K)	THERMAL RESISTANCE R (h ft^2 F/ BTU)
PSM60	13	0.574	9.90
PSM80	15	0.443	12.81
PSM100	17	0.361	15.72
PSM120	19	0.305	18.64
PSM140	21	0.261	21.55

NOTE: The values shown on table above are obtained considering a thermal conductivity **λ = 0.039 watt/m^{2}K** (this is a value generally used for the calculation of the thermal transmittance. It's bigger than the value obtained from the test.)

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❖ FIRE RESISTANCE

- SINGLE PANEL PSM80 AS LOAD BEARING WALL (see test result at annex on page 11)
Test performed with vertical load applied to 70.65 KN/m

REI 90
RE 120

NOTE:
- R means that panel is able to ensure the load bearing capacity;
- E means that panel ensures the requirement of panel sealing (that avoids the passage or the production of flames or smoke on the side not exposed to the test);
- I means that panel is able to ensure a level of thermal insulation, namely that the panel is able to maintain the temperature increase on the unexposed side within certain parameters;
- The number indicates the minutes for which the above requirements are valid.

- SINGLE PANEL PSM40 NOT AS LOAD BEARING WALL (see test result at annex on page 12)
Test performed without vertical load

REI 120
RE 180

NOTE:
- R means that panel is able to ensure the load bearing capacity;
- E means that panel ensures the requirement of panel sealing (that avoids the passage or the production of flames or smoke on the side not exposed to the test);
- I means that panel is able to ensure a level of thermal insulation, namely that the panel is able to maintain the temperature increase on the unexposed side within certain parameters;
- The number indicates the minutes for which the above requirements are valid.

- SINGLE PANEL PSM80 AS SLAB (see test result at annex on page 13)
Test performed with the application of a load of about 3.1 kN/m^2 on a plate 4x4 m submitted to fire.

Mechanical stability > 60 minutes

NOTE: the requirement is achieved if the temperature of the panel is below certain limit values.

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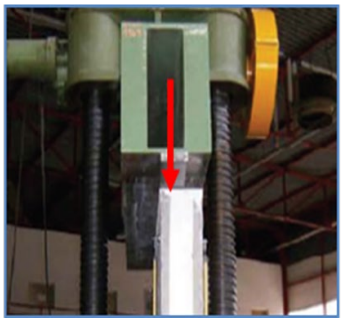
❖ MECHANICAL RESISTANCE – COMPRESSION TEST

- CENTRED COMPRESSION TEST ON SLENDER SINGLE PANEL PSM80 (see test results at annex on page 14)

MAXIMUM LOAD APPLIED = **1 155 KN/m (average value)**

NOTE: The tested panels had a height of about 270 cm and a width of 113 cm. They generally broke during the test due to instability.



- ECCENTRIC COMPRESSION TEST ON SLENDER SINGLE PANEL PSM80 (see test results at annex on page 15)

MAXIMUM LOAD APPLIED = **760 KN/m (average value)**

NOTE: The tested panels had a height of about 270 cm and a width of 113 cm, with an eccentric load approximately of 5.25 cm. In this case the breaking load is lower, because during the test there was a considerable moment of the first order due to the eccentricity.

- CENTRED COMPRESSION TEST ON SHORT SINGLE PANEL PSM80 (see test results at annex on page 16)

MAXIMUM LOAD APPLIED = **1 600 KN/m (average value)**

NOTE: The tested panels had a height of about 113 cm and a width variable from 60 to 113 cm.

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❖ MECHANICAL RESISTANCE – BENDING TEST

Several bending tests were performed on the panels with different thickness and density. Each panel was subjected to rupture by the application of two loads placed at a distance of L/3 from the support, where L stands for the length of the test span. In the first table it is shown the total load of rupture for each test, (excluding its own weight), while in the second table it is shown the load that would be associated to a deflection limit of L/250, that is the maximum applicable load for the that span as a function of the chosen panel.

(on pages 17-18 some flexural tests results are shown)

Type of panel	Dimension (m)	Density EPS (Kg/m³)	Span L (m)	Failure load (Kg)
PSM 80	2.25X4.00	15	3.50	3500
PSM 80	2.25X4.00	15	3.50	3600
PSM 80	2.25X4.00	25	3.50	5500
PSM 80	2.25X4.00	25	3.50	5800
PSM 160	2.25X5.00	15	4.50	5000
PSM 160	2.25X5.00	15	4.50	5800
PSM 160	2.25X5.00	25	4.50	6200
PSM 160	2.25X5.00	25	4.50	6200

Type of panel	Dimension (m)	Density EPS (Kg/m³)	Allowable deflection (L/250) cm	Load related to deflection (Kg)	Distributed equivalent load (Kg/m²)	Average distributed load q_{amm} (Kg/m²)
PSM 80	2.25X4.00	15	1.4	1620	280.4	270.8
PSM 80	2.25X4.00	15	1.4	1509	261.2	
PSM 80	2.25X4.00	25	1.4	2109	365.0	390.8
PSM 80	2.25X4.00	25	1.4	2407	416.6	
PSM 160	2.25X5.00	15	1.8	2233	300.6	312.9
PSM 160	2.25X5.00	15	1.8	2415	325.1	
PSM 160	2.25X5.00	25	1.8	2429	327.0	331.6
PSM 160	2.25X5.00	25	1.8	2497	336.1	

NOTE: Allowable loads (qamm) in Kg/m² (lbs/ft²) for every type of slab. The load consists of dead load + live load, excluding slab weight.

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❖ MECHANICAL RESISTANCE – SHEAR TEST IN PLANE

- SINGLE PANEL PSM80 (see test results at annex on page 19)

MAXIMUM SHEAR STRAIN = **1.51 MPa average value**

NOTE: The tested panels had more or less a square shape with side 113 cm. The load was applied on the corner at the top of the tested panel.

