EUROPEAN ASSESSMENT DOCUMENT

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REINFORCED HIGH DENSITY EPS STRUCTURAL PANEL SYSTEM FOR BUILDING UNITS

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This European Assessment Document (EAD) has been developed taking into account up-to-date technical and scientific knowledge at the time of issue and is published in accordance with the relevant provisions of Regulation (EU) 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

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1 SCOPE OF THE EAD

1.1 Description of the construction product

The “reinforced high density eps structural panel system for building units” is a system composed of high density polystyrene structural panels connected on site to each other through steel mechanical brackets to build buildings unit.

The panel reinforcement is obtained by a three-dimensional grid made of galvanized steel wire.

The panel’s core is made of expanded polystyrene with a density ≥ 35 kg/m^3.

The building kit is composed of:

- Loadbearing panels (wall, floor and roof) (Figure 1.1a);
- Steel fixing bracket anchored to steel grid (Figure 1.1b);
- Steel hooking systems (Figure 1.2).

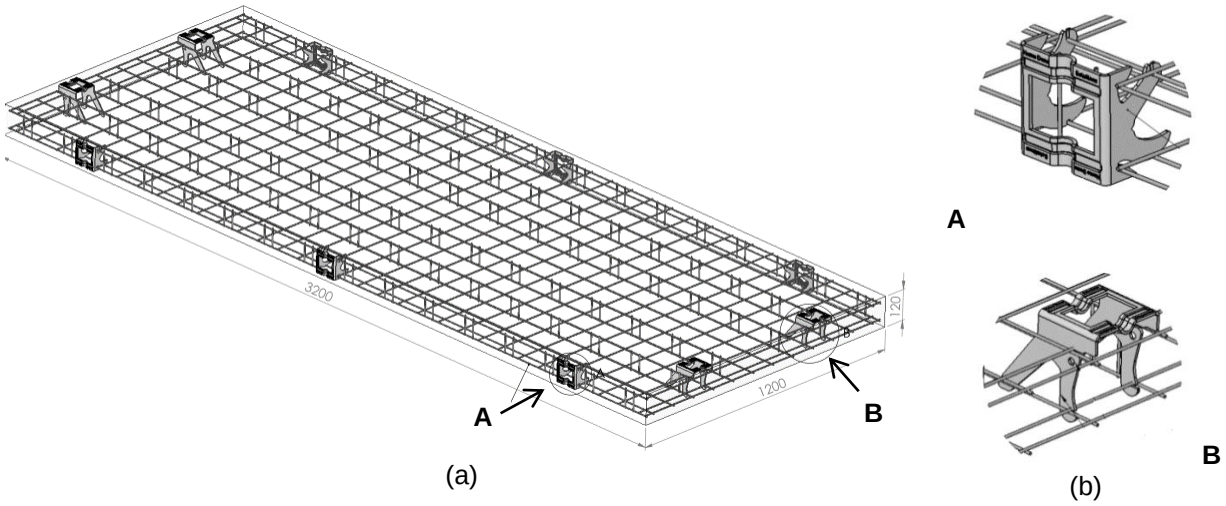


Figure 1.1 - (a) Loadbearing panels and particular of the fixing brackets: (b) “A” system and “B” system

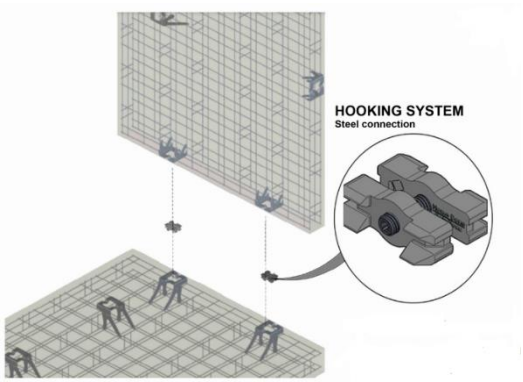


Figure 1.2 - Particular of the hooking system

The product is not covered by a harmonised European standard (hEN).

Concerning product packaging, transport, storage, maintenance, replacement and repair it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on the transport, storage, maintenance, replacement and repair of the product as he considers necessary.

It is assumed that the product will be installed according to the manufacturer's instructions or (in absence of such instructions) according to the usual practice of the building professionals.

Relevant manufacturer's stipulations having influence on the performance of the product covered by this European Assessment Document shall be considered for the determination of the performance and detailed in the ETA.

1.2 Information on the intended use(s) of the construction product

1.2.1 Intended use(s)

The "reinforced high density eps structural panel system for building units" is used for the construction of one or multi-storey residential units and industrial buildings. The building units are formed by linking together the load bearing panels, aligning and fixing the steel brackets through the hooking system.

The kit does not include finishing, neither internal nor external.

This EAD applies to the use with static, quasi-static and seismic load.

1.2.2 Working life/Durability

The assessment methods included or referred to in this EAD have been written based on the manufacturer's request to take into account a working life of the "reinforced high density EPS structural panel system" for the intended use of 50 years when installed in the works (provided that the "reinforced high density EPS structural panel system" is subject to appropriate installation). These provisions are based upon the current state of the art and the available knowledge and experience.

When assessing the product the intended use as foreseen by the manufacturer shall be taken into account. The real working life may be, in normal use conditions, considerably longer without major degradation affecting the basic requirements for works[1].

The indications given as to the working life of the construction product cannot be interpreted as a guarantee neither given by the product manufacturer or his representative nor by EOTA when drafting this EAD nor by the Technical Assessment Body issuing an ETA based on this EAD, but are regarded only as a means for expressing the expected economically reasonable working life of the product.

1 The real working life of a product incorporated in a specific works depends on the environmental conditions to which that works is subject, as well as on the particular conditions of the design, execution, use and maintenance of that works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than referred to above.

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

All undated references to standards or to EAD's in this EAD are to be understood as references to the dated versions listed in chapter 4.

2.1 Essential characteristics of the product

Table 2.1 shows how the performance of "reinforced high density EPS structural panel system for building units" is assessed in relation to the essential characteristics.

Table 2.1 Essential characteristics of the product and methods and criteria for assessing the performance of the product in relation to those essential characteristics

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 1: Mechanical resistance and stability			
1	Tensile strength and modulus of elasticity of the EPS (in tension)	2.2.1.1	Level $\sigma_{mt}\ [MPa]$ $E\ [MPa]$
2	Compressive strength at the 10% of deformation and modulus of elasticity of the EPS (in compression)	2.2.1.2	Level $\sigma_{c,10\%}\ [MPa]$ $E_c\ [MPa]$
3	Shear strength and modulus of elasticity of the EPS (shear)	2.2.1.3	Level $\sigma_s\ [MPa]$ $E_s\ [MPa]$
4	Flexural strength of the panel	2.2.2	Level $F_{f,max}\ [kN/m^2]$ $d_{f,max}\ [mm]$
5	Concentrated load bearing capacity of the panel	2.2.3	Level $d_c\ [mm]$
6	Axial load bearing capacity of the panel	2.2.4	Level $F_{ax,max}\ [kN]$ $d_{ax,max}\ [mm]$ $d_{lat,max}\ [mm]$
7	Racking strength of the panel and panel assembly	2.2.5	Level $F_R\ [kN]$
8	Tensile strength of the joint between panels	2.2.6	Level $F_{j,t}\ [kN]$
9	Shear strength of the joint between panels	2.2.7	Level $F_{j,s}\ [kN]$
10	Resistance to seismic loads of the unit	2.2.8	Level and description $a_{g,DS1}\ [g]$ $a_{g,DS2}\ [g]$ $a_{g,DS3}\ [g]$ $\Delta d_{max,DS1}\ [\%]$ $\Delta d_{max,DS2}\ [\%]$ $\Delta d_{max,DS3}\ [\%]$

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 2: Safety in case of fire			
11	Reaction to fire	2.2.9	Class
Basic Works Requirement 4: Safety and accessibility in use			
12	Impact resistance of the monolithic panel	2.2.10	Description
13	Creep coefficient of the panel	2.2.11	Level φ_t [%]
Basic Works Requirement 6: Energy economy and heat retention			
14	Water permeability	2.2.12	Description
15	Air permeability of the assembled panels	2.2.13	Level $\dot{V}$ $[m^3/h]$
16	Thermal resistance	2.2.14	Level R $\left[\frac{m^2K}{W}\right]$

2.2 Methods and criteria for assessing the performance of the product in relation to essential characteristics of the product

This chapter is intended to provide instructions for TABs. Therefore, the use of wordings such as “shall be stated in the ETA” or “it has to be given in the ETA” shall be understood only as such instructions for TABs on how results of assessments shall be presented in the ETA. Such wordings do not impose any obligations for the manufacturer and the TAB shall not carry out the assessment of the performance in relation to a given essential characteristic when the manufacturer does not wish to declare this performance in the Declaration of Performance.

Testing will be limited only to the essential characteristics which the manufacturer intends to declare. If for any components covered by harmonised standards or European Technical Assessments the manufacturer of the component has included the performance regarding the relevant characteristic in the Declaration of Performance, retesting of that component for issuing the ETA under the current EAD is not required.

2.2.1 Mechanical properties of the EPS

The mechanical properties of the EPS shall be presented in terms of tensile, compressive and shear behaviour.

2.2.1.1 Tensile strength and Young modulus

Purpose of the assessment

The purpose of the test methods herein presented is the evaluation of the tensile behaviour of the EPS panel including the steel reinforcement.

Assessment method

The EPS tensile behaviour shall be evaluated according to the method provided by EN 1607. Concerning the sample preparation, in addition to provision provided in section 6 of EN 1607, the dimension of the specimen shall be chosen in such way that a mesh of grid shall be included in the cut sample.

Expression of results

The tensile behaviour of the EPS shall be reported in the ETA by all individual values and the mean value of:

- Tensile strength perpendicular to faces: σ_{mt} [MPa];
- Young modulus: E_t [MPa] evaluated as the slope of the stress-strain curve in the linear section

2.2.1.2 Compressive strength at the 10% of the deformation and Young modulus

Purpose of the assessment

The purpose of the test method herein presented is the evaluation of the compressive behaviour of the EPS panel including the steel reinforcement.

Assessment method

The compressive behaviour of the EPS shall be determined according to the test method included in EN 826. Concerning the sample preparation, in addition to provision provided in section 6 of EN 826, the dimension of the specimen shall be chosen in such way that a mesh of grid shall be included in the cut sample.

Expression of results

The compressive behaviour of the EPS shall be represented in the ETA by all individual values and the mean value of

- Compressive strength at the 10% of deformation: $\sigma_{c,10\%}$ [MPa]
- Young modulus: E_c [MPa]

2.2.1.3 Shear strength and Young modulus

Purpose of the assessment

The purpose of the test method herein presented is the evaluation of the shear behaviour of the EPS panel including the steel reinforcement.

Assessment method

The shear behaviour of the EPS shall be determined according to the test method included in EN 12090. Concerning the sample preparation, in addition to provision provided in section 6 of EN 12090, the dimension of the specimen shall be chosen in such way that a mesh of grid shall be included in the cut sample.

Expression of results

The shear behaviour of the EPS shall be represented in the ETA by all individual values and the mean value of :

- Shear strength: σ_s [MPa]
- Young modulus: E_s [MPa]

2.2.2 Flexural strength of the panel

Purpose of the assessment

The purpose of the test method herein included is the evaluation of the flexural behaviour of the single panel.

Assessment method

The flexural strength shall be determined in accordance with the test method included in ANNEX A of this EAD.

Expression of results

The flexural strength shall be reported in the ETA by the values of the maximum force, $F_{f,max}$ [kN/m^2] and maximum deflection $d_{f,max}$[mm], read on the average load-deflection curve, as specified in ANNEX A.

2.2.3 Concentrated load bearing capacity of the panel

Purpose of the assessment

The purpose of the test method herein included is the evaluation of the safety and the serviceability of roof or ceiling panels when subjected to concentrated loads, due to for example to a single person walking in on the panel, for occasional access both during and after erection.

Assessment method

The concentrated load bearing capacity shall be determined in accordance with the test method included in clause A.9.1 of Annex A of EN 14509.

Expression of results

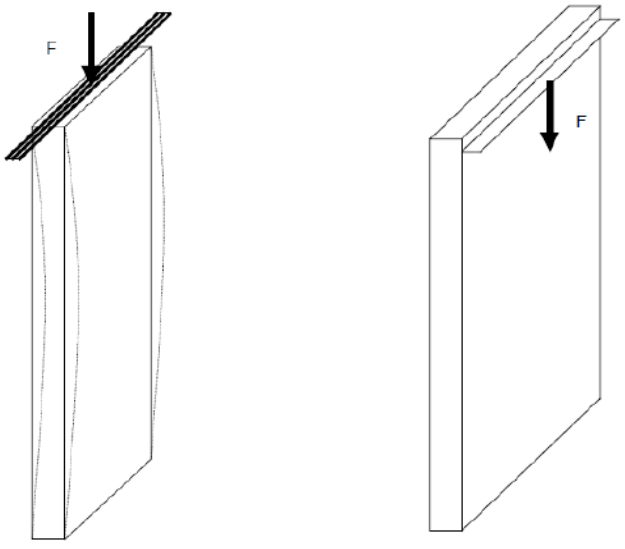
The concentrated load bearing capacity shall be represented by the average value of deformations reached during each test corresponding to the maximum applied load, $d_c\ [mm]$..

2.2.4 Axial load bearing capacity of the panel

Purpose of the assessment

The purpose of the test method herein included is the evaluation of the behaviour of the single panel when subject to axial load as shown in Figure 2.1Figure 2.1a.

Since the load-bearing panels are part of a composite panel kit, the way in which components are fixed to each other shall reproduce actual condition of use, with respect to the nature, type and position of the fixing and the distance between them. If the position of the fixing is not centred with axis of the panel, the behaviour under eccentric axial load Figure 2.1b shall be investigated.



(a) (b)

Figure 2.1 - Schematic view of panel subject to (a) axial loads and (b) eccentric axial load

Assessment method

The axial load bearing capacity shall be determined in accordance with the test method included in ANNEX B of this EAD.

Expression of results

The axial load bearing capacity shall be represented in the ETA by the relevant parameters of the average load-deflection curve, $F_{ax,\mathrm{d},max}\ [kN]$, $d_{lat,max}\ [mm]$, and the relevant parameters of the average load-compression curve, $F_{ax,c,max}\ [kN]$ $d_{ax,max}\ [mm]$, as defined in ANNEX B.

2.2.5 Racking strength of the panels and panel assembly

Purpose of the assessment

The purpose of the test method herein included is to determine the racking resistance of a single panel and of panel assemblies, in the last case to test the efficiency of interlocking systems.

Assessment method

The racking strength shall be determined in accordance with the test method included ANNEX C of this EAD.

Expression of results

The racking strength of a single panel and of a panel assembly shall be represented in the ETA by the average values of:

- racking strength, F_R[kN].

evaluated as reported in ANNEX C of this EAD.

2.2.6 Tensile strength of the joint between panels

Purpose of the assessment

The purpose of the test method herein included is the evaluation of the tensile strength of the joint between panels.

Assessment method

The tensile strength of the joint between panels shall be determined according to the test method included in ANNEX D.

Expression of results

The tensile strength, $F_{j,t}$ [kN] is represented by the average value of the maximum forces reached during the test and corresponding to the failure of the panel-to-panel joint.

2.2.7 Shear strength of the joint between panels

Purpose of the assessment

The purpose of the test method herein included is the evaluation of the shear strength of the joint between panels.

Assessment method

The shear strength of the joint between panels shall be determined according to the test method included in ANNEX D.

Expression of results

The shear strength $F_{j,s}\ [kN]$ is represented by the average value of the forces reached during the test and corresponding to the failure of the panel-to-panel joint.

2.2.8 Resistance to seismic loads of the unit

Purpose of the assessment

The purpose of the experimental and numerical methods herein presented is the evaluation of the resistance to seismic actions of the prefabricated kit. In particular the seismic behaviour shall be presented by defining the maximum applied acceleration and the maximum recorded drift at the top of the structure, corresponding to *building damage level* defined in Table 2.2.