❖ MECHANICAL RESISTANCE – JOINT TEST

- SINGLE PANEL PSM40

MAXIMUM LOAD APPLIED = **72.7 KN**

NOTE: The tested vertical panels had a height of 110 cm, while the horizontal panel had a span of 105 cm. All the panels had a width of 112.5 cm. The test was stopped due to the flexural failure of the horizontal panel, **this indicates that the shear strength of the knot, with standard connections, is higher than 36.35 KN**

❖ MECHANICAL RESISTANCE – DELAMINATION TEST

- SINGLE PANEL PSM80 (see test results at annex on page 20)
Test to evaluate the shear strength of the connection

MAXIMUM LOAD APPLIED = **10.5 tonn (average value)**

NOTE: The tested panels had a square size of 112.5 cm on side, **in this way it is possible to evaluate the tangential resistance of panel connection as 0.83 daN/cm^2**

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❖ MECHANICAL RESISTANCE – SEISMIC TEST

- SINGLE PANEL PSM80 (see test results at annex on page 21)

P.G.A. (peak ground acceleration) APPLIED = 0.45g = 4.41 m/sec^2

NOTE: it must be noted that the sample on the photo was not subjected at the base to the highest accelerations due to inability of the instrumentation. However, **despite the high P.G.A. applied, the sample did not show any damage, therefore the test result is really acceptable for earthquakes of such an intensity.**

❖ WEATHER RESISTANCE - WIND DRIVEN RAIN TEST

- SINGLE PANEL PSM140 (see test results at annex on page 22)
Test to determine the resistance of external wall systems to driving rain under pulsating air pressure

MAXIMUM AIR PRESSURE APPLIED = **1 650 Pa**
(together the water)

NOTE: There is no pass or fail criteria within BS EN 12865, there was a water ingress around the window aperture at the 1650 Pascal stage of the testing.

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ACOUSTIC TEST SINGLE PANEL PSM80

LABORATORY TEST ISTITUTO GIORDANO – 04/12/2003

(Rapporto di prova n. 178090 del 04/12/2003) segue - foglio n. 8 di 8

Superficie utile di misura del campione:

10,80 m^2

Volume della camera emittente:

57,0 m^3

Volume della camera ricevente:

88,0 m^3

Tipo di rumore:

Rosa

Tipo di filtro:

⅓ d'ottava

Esito della prova:

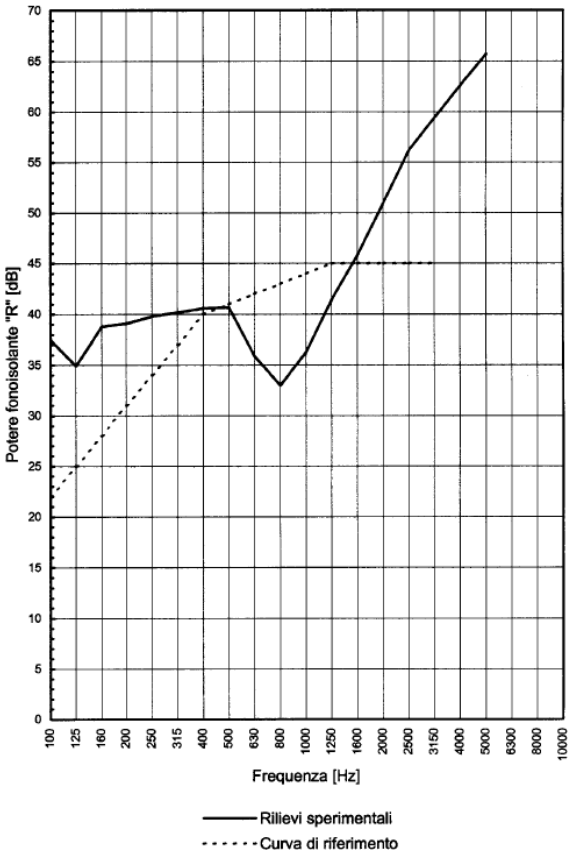
Indice di valutazione a 500 Hz nella banda di frequenze comprese fra 100 Hz e 3150 Hz: **R_w = 41 dB**

Bande di frequenze con scarto sfavorevole maggiore di 8 dB:

800 Hz

Termini di correzione:

C = -1 dB
C_{tr} = -3 dB



ISTITUTO GIORDANO - RICERCHE DIFESA LABORATORIO DI ACUSTICA - ITALY

Il Responsabile Tecnico di Prova (Geom. Omar Nanni)

Il Responsabile del Laboratorio di Acustica e Vibrazioni (Dott. Andrea Bruschi)

Il Presidente o l'Amministratore Delegato
Dott. Ing. Vincenzo Iommi

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THERMAL CONDUCTIVITY TEST EPS DENSITY 15Kg/m³

LABORATORY TEST LAPI "PRATO" – 06/05/2010

Rapporto di Prova no. 467.2DC0050/10 del 06/05/2010
Test Report no. *of*

n° 0086

PROCEDIMENTO DI PROVA
Test procedure

Il materiale è stato sottoposto a prova secondo quanto previsto dalla UNI EN 12667: 2002.
E' stato prelevato casualmente 1 provino da ciascuno dei lotti, come previsto da UNI EN 13172.
The material has been submitted to the test as described by UNI EN 12667:2002.
One specimen have been sampled randomly from all the batches, as prescribed by UNI EN 13172.