Table 2.2 Structural performance level and damage

	Performance level		
	Operational level DS1	Life safety level DS2	Collapse prevention level DS3
Recorded damage	-No fall out of pieces. -No cracking.	Local cracking of panel not providing fall out of pieces with mass equal or more than 0.02 kg.	-Fall out of pieces with mass more than 0.02 kg. -Partial or total collapse of the structures.

Assessment method

The seismic resistance of the panels kit could be experimentally evaluated according to the procedure explained in ANNEX E.

Expression of results

The resistance to seismic loads shall be reported in the ETA by the level of:

- the maximum applied acceleration [g] corresponding to the achievement of DS1, DS2, DS3:
  - $a_{g,DS1}$
  - $a_{g,DS2}$
  - $a_{g,DS3}$
- the maximum recorded interstory-drift [%] corresponding to the achievement of DS1, DS2, DS3:
  - $\Delta d_{max,DS1}$
  - $\Delta d_{max,DS2}$
  - $\Delta d_{max,DS3}$

2.2.9 Reaction to fire

Purpose of the assessment

The purpose of the method herein presented is the evaluation of the fire reaction of panels.

Assessment method

The components of the kit, i.e. steel and EPS shall be tested (*) according to the method(s) referred to in EN 13501-1 and relevant for the corresponding reaction to fire class. The product shall be classified according to the Commission Delegated Regulation (EU) No 2016/364.

(*)or classified without testing (CWT) or without further testing (CWFT) on the basis of specific EC decisions.

Expression of results

The fire reaction of the panels shall be represented in the ETA by the fire reaction classes obtained for each component (steel and EPS).

2.2.10 Impact resistance of the monolithic panel

Purpose of the assessment

The purpose of the test method herein included is the evaluation of the impact resistance of the monolithic panels.

Assessment method

The impact resistance of wall or floors assemblies is split into the following characteristics:

- Resistance to functional failure from soft body impact load – 50 kg bag

  The resistance to functional failure from soft body impact load will be determined in accordance with the clause 2.2.6.1 of EAD 210005-00-0505.

- Resistance to functional failure from hard body impact load – 0,5 kg and 1 kg steel ball

  The resistance to functional failure from hard body impact load will be determined in accordance with the clause 2.2.6.2 of EAD 210005-00-0505.

Expression of results

The impact resistance shall be given in the ETA as a use category based on the tests performed according Annex B of EAD 210005-00-0505.

2.2.11 Creep coefficient of the panel

Purpose of the assessment

The purpose of the test method herein included is the evaluation of the creep coefficient of the monolithic panels.

Assessment method

The creep coefficient of the panel (φ_t) shall be determined in accordance with clause A.6 of annex A of EN 14509. In addition to indications provided by EN 14509, the following provisions shall be addressed:

- the reaction supports shall be properly widened in order to not allow local deformation of EPS;
- the load used for the creep test shall be chosen starting from shear strength of EPS evaluated according to §2.2.1.3;
- a time ”t” of at least 2000 h shall be used for testing.

The creep coefficient of the panel is to be determined only for panels used for floors and roofs.

One specimen shall be tested. The thickest panel in the defined range must be tested,

Expression of results

The creep coefficient of the panel shall be expressed in the ETA by means of the level, as follow:

$$\varphi_t \ [\%]$$

The value shall be calculated according to equations reported in section A.6.5 of EN 14509, be considering:

- w_b (deflection caused by the elastic extension of the faces) = 0;
- t= 2000 h (for snow load).

2.2.12 Water permeability

Purpose of the assessment

The purpose of the test method herein included is the evaluation of the resistance of the monolithic panel assembly to driving rain under pulsating air pressure. The water permeability is only relevant for panels which contribute to the water tightness (external walls and roofs).

Assessment method

The water permeability will be determined according to testing procedure included in EN 12865. In addition to indications provided by EN 12865, the following provisions shall be addressed:

- the specimen shall be prepared ensuring the presence of joints between panels for at least 3 m;
- the test shall be performed on the external side of the panel, if identified. Otherwise both sides shall be tested.

One specimen shall be tested. The procedure A provided in table 1 of EN 12865 shall be carried out.

Expression of results

The water permeability shall be expressed in the ETA by means of a description according to the criteria defined in clause A.11.5 of EN 14509.

2.2.13 Air permeability of the assembled panels

Purpose of the assessment

The purpose of the test method herein included is the evaluation of air permeability of the wall panel assemblies.

Assessment method

The air permeability of the kit will be determined according to EN 12114.

The air permeability is only relevant for panels of external walls and roofs.

Expression of results

The air permeability of the kit shall be expressed in the ETA by means of a level in tabular and/or graphical form.

2.2.14 Thermal resistance

Purpose of the assessment

The purpose of the test herein included is the evaluation of the thermal resistance of the panel.

Assessment method

The thermal resistance of the panel shall be determined according to the test method reported in EN 12667 Section 5.2 (Hot Guarded Plate Method). Furthermore, the following provisions shall be considered:

- the specimen shall have a dimension of minimum 600 x 600 mm;
- each specimen shall be cut from the central part of the panel in such way that at least one mesh of grid shall be included in the sample;
- the specimen shall be tested in normal condition of humidity.

A minimum of three tests shall be performed.

Expression of results

The thermal resistance of the panel shall be expressed in the ETA as the average value of R [m^2K/W].

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System(s) of assessment and verification of constancy of performance to be applied

For the products covered by this EAD the applicable European legal act is: Decision 2003/728/EC.

The system is: **1**

3.2 Tasks of the manufacturer

The cornerstones of the actions to be undertaken by the manufacturer of the product in the procedure of assessment and verification of constancy of performance are laid down in Table 3.1.

For kits: The manufacturer (regarding the components he buys from the market with DoP) shall take into account the Declaration of Performance issued by the manufacturer of that component. No retesting is necessary.

Table 3.1 Control plan for the manufacturer; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Factory production control (FPC) [including testing of samples taken at the factory in accordance with a prescribed test plan]					
1	Incoming material	Visual check	Conformity with the order, throughout checks of: • delivery ticket or label on the package • suppliers certificates or supplier data tests	-	Each delivery
2	Core material (EPS)/density	EN 1602	According to Control Plan	3	1 per shift / 6 h or 8 h
3	Core material (EPS)/mechanical properties (tensile strength and tensile modulus, compression strength at 10% of deformation and compression modulus, shear strength and shear modulus)	2.2.1	According to Control Plan	3	1 per week
4	Steel wire weld joint /shear strength	EN 10223-4	According to Control Plan	3	1 per 6 months
5	Panel/Dimensions	Measurement-gauge/meter and visual check	According to productions drawings	According to Control Plan	1 per shift / 6 h or 8 h
6	Panel/Planarity and squareness	Measurement-gauge/meter and visual check	According to productions drawings	According to Control Plan	1 per shift / 6 h or 8 h
7	Core material (EPS)/ reaction to fire	Test based on the relevant standard	According to Control Plan	1	1 per week
8	Core material (EPS)/ thermal resistance and thermal conductivity	EN 12667	According to Control Plan	According to Control Plan	1 per 24 h (direct testing) or 1 per year (direct testing) and 1 per 2 h (indirect testing, using a manufacturer's correlation)

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body of the product in the procedure of assessment and verification of constancy of performance are laid down in Table 3.2.