DEROGHE DAL PROCEDIMENTO DI PROVA
Variations form the test procedure
Nessuna / *None.*

RISULTATI
Results

Temperatura ambiente / *Ambient temperature:*	(23±2)°C
Umidità relativa / *Relative humidity:*	(50±5)%

Temperatura di prova / *Test temperature*: 10°C

Lotti *Batchs*	**N° 1**	**N° 2**	**N° 3**	**N° 4**	**Medie** *Averages*
Spessore medio rilevato *Average thickness detected* [mm]	51.2	52.0	51.1	51.1	51.4
Conducibilità Termica *Thermal conductivity* [λ_{10}; W/m·K]	0.0358	0.0358	0.0369	0.0358	0.0361
Resistenza Termica *Thermal Resistance* [R; m^2·K / W]	1.43	1.45	1.38	1.43	1.42
Massa Volumica *Density* [kg/m^3]	15.9	16.6	16.3	16.1	16.2

FIRE RESISTANCE PSM80 AS LOAD BEARING WALL

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LABORATORY TEST CSI MILANO – 26/09/2013

CSI CERTIFICAZIONE E TESTING

RAPPORTO DI CLASSIFICAZIONE / *CLASSIFICATION REPORT CSI1880FR*
Data / *Date* 30.05.2013

5. CLASSIFICAZIONE / *CLASSIFICATION*

5.1. Riferimento della classificazione / *Reference of classification*
Questa classificazione è stata condotta conformemente al paragrafo 7.3.2 della norma UNI EN 13501-2: 2009. / *This classification has been carried out in accordance with clause 7.3.2 of UNI EN 13501-2: 2009 standard.*

5.2. Classificazione / *Classification*
L'elemento costruttivo provato denominato **PSM80** è classificato secondo la seguente combinazione di parametri di prestazione e classi. Non sono consentite altre classificazioni. / *The element of building construction tested named **PSM80** is classified according to the following combinations of performance parameters and classes. No other classifications are permitted.*

R	E	I		9	0

R	E		1	2	0

Nota: la presente classificazione di resistenza al fuoco, in base alla tabella A.2.1 del D.M. 16.2.2007 e allo scopo della prova, previsto dalla norma UNI EN 1365-1: 2002, si applica esclusivamente a pareti divisorie portanti nella loro interezza, cioè comprensive di eventuali interventi di finitura superficiale. Detta classificazione non è, in ogni caso, applicabile ai singoli componenti costituenti la parete.

/

Note: this resistance to fire classification, referring to tabe A.2.1 of D.M. 16.2.2007 and to the scope of the test, described in the standard UNI EN 1365-1: 2002, shall be applied exclusively to loadbearing separating walls in their entirety, comprehensive of additional finishings. In any case, this classification is not applicabile to the single components of the wall that constitute the wall.

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FIRE RESISTANCE PSM40 NOT AS LOAD BEARING WALL

LABORATORY TEST CSI MILANO – 04/08/2003

CSI

Test Report N°:	*Date*	*Page*
CSI1058RF	**04/08/2003**	**4 of 11**

4. TEST RESULT

The following meaningful phenomena have occurred during the test:

Minute	Phenomenon noticed
112'	Formation of non-passing fissures horizontally and vertically, at the perimeter of the panel
151'	Temperature of the thermo-couple no.10>180°C
180'	The test has been interrupted. No passage of flame or hot gas has been noticed on the panel side not exposed to fire.

Table 2. Phenomena noticed during the test.

The temperatures taken by the thermo-couples on the not exposed side at test completion are the following:

Thermo-couple	Temperature (°C)
Thermo-couple n° 7	143,8
Thermo-couple n° 8	225,6
Thermo-couple n° 9	191
Thermo-couple n° 10	228,2
Thermo-couple n° 11	149

Table 3. Maximum temperatures taken at test completion.

5. CONCLUSIONS

In compliance with the Circular no.91 and the M.D. November 30th 1983 "Terms, general definitions and graphic symbols for fire prevention", the fire resistance of the partition panel examined, named **"PSME 80"**, presented by the firm **EMMEDUE S.r.l. via Toniolo, 39/b – Z.I. Bellocchi – 61032, Fano (PU)**, turns out to be:

REI 151 – RE 180

and, therefore, the non-load bearing element examined can be classified REI 120 and RE 180.
The photographs no.1, 2, 3 and 4 (Attachment D) show the element before and after testing.

Date of issue: **August 4th 2003**

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GRUPPO IMQ

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FIRE RESISTANCE PSM80 AS SLAB

LABORATORY TEST MADERA TOLEDO – 28/07/2003

CENTRO TECNOLOGICO DE LA MADERA
A.I.M.C.M.

INFORME DE ENSAYO

REGISTRO DE SALIDA
Num. .....
Fecha 29 JUL 2003

- RESISTENCIA AL FUEGO -

Expediente nº F-398/03-02 Hoja nº 9 de 20

1.4.4.- Eventos durante el ensayo

ARCHIVO f 398-03

EVENTOS
* -

2:- RESULTADOS:

2.1.-Resultados Resistencia al Fuego

Los resultados obtenidos para el ensayo correspondiente al apartado 1.1.-, sin tener en cuenta las uniones con las paredes laterales entre forjado y horno han sido:

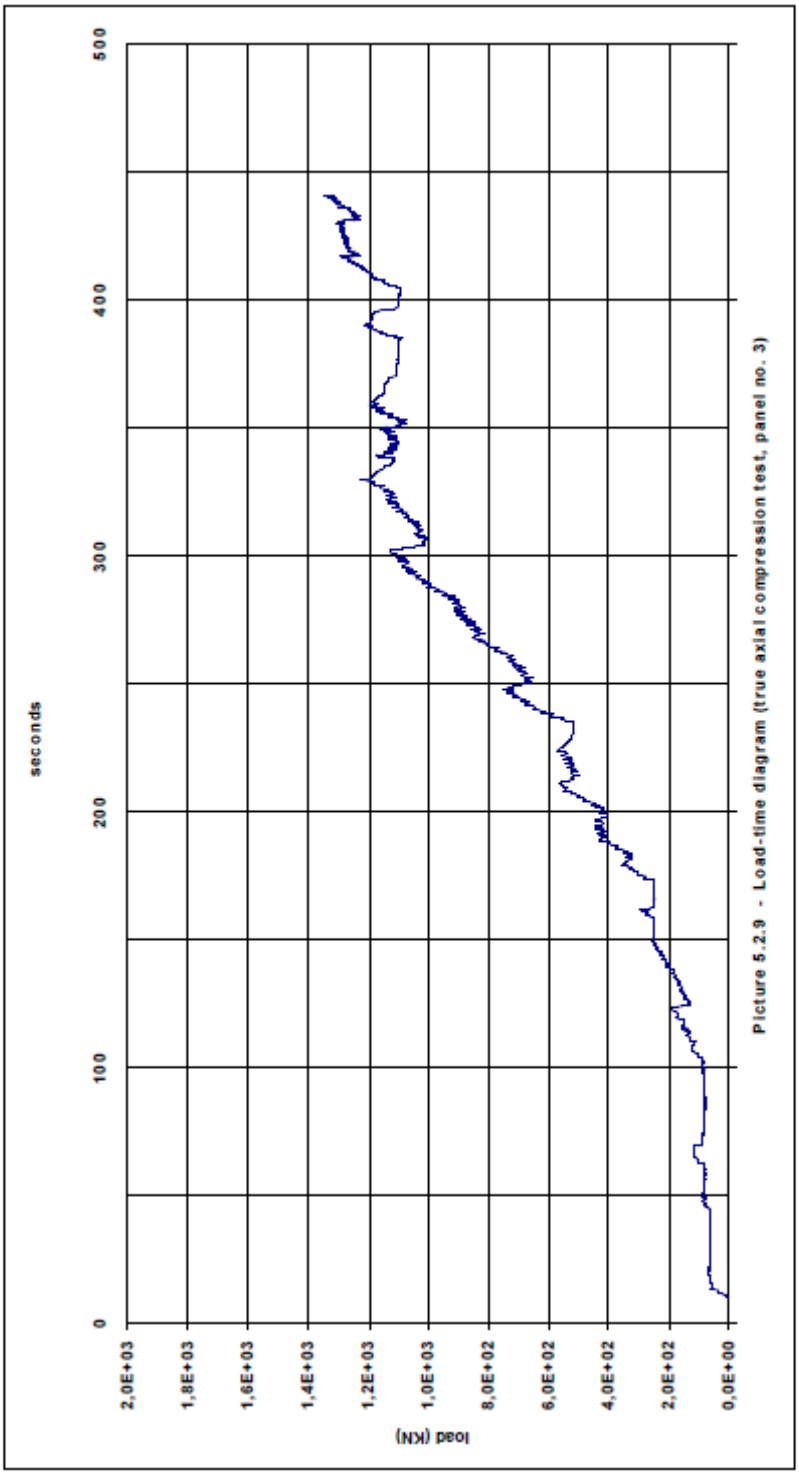
RESULTADOS	
Duración total del ensayo:	63 min
CRITERIOS	CARA NO EXPUESTA
a) Estabilidad mecánica	Duración de cumplimiento de criterios
	> 60 minutos
Temperatura media cara no expuesta	Tiempo al que la temperatura media es igual a 140 ºC + temp. inicial
	> 60 minutos
Temperatura máxima cara no expuesta:	Tiempo al que la temperatura máxima es igual a 180 ºC + temp. Inicial
	> 60 minutos
Temperatura de radiación	-

A.I.M.C.M. - CENTRO TECNOLÓGICO DE LA MADERA - c/Río Estenilla s/n - Polígono Industrial Nª Sra. de Benquerencia - Tel. 925-240666-67 Fax: 925-240679 45007 TOLEDO

-

CENTRED COMPRESSIVE TEST ON SLENDER PSM80

LABORATORY TEST ISRIM "UNIVERSITY OF PERUGIA" – 06/09/2000



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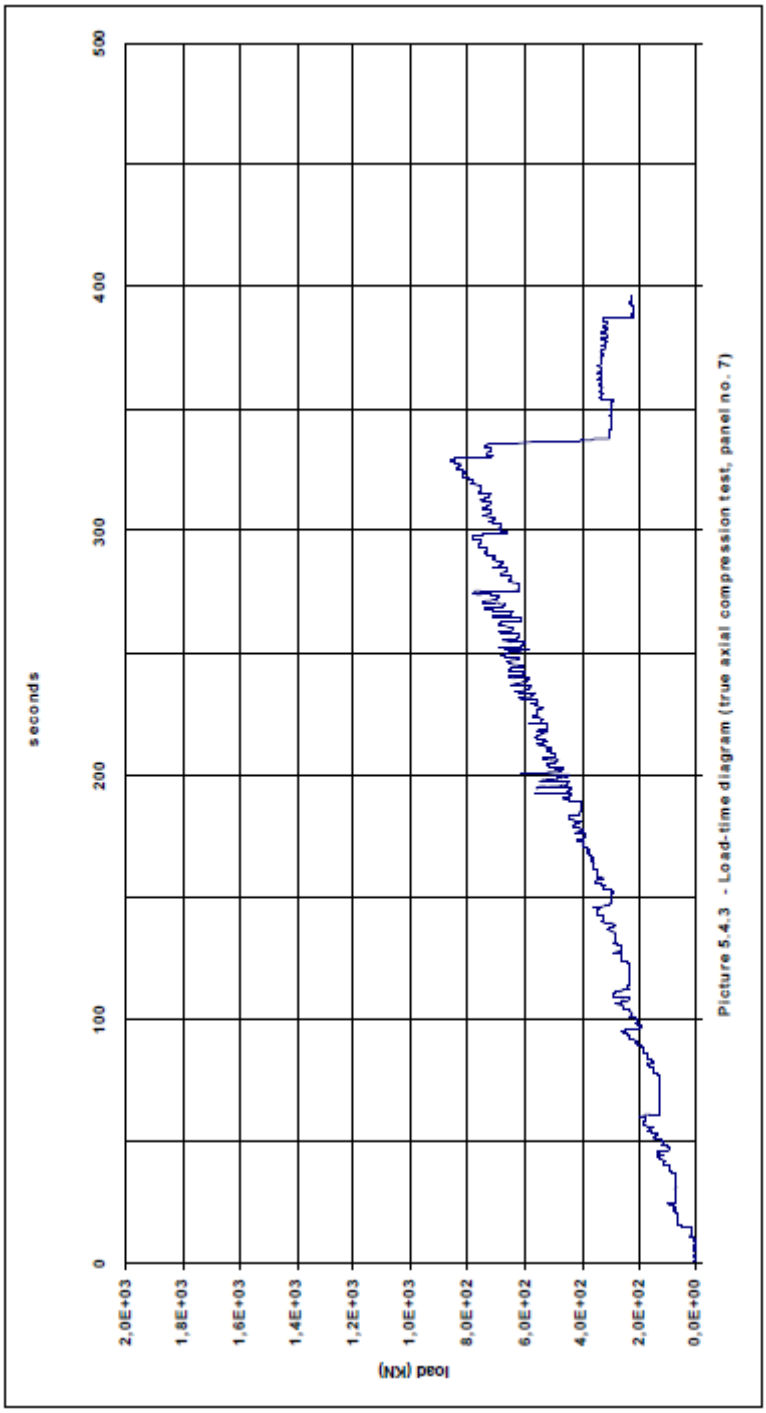
ECCENTRIC COMPRESSIVE TEST ON SLENDER PSM80

LABORATORY TEST ISRIM "UNIVERSITY OF PERUGIA" – 06/09/2000



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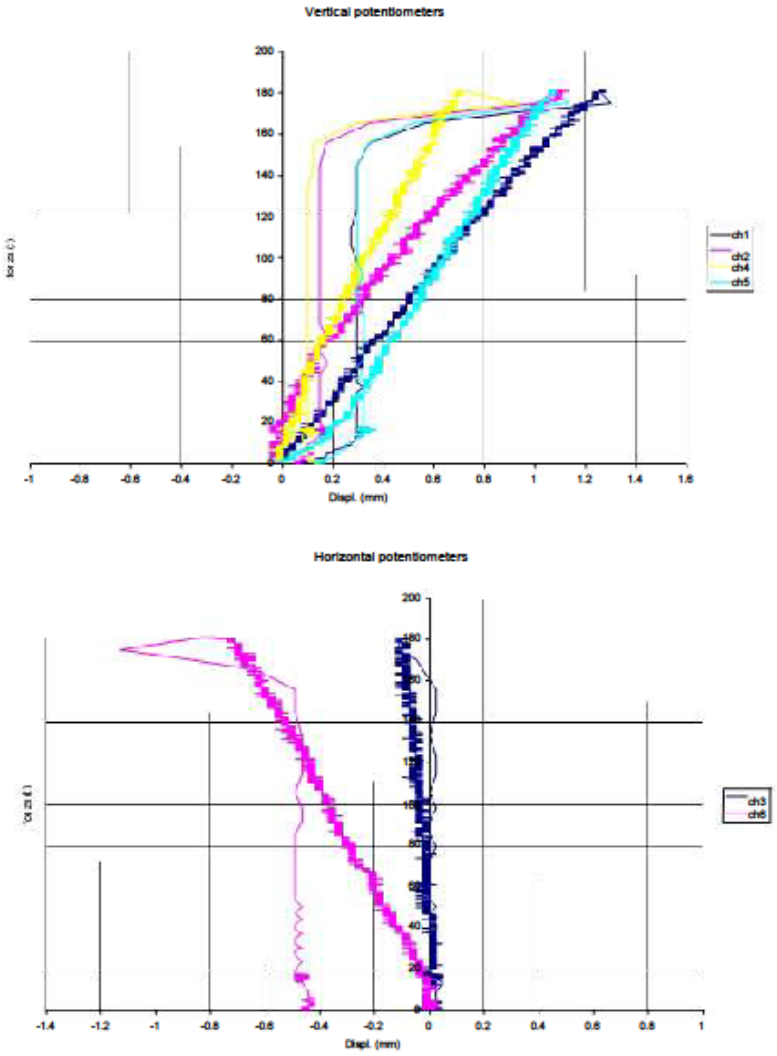
CENTRED COMPRESSIVE TEST ON SHORTER PSM80

LABORATORY TEST EUCENTRE "PAVIA" – 01/06/2008

EUCENTRE European Centre for Training and Research in Earthquake Engineering

6.1.5 Test C5

Test performed on 10/03/08



Note: Card with inverted polarity: Positive shortening, negative elongation

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BENDING TEST ON PSM80 DENSITY 15Kg/m³