Table 3.2 Control plan for the notified body; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control					
1	The notified body shall ascertain that, in accordance with the control plan, the manufacturing plant of the product manufacturer, in particular personnel and equipment, and the factory production control are suitable to ensure a continuous and orderly manufacturing of the components of the system. Particular attention should be paid to the phases of expansion of EPS and insertion of steel fixing brackets and hooking systems.	Verification of the complete FPC as described in the control plan agreed between the TAB and the manufacturer	As defined in the control plan	As defined in the control plan	When starting the production or a new line
2	Initial inspection of the manufacturing plant and of factory production control carried out by the manufacturer regarding the constancy of performance related to reaction to fire, taking into account the limitation on organic material and/or the addition of fire retardant.	Verification of the complete FPC as described in the control plan agreed between the TAB and the manufacturer	As defined in the control plan	As defined in the control plan	When starting the production or a new line
Continuous surveillance, assessment and evaluation of factory production control					
1	It shall be verified that the system of factory production control and the specified manufacturing process are maintained in accordance with the control plan in order to ensure the constancy of product performance. Particular attention should be paid to the phases of expansion of EPS and insertion of steel fixing brackets and hooking systems.	Verification of the controls carried out by the manufacturer as described in the control plan agreed between the TAB and the manufacturer with reference to the raw materials, to the process and to the product as indicated in Table 3.1	As defined in the control plan	As defined in the control plan	Once per year
2	Continuous surveillance, assessment and evaluation of the factory production control carried out by the manufacturer considering the constancy of performances of reaction to fire and taking into account the limitation on organic material and/or the addition of fire retardants.	Verification of the controls carried out by the manufacturer as described in the control plan agreed between the TAB and the manufacturer with reference to the raw materials, to the process and to the product as indicated in Table 3.1	As defined in the control plan	As defined in the control plan	Once per year

4 REFERENCE DOCUMENTS

EAD 210005-00-0505:2019	Internal partition kits for use as non-loadbearing walls
EN 826:2013	Thermal insulating product for building – Determination of compression behaviour
EN 1602:2013	Thermal insulating products for building applications – Determination of the apparent density
EN 1607:2013	Thermal insulating product for building applications – Determination of tensile strength perpendicular to face
EN 1998-1:2013	Eurocode 8: Design of structures for earthquake resistance – Part 1: General rules, seismic actions and rules for buildings.
EN 10223-4:2013	Steel wire and wire product for fencing and netting – Part 4: steel wire mesh fencing
EN 12090:2013	Thermal insulating product for building – Determination of shear behaviour
EN 12114:2001	Thermal performance of building elements – Laboratory test method
EN 12667:2002	Thermal performance of building materials and products – Determination of thermal resistance by means of guarded hot plate and heat flow meter methods – Products of high and medium thermal resistance
EN 12865:2003	Hygrothermal performance of building components and buildings elements – Determination of the resistance of external wall system
EN 13501-1:2019	Fire classification of construction products and building elements - Part 1: Classification using data from reaction to fire tests
EN 14509:2013	Self-supporting double skin metal faced insulating panels – Factory made products – Specifications

ANNEX A EXPERIMENTAL METHOD FOR DETERMINING THE FLEXURAL STRENGTH OF THE PANEL

A.1 General

This test method is derived from ASTM E72-15 Standard Test method of Conducting Strength Tests of Panels for Building Construction.

A.2 Test specimens

The specimens to test shall have the maximum height and width of the panel covered by the ETA.

A.3 Number of tests

A minimum of three tests for each configuration shall be performed.

A.4 Test setup and equipment

The test setup shall be assembled as shown in Figure A.1. Two steel rollers with a dimension of 40 ± 10 mm shall be used as supporting device and with a steel plate with a dimension of 80 ± 20 mm between each supporting rollers and the specimen. A frame shall be placed on the upper face of the specimen. To prevent stresses deforming the frame as the specimen deforms under load, this frame shall rest on three hardened steel balls, each supported by a steel block on the face of the specimen. Two of the balls shall be placed in a line vertically above one support and the third ball vertically above the other support. Two deflection measuring device, one near each longitudinal edge of the specimen, shall be attached to the frame at midspan.

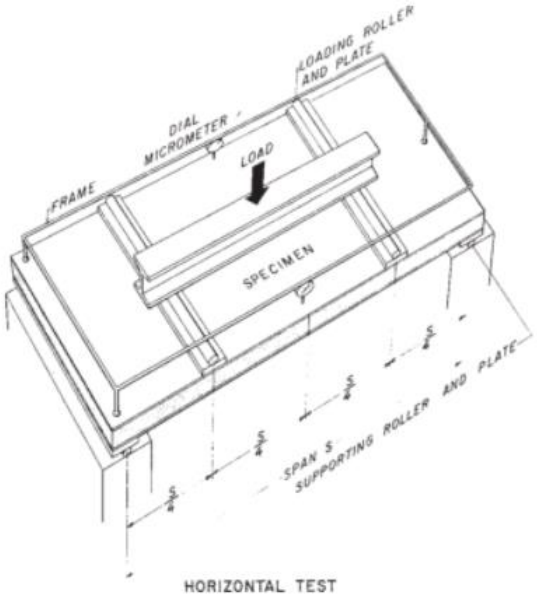


Figure A.1 - Setup for flexural test

A.5 Test procedure

The specimen shall be tested as a simple beam on a span 150 mm less than the specimen. Two equal loads shall be applied, each at the distance of one quarter of the span from the supports. For wall specimens tested horizontally, the load on the specimen shall include the weight of the specimen between the supports.

Uniformly distributed loading may be used instead of quarter-point loading, if a satisfactory method is available. Uniformly distributed load may be applied by air pressure, either in a bag or in a chamber having the specimen as one face.

For each measuring device, the deflection under a given load as the difference between the reading of the device when the load is applied and the initial reading shall be calculated. Calculate the deflection of the specimen as the average of the deflections obtained from each measuring device. The maximum load for each specimen shall be recorded.

A.6 Test report

As a minimum requirement, the report shall include at least the following information:

General

- Description of the specimen in terms of dimension and used material
- Description of the test setup (geometry)
- Description of the testing equipment: load cells, displacement transducers, software, hardware, data recording system
- Number of executed tests

Measured values

- Parameters of load application (e.g. rate of increase of load or size of load increase steps);
- Loads and deformations for each test
- Load-deflection curve, obtained as the average value of the three specimens with relevant parameters:
    - $F_{f,max}$, the maximum load [kN];
    - $d_{f,max}$ the panel deflection corresponding to $F_{f,max}$ [mm]

  The average curves shall be obtained by calculating the average of the loads corresponding to each value of the deformation of the three curves.

ANNEX B EXPERIMENTAL METHOD FOR DETERMINING THE AXIAL LOAD BEARIGN CAPACITY OF THE PANEL

B.1 General

This test method is derived from ASTM E72-15 Standard Test method of Conducting Strength Tests of Panels for Building Construction.

B.2 Test specimens

The test specimen is represented by the most onerous panel, i.e., the panel with the highest ratio length (or height) over width in its minimum thickness.

B.3 Number of tests

A minimum of three tests for each configuration shall be performed.

B.4 Test setup and equipment

The panel assembly shall be mounted in accordance with the manufactures installation specifications and reproduce actual conditions of use. The apparatus shall be assembled as shown in Figure B.1.

Four compression meters shall be attached to the face of the specimen, one near each corner of the specimen, to measure the shortening of the specimen. Two deflectometers, one to each edge of the specimen, shall be attached to the specimen as shown in Figure B.1.

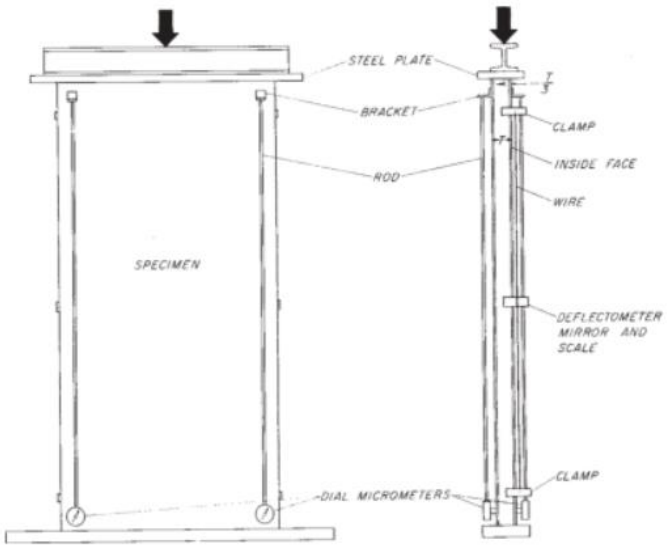


Figure B.1 - Setup for axial load test

B.5 Test procedure

The panels shall be tested as a column, having a flat end at the bottom. Compressive loads shall be applied to a steel plate covering the upper end of the assembly. The load shall be applied uniformly along a line parallel to the inside face, and one-third the thickness of the specimen from the inside face. A rate of loading corresponding to a movement of the testing machine crosshead of nominally 0.8 mm/min could be used.

B.6 Test report

As a minimum requirement, the report shall include at least the following information:

General

- Description of the specimen in terms of dimension and used material
- Description of the test setup (geometry)

- Description of the testing equipment: load cells, displacement transducers, software, hardware, data recording system
- Number of executed tests

Measured values

- Parameters of load application (e.g., rate of increase of load or size of load increase steps);
- Loads and deformations for each test;
- Load-deflection curve, obtained as the average value of the three specimens with relevant parameters:
  - $F_{ax,\mathrm{d},max}$, the maximum load;
  - $d_{lat,max}$ the panel out of plane deflection corresponding to $F_{ax,\mathrm{d},max}$.
- Load-compression curve, obtained as the average value of the three specimens with relevant parameters:
  - $F_{ax,c,max}$, the maximum load;
  - $d_{ax,max}$ the panel shortening corresponding to $F_{ax,c,max}$

  The average curves shall be obtained by calculating the average of the loads corresponding to each value of the deformation of the three curves.

ANNEX C EXPERIMENTAL METHOD FOR DETERMINING THE RACKING STRENGTH OF THE PANEL AND PANEL ASSEMBLY

C.1 General

This test method is derived from ASTM E72-15 Standard Test method of Conducting Strength Tests of Panels for Building Construction.

C.2 Test specimens

The panel with the highest ratio height over width in its minimum thickness, for which the manufacturer claims for racking resistance shall be tested.

The racking resistance of wall panel assemblies shall be also determined. The following configurations could be considered:

- an external wall panel assembly with the maximum opening size;
- an external wall panel assembly without openings;
- an internal wall panel assembly.

The assembly will consist at least of two interlocked panels.

C.3 Number of tests

Three tests shall be performed on a single panel and three test on each wall panel assembly.

C.4 Test setup and equipment

The test specimen shall be mounted in accordance with the manufactures installation specifications and reproduce actual conditions of use. The apparatus shall be assembled as shown in Figure C.1.

The test panel shall be attached to timber or steel base and loading fixtures. The base fixture is in turn attached rigidly to the base of the test frame. The base and loading fixtures shall be of any convenient cross section, but shall be at least as long as the panel and not wider than the width of the framing lumber used to construct the wood frame. Means shall be provided to bolt or otherwise attach the top and bottom plates of the test panel firmly to the base and loading fixtures.

A hold-down shall be provided as shown in Figure C.1 to rigidly overcome the tendency of one end of the panel to rise as the racking load is applied. Plates and rollers shall be provided between the loading fixture and the hold-down so that the top of the specimen can deflect horizontally with respect to the bottom without interference from the hold-down. Because the amount of tension in the rods of the hold-down may have an effect on the results of the test, nuts on the hold-down rods shall be tightened prior to load application so that the total force in each rod does not exceed 90 N at the beginning of test as determined by previous calibration.

Load shall be applied to the specimen in shear through a horizontal compressive force applied to the loading fixture parallel to the top plate. Lateral guides shall be provided so that the specimen will deflect in a plane. The rollers should be bearing-supported to reduce friction to a minimum. The lateral guides shall be firmly attached to the loading frame. Plates for the rollers shall be provided.

Linear displacement measuring devices shall be provided to measure the displacement of the different parts of the panel during test. The locations and sign conventions of the displacement measuring devices shall be as shown in Figure C.1. The devices are used to measure: the lateral displacement of the centreline of the top plate ($\Delta 1$) and the bottom plate ($\Delta 2$), and the vertical displacement at the centre of the tension stud ($\Delta 3$) and the compression stud ($\Delta 4$).

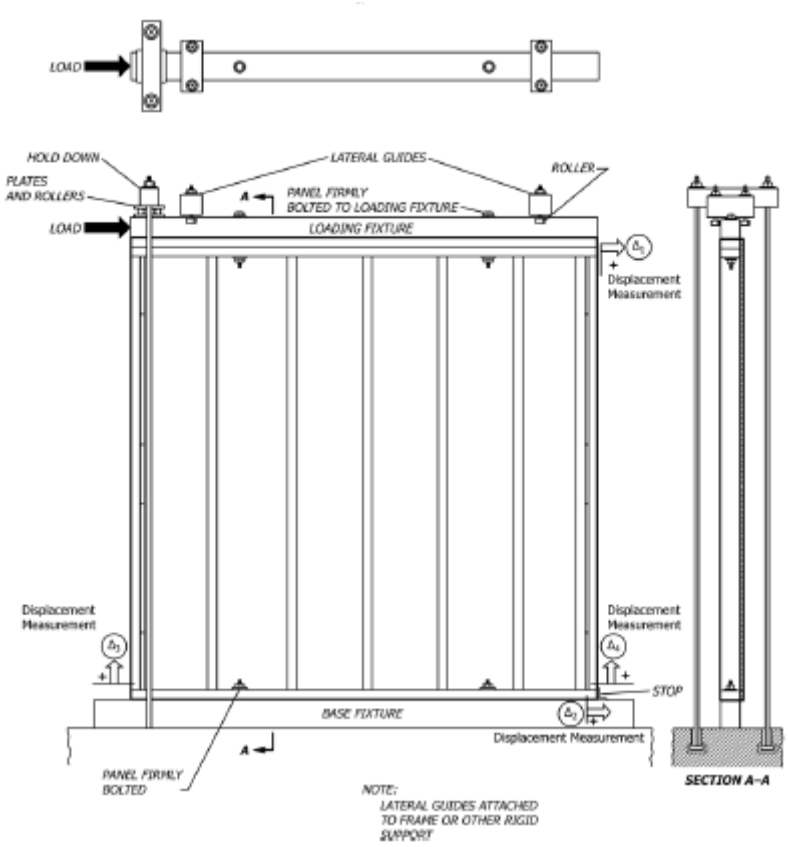


Figure C.1 - Setup for racking load test

C.5 Test procedure

The racking load shall be applied using a series of stages that are a function of the expected maximum load. The panel shall be loaded at a constant rate using a minimum of three stages, with the final stage loading the panel to failure. Loads and displacements are measured and recorded through all stages at a frequency of not less than once every 10 s.

Load shall be applied continuously throughout test at a uniform rate of racking load or fixture displacement. The loading rate shall be such that the peak load in the first stage shall be achieved in not less than 2 min. The same load or displacement rate shall be used for subsequent stages. Report the loading rate used and the time from load initiation to maximum load for each test specimen. The average time to the maximum load, excluding relaxation time, for a series of specimens shall not be less than 10 min.

Load the specimen using a minimum of the three mandatory stages outlined below:

- *First Stage*—Load the specimen to a load level not less than 30 % of the expected maximum load. Unload the specimen in 30 s or less and record the set.
- *Second Stage*—Load the specimen to not less than 60 % of the expected maximum load. Unload the specimen in 30 s or less and record the set.
- Third Stage—Load the specimen beyond the maximum load to failure or to the point where the measured post-peak racking resistance represents 80 % of the maximum load, whichever occurs first.

Additional preliminary stages shall be permitted.

C.6 Test report

As a minimum requirement, the report shall include at least the following information:

General
- Description of the specimen in terms of dimension and used material
- Description of the test setup (geometry)

- Description of the testing equipment: load cells, displacement transducers, software, hardware, data recording system
- Number of executed tests

Measured values

- Parameters of load application (e.g. rate of increase of load or size of load increase steps).
- Deformation: for each measuring device, calculate the movement under each racking load as the difference between the readings when load is applied and the initial readings at the start of the test. Calculate set readings as the difference between the readings when the load is removed and the initial readings. Calculate and report the horizontal deformation of the test specimen as:

$$\Delta_h = \Delta_1 - \Delta_2 - (\Delta_3 - \Delta_4)$$

  where:
  - Δ_h= horizontal deformation of the assembly that excludes movement from rigid body rotation and translation, (mm)
  - Δ_1 = horizontal displacement of the top plate, (mm)
  - Δ_2 = horizontal displacement of the bottom plate, (mm)
  - Δ_3 = vertical displacement of the tension stud, (mm)
  - Δ_4 = vertical displacement of the compression stud, (mm)
- Load-deflection curves obtained in the form of a graph, including:
  - Maximum load (racking strength), F_R (kN);
  - The post peak deflection at 80% of the maximum load, Δ_{pp} (mm)

-

ANNEX D EXPERIMENTAL METHOD FOR DETERMINING THE TENSILE AND SHEAR STRENGTH OF THE JOINT BETWEEN PANELS

D.1 Test specimens

An example of test specimen for the determination of tensile strength of the joint between panels is reported in Figure D.1: it could be represented by a portion of panel, cut over its length and with a width and a thickness equal to those of the panel, as schematically reported in Figure D.1.