LABORATORY TEST EUCENTRE "PAVIA" – 01/06/2008

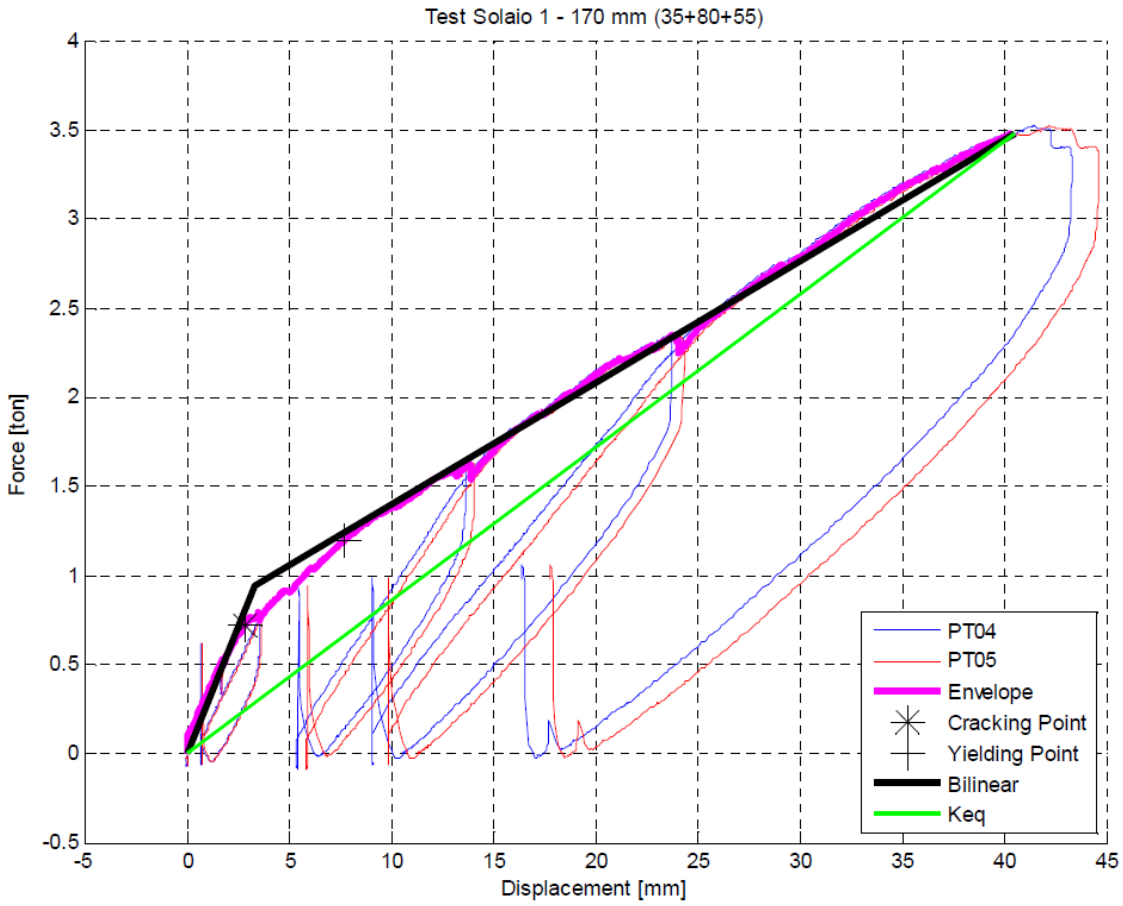

Figure 179 Force - Displacement plot

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BENDING TEST ON PSM80 DENSITY 25Kg/m³