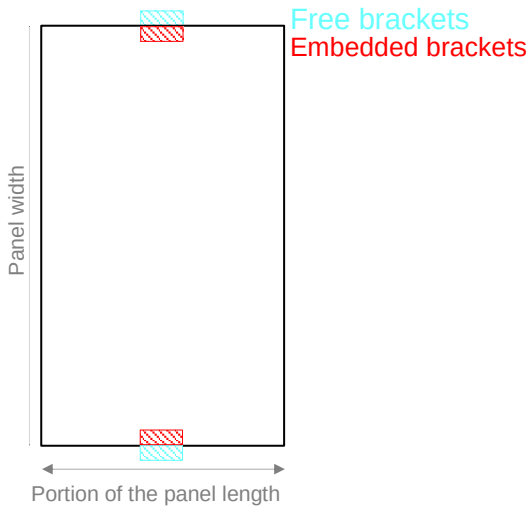


Figure D.1 - Example of test specimen for tensile tests of the joint between panels

The test specimen for tensile tests shall be symmetric, i.e. with a connection system on each side. Each connection shall be composed by brackets embedded in the panel and anchored to the steel grid, free brackets which simulate an adjacent panel and hooking systems which connects brackets.

In any case, the dimension of the specimen shall be chosen in order to not interfere with the test setup. The test setup shall guarantee the determination of the tensile strength of the joint.

The test specimen for shear tests shall be symmetric (Figure D.2), i.e. composed by three portions of panels connected each other by means of interlocking systems, in order to avoid eccentric loads.

The dimension of the specimen shall be chosen in order to not interfere with the test setup. The test setup shall guarantee the determination of the shear strength of the joint.

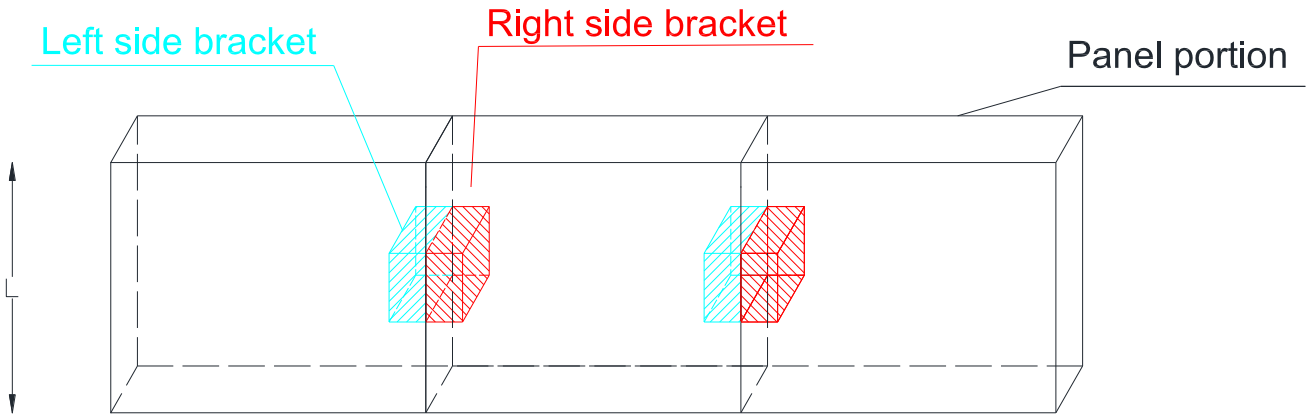


Figure D.2 - Example of test specimen for shear tests of the joint between panels

D.2 Number of tests

A minimum of three tests for each configuration shall be performed.

D.3 Test setup and equipment

Example of tensile and shear test assemblies are shown in Figure D.3 and Figure D.4.

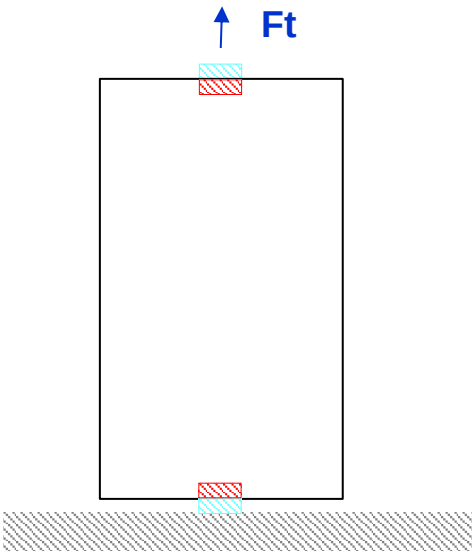


Figure D.3 - Example of tensile tests assembly

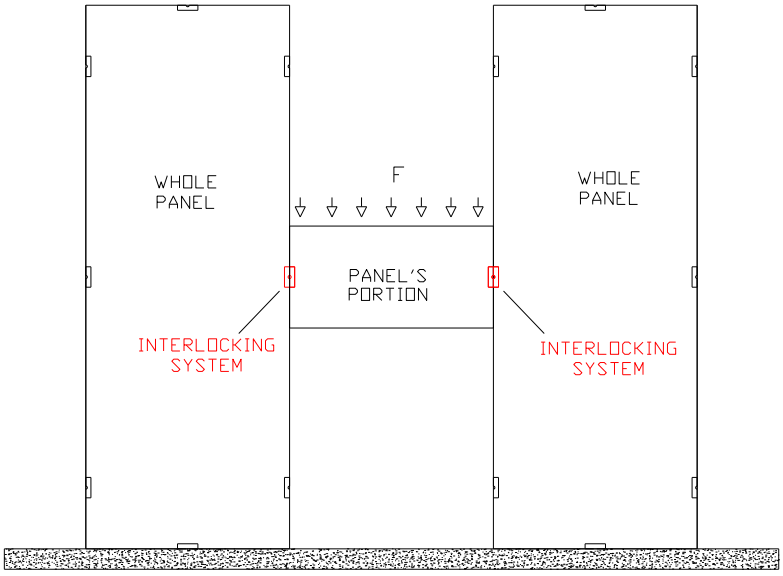


Figure D.4 - Example of shear tests assembly

D.4 Test procedure

Tensile loads shall be applied to a steel plate covering the upper end of the assembly for tensile tests. Compressive loads shall be applied to a steel plate covering the upper end of the assembly for shear tests. A rate of loading corresponding to a movement of the testing machine crosshead of nominally 0.8 mm/min shall be used.

D.5 Test report

As a minimum requirement, the report shall include at least the following information:

General

- Description of the specimen in terms of dimension and used material
- Description of the test setup (geometry)
- Description of the testing equipment: load cells, displacement transducers, software, hardware, data recording system
- Number of executed tests

Measured values

- Load-deformation curve
- Maximum recorded load corresponding to tensile $F_{j,t}$ and shear failure $F_{j,s}$ of the interlocking systems.

ANNEX E TEST METHOD FOR THE EVALUATION OF THE SEISMIC BEHAVIOR OF THE UNIT

The test specimen shall be representative of a housing unit. An example of the specimen is reported in Figure E.1.
The sample shall be assembled in strict accordance with the manufacturer's drawings and specifications.

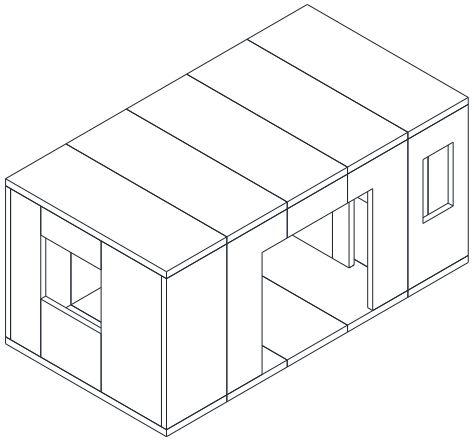


Figure E.1 - Schematic view of the specimen

E.1 Test setup and equipment

The test setup is shown in Figure E.2 and Figure E.3. The specimen shall be connected to the floor of the shaking table according to the real condition of installation.

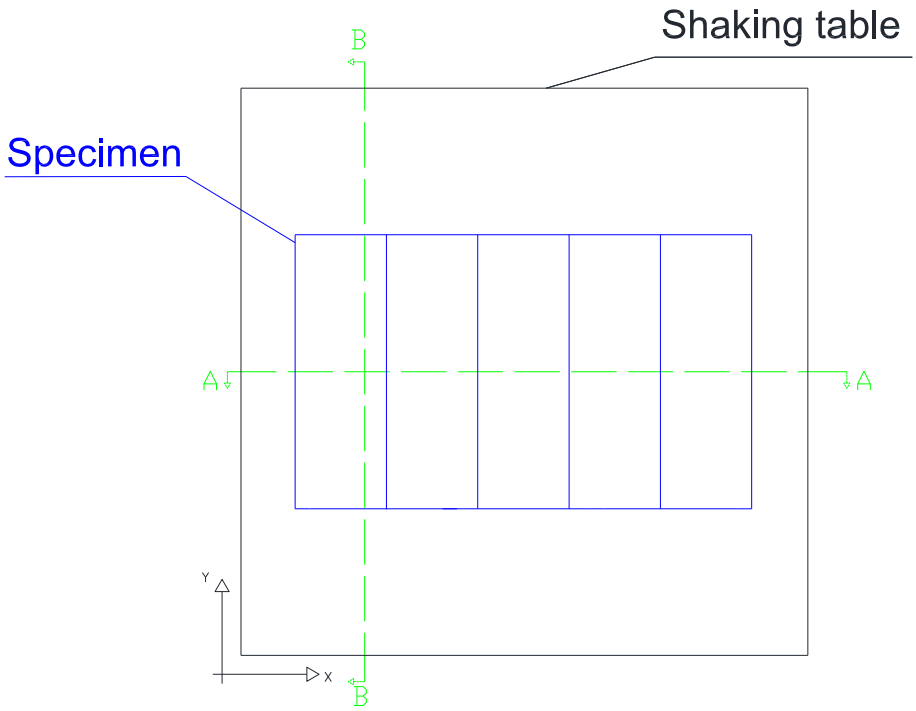


Figure E.2 - Plane view of the test setup

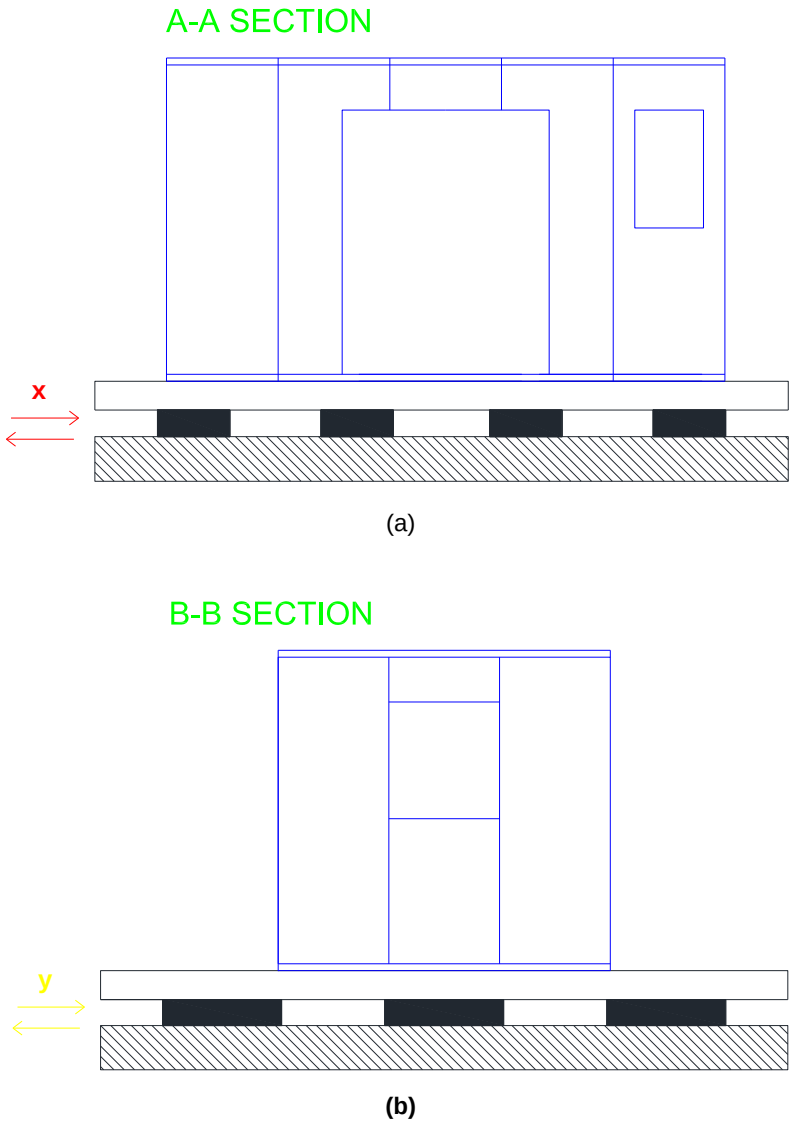


Figure E.3 - Lateral view of the test setup in (a) x and (b) y direction

The specimen response shall be measured in real time, by means of accelerometers and displacement transducers, allocated as minimum as reported in Figure E.4.