LABORATORY TEST EUCENTRE "PAVIA" – 01/06/2008

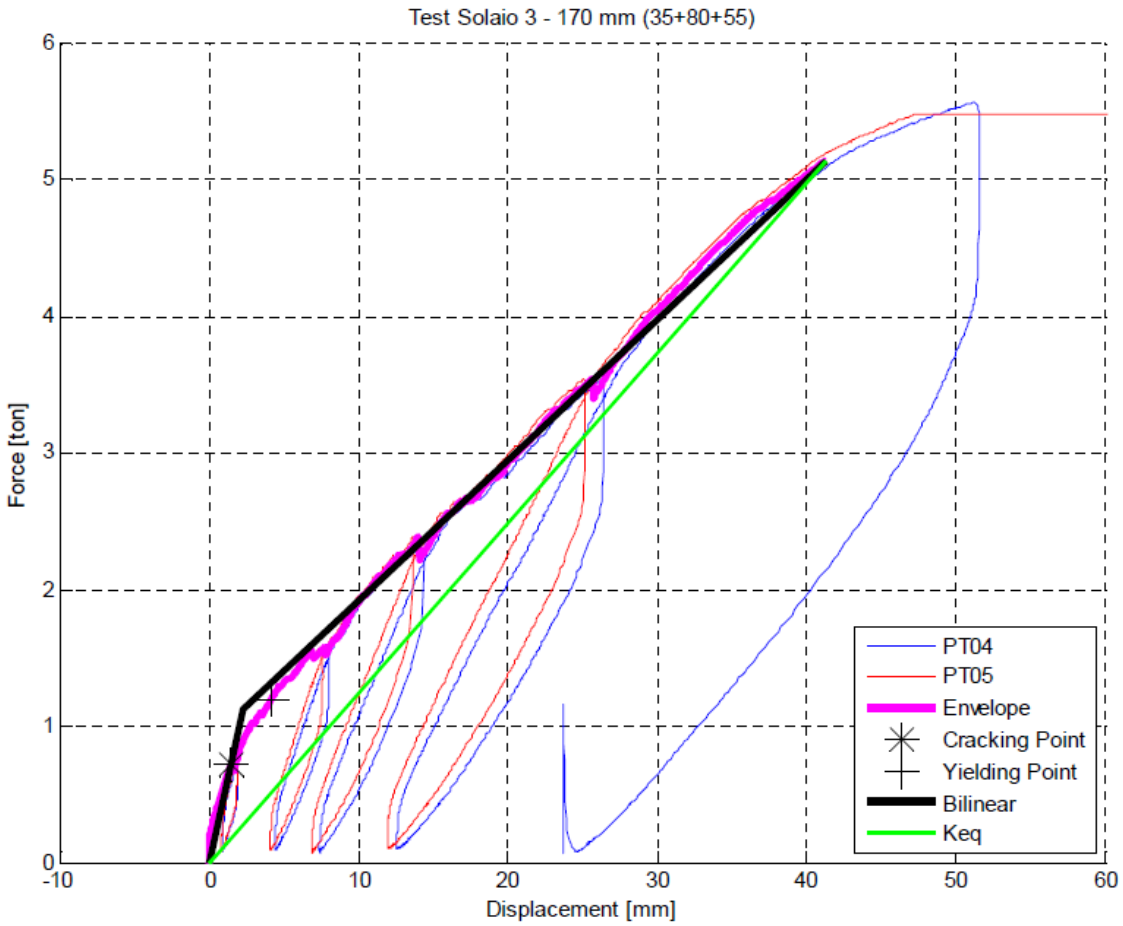

Figure 184 Force - Displacement

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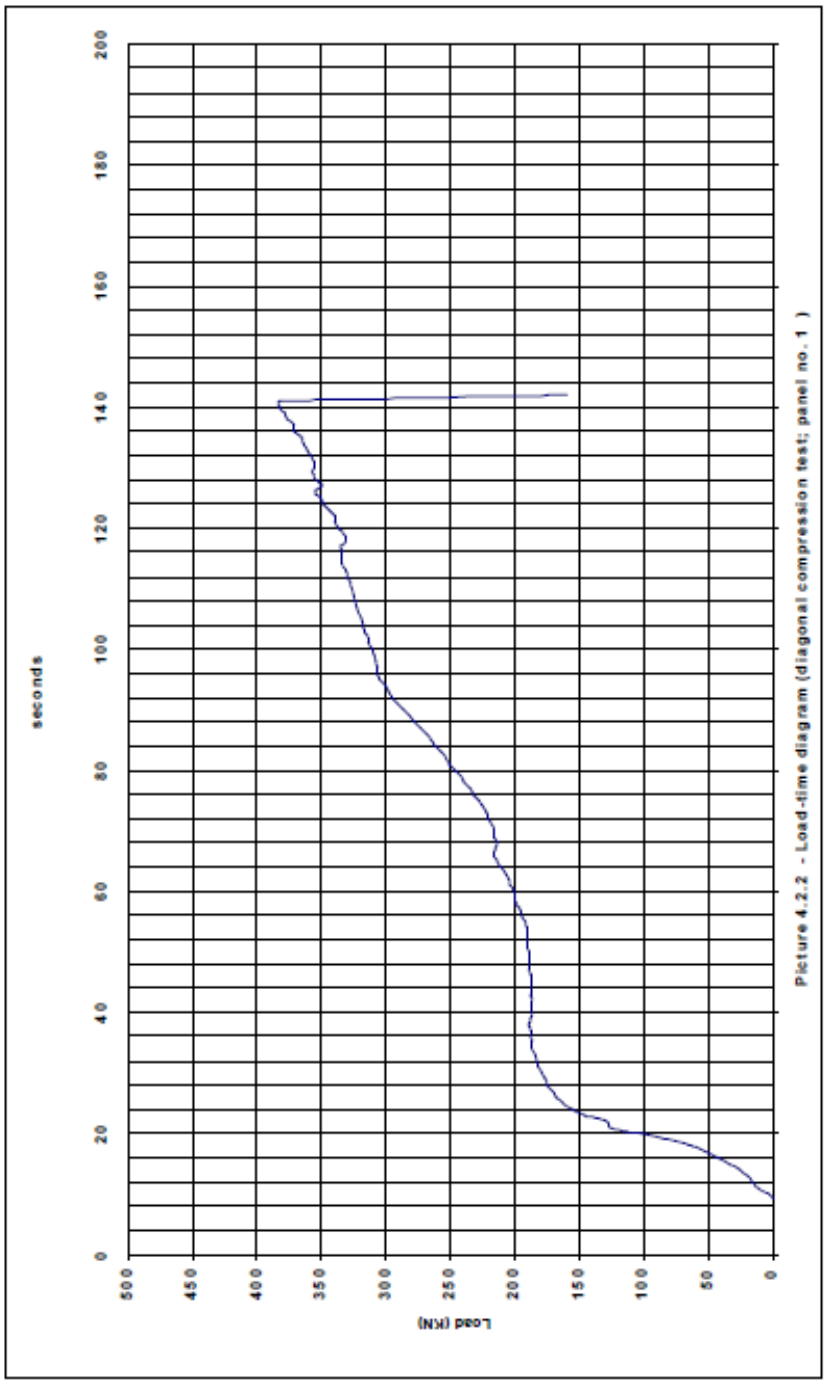
SHEAR TEST ON PSM80