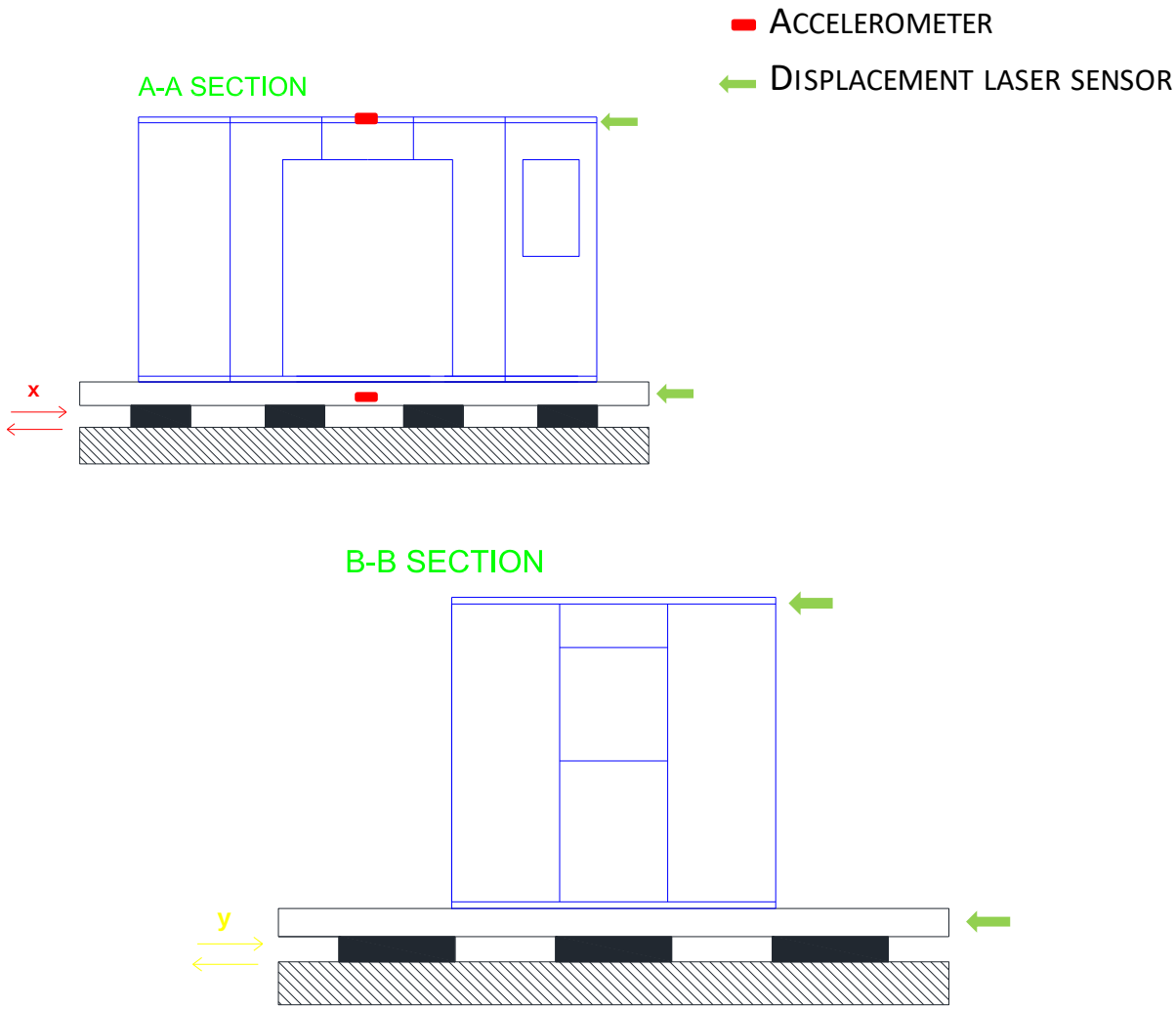


Figure E.4 - Example of specimen monitoring system

E.2 Test procedure

The specimen shall be subjected to dynamic tests according to the procedures explained below.

Dynamic tests shall be performed by applying simultaneously acceleration time-histories in two horizontal directions. The acceleration time-histories shall be nonstationary broadband random excitations having an energy content ranging from 1.3 to 33.3 Hz and a bandwidth resolution equal to one sixth-octave. The total duration of the input motion shall be 30 seconds, which includes 5 seconds for the acceleration ramp-up, 20 seconds of strong motion time duration and 5 seconds for the decay time.

The acceleration response spectrum (TRS), which is developed from the acceleration time-histories, shall be calculated using a damping value equal to 5 percent of critical damping. The TRS must envelop the required response spectrum (RRS) based on a maximum-one-sixth octave bandwidth resolution over the frequency range from 1.3 to 33.3 Hz.

The amplitude of each narrowband signal shall be independently adjusted in each of the principal axes until the TRS envelops the RRS. This can be achieved through a spectrum-matching procedure by RSP Match software (Figure E.5). It is recommended that the TRS should not exceed the RRS by more than 30 percent over the amplified region of the RRS. Any acceleration-signal filtering performed within the range of analysis must be defined. The general requirement for the enveloping of the RRS by the TRS can be modified under the following conditions.

In the performance of a test program, the TRS may not fully envelop the amplified region of the RRS (frequencies less than or equal to 8.3 Hz) or the ZPA region of the RRS (frequencies greater than 8.3 Hz). The general requirement for a retest may be exempted if the following criteria are met:

- In those cases in which it can be shown by use of the resonance search, that no resonance response phenomena exist below 5 Hz, the TRS is required to envelop the RRS only down to 3.5 Hz. Excitation must continue to be maintained in the 1.3 Hz to 3.5 Hz range, within the limitations of the shake table;
- When resonance phenomena exist below 5 Hz, the TRS is required to envelop the RRS only down to 75 percent of the lowest frequency of resonance;
- When the absence of resonance response phenomena below 5 Hz cannot be justified, the general requirement applies and the low-frequency enveloping should be maintained down to 1.3 Hz;
- A single point of the TRS may fall below the RRS (for frequencies less than or equal to 8.3 Hz) by 10 percent or less, provided the adjacent one-sixth-octave points are at least equal to the RRS;
- A single point of the TRS may fall below the RRS (for frequencies less than or equal to 8.3 Hz) by 10 percent or less, provided the adjacent one-sixth-octave points are at least equal to the RRS and a maximum of two of the one-sixth octave analysis points may be below the RRS;
- A single point of the TRS may fall below the RRS (for frequencies greater than 8.3 Hz) by 10 percent or less, provided the adjacent one-sixth-octave points are at least equal to the RRS and a maximum of two of the one sixth octave analysis points may be below the RRS;
- To achieve the minimum acceleration requirements, the peak shake table acceleration shall equal or exceed 90 percent of A_{RIG}.

In order to define the required response spectrum (RRS), the following parameters shall be considered:

$$A_{RIG} = 0.4\, S_{DS}(1 + 2\, z/h) \tag{A.3.1}$$

$$A_{FLX} = S_{DS}(1 + 2\, z/h) \leq 1.6 S_{DS} \tag{A.3.2}$$

where

- height factor ratio z/h=1.0
- the site-specific ground spectral acceleration factor S_{DS} =1 g, with “g” is the gravity acceleration.

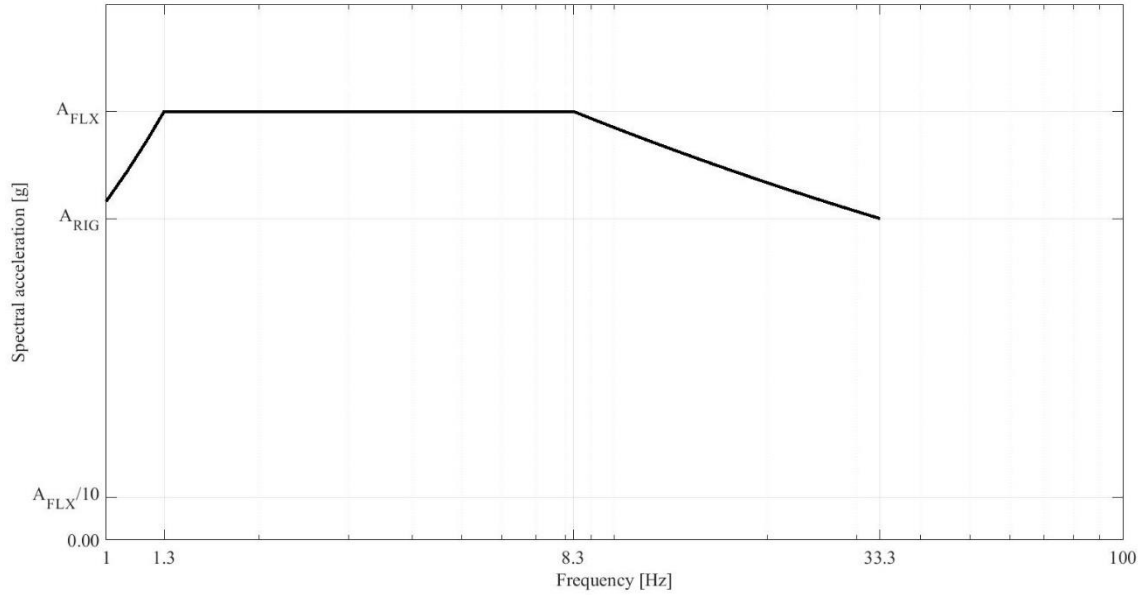


Figure E.5 - Required response spectrum (RRS), 5% damping

The obtained acceleration time-histories in the two directions of the plane can be applied by scaling the maximum acceleration values, starting from 10% a_{max} up to either the failure of the specimen or the attainment of the test facility limits, with a step of 10%. After each tests, resonance-search tests shall be undertaken to establish the natural frequencies of the specimen. The resonance-search tests shall be achieved with signal a low-level amplitude (0.1± 0.05 g peak input; a lower input level may be used to avoid component damage) single-axis sinusoidal sweep from 1.3 to 33.3 Hz shall be performed in each

orthogonal component axis to determine resonant frequencies. The sweep rate shall be two octaves per minute, or less, to ensure adequate time for maximum response at the resonant frequencies.

E.3 Test report

As a minimum requirement, the report shall include at least the following information:

General

- Description of the specimen in terms of dimension and used material
- Description of the test setup (geometry),
- Description of the testing equipment: load cells, accelerometers, displacement transducers, software, hardware, data recording system,
- Description of loading procedure (mean features of input accelerograms),
- Number of executed tests,

Measured values

- Maximum acceleration applied during the test corresponding to the achievement of each damage state;
- Maximum acceleration recorded during the test and corresponding to the achievement of each damage state;
- Maximum displacement recorded during the test and corresponding to the achievement of each damage state.