LABORATORY TEST ISRIM "UNIVERSITY OF PERUGIA" – 06/09/2000



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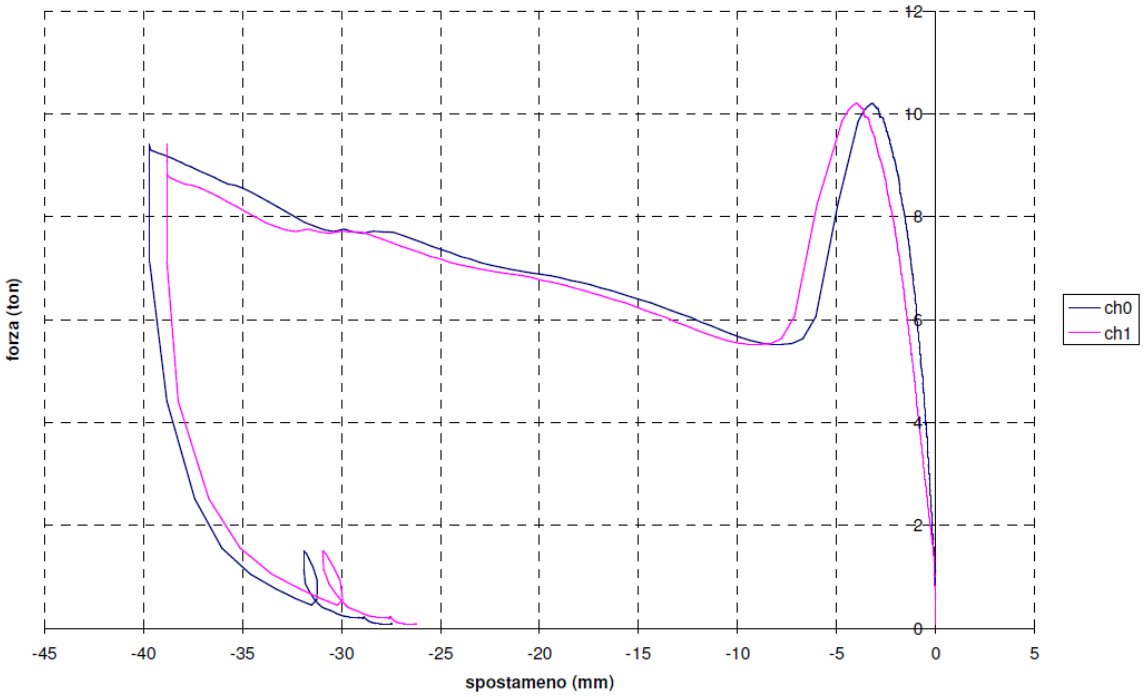
DELAMINATION TEST ON PSM80 DENSITY 15Kg/m^3

LABORATORY TEST EUCENTRE "PAVIA" – 08/04/2008

6.4.2 Prova De1

Prova eseguita in data 08/04/08



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SEISMIC TEST ON HOUSE WITH PSM80

LABORATORY TEST ENEA "ROMA" – 27/11/2008

ENEA
Institution for New technology, Energy and the Environment

2.3 Data analyses

All of the readings were analyzed:

- in the field of time (th);
- in the field of frequency, illustrating: The power spectral auto-densities (PSD); the cross spectral power densities (CSD), for all of the pairs of sensors, in terms of amplitude and phase factors with the relative coherence functions; the transfer functions from the base to the summit for the most significant sensors.

Please be reminded that the presence of peaks in the PSD graphics indicates possible structural resonance frequencies; the confirmation of this is shown by the presence of peaks in the cross spectra in relation to the same frequencies with significant phase factor values and coherence function values. Peaks which do not correspond to structural resonance can be caused by the nature of the input or other factors. Keeping in mind the phase factors, information regarding the modal forms can be collected from the spectral amplitudes.
Downstream from the present report can be found the graphics (time-history, auto-spectra, cross-spectra and transfer functions) regarding characterization and seismic testing:

- CO045 (Colfiorito. PGA = 0.45g)
- TO045 (Tolmezzo. PGA = 0.45g)
- SI045 (Synthetic. PGA = 0.45g)

During the entire testing cycle no damage was encountered, even in relation to the highest levels of applied stress. The analysis of the graphics produced confirmed the substantial preservation of the model's dynamic characteristics.

2.3.1 Dynamic characterization testing

The analysis of the time-history did not reveal a significant amplification at the summit with respect to the base, indicating considerable model rigidity.
Figure 7 shows the auto-spectra relative to the initial dynamic characterization performed before subjecting the model to the seismic tests. Evident natural structural frequencies, around 10 Hz, appear for both directions. It must be noted, however, that due to the model's high rigidity, the auto-spectra do not clearly highlight the amplification in relation to the natural frequencies. Analogous results can be seen in all of the other characterizations.

In reference to another characterization test (Figure 8), the transfer functions clearly highlight the first structural frequency of 10Hz in the Y direction. In the X direction, the first structural frequency is between 11 and 12 Hz (Figure 9), which is coherent with the increased rigidity of the structure in this direction.

As indicated above, no variations were observed in the structural frequency identified for the different characterizations, which confirms that no type of structural damage took place; for this purpose, as an example, analogous diagrams are shown for the final characterization in the Y direction (Figure 10).

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WIND DRIVEN RAIN TEST ON PSM140

LABORATORY LUCIDEON "STOKE ON TRENT"– 29/11/2018

	Procedure A		Procedure B	
Pressure difference Pa	Time interval min	Total time at end of steps min	Time interval min	Total time at end of steps min
0	20	20	60	60
0 to 150	10	30	60	120
0 to 300	10	40	60	180
0 to 450	10	50	60	240
0 to 600	10	60	60	300
600 + i · 150 i= 1,2,3,…n	10	60 + i · 10	60	300 + i · 60

Each pressure pulse consists of four stages: a rising pressure stage of (3 ± 1) seconds, a maximum pressure stage of (5 ± 1) seconds, a falling pressure stage of (2 ± 1) seconds and a zero pressure stage of (5 ± 1) seconds.

Procedure B was used for this testing.

The sample was inspected at intervals of 15 minutes during testing so as to ascertain when there was a failure within the system.

4 RESULTS

There is no pass or fail criteria within BS EN 12865, however, a pressure value of above 1200 Pascals is usually taken as the industry standard for this test.

The structural panel showed signs of water ingress around the window aperture at the 1650 Pascal stage of the testing and as such 1500 Pascals is the failure pressure for the system.

NOTE: The results given in this report apply only to the samples that have been tested.

END OF REPORT

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