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European Assessment Document for

Kits for connection of precast concrete façade elements to concrete structures based on anchor channels

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 kits for connection of precast concrete façade elements to concrete structures based on anchor channels (hereinafter referred to as "connection kit"), schematically shown in Figure 1.1.1, is constituted by:

- two anchor channels, each of them embedded in the precast element (panel and beam/column);
- a ribbed steel plate and bolt allowing the regulation of the system during the assembly phase;
- two nuts, pre-inserted in the anchor channels, that can slide and allow the relative displacements between the panel and the main structure, both in horizontal and vertical direction;
- related bolts, washers and ancillaries.

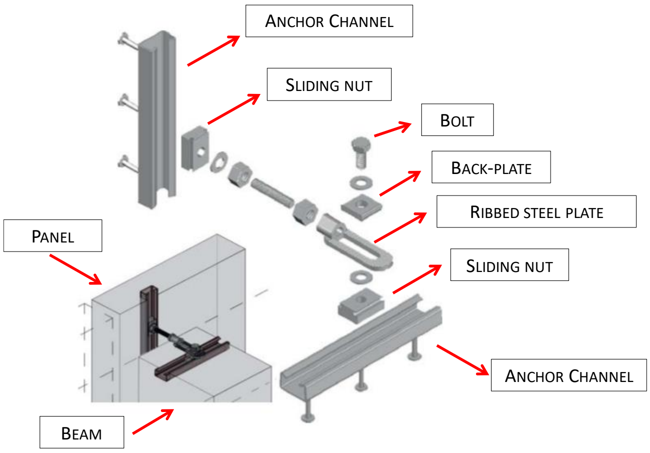


Figure 1.1.1: Connection kit

Each component of the connection kit is made of steel, stainless steel or galvanized steel and does not contain more than 1,0 % by weight or volume (whichever is the more onerous) of homogeneously distributed organic material.

The product is not fully covered by EAD 330008-04-0601 since this concerns only components of the connection kit related to one anchor channel, i.e., the anchor channel itself, channel bolt, nut and washer. For this reason, the mechanical resistance to cyclic quasi-static and dynamic actions has been developed in more detail for the kit at hand in this EAD and the characteristic resistance under seismic loading (seismic performance category C1) of EAD 330008-04-0601 (clauses 2.2.28 to 2.2.30) has not been considered here.

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, e.g., with regard to the intended end use conditions, 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 as long as the details of the assessment methods as laid down in this EAD are respected.

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

1.2.1 Intended use(s)

The connection kit allows the connection of both vertical and horizontal precast concrete cladding panels to beams and columns respectively, as shown in Figure 1.2.1.1 and Figure 1.2.1.2.

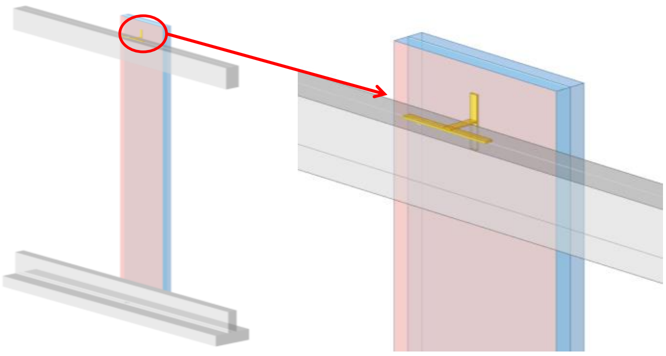
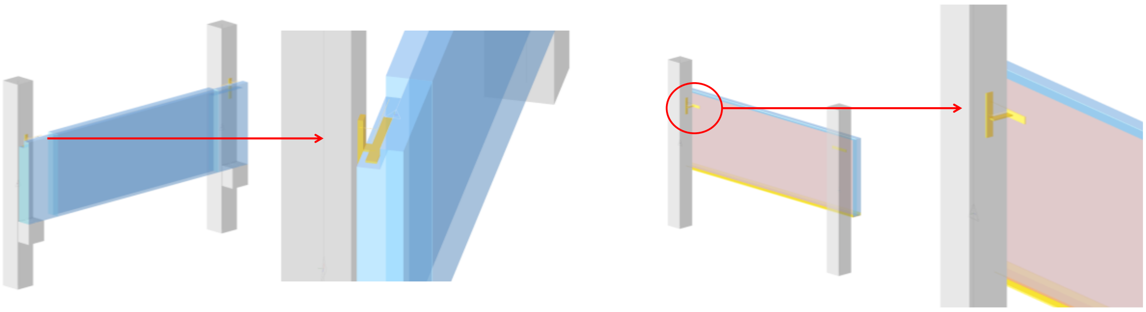


Figure 1.2.1.1: Scheme of a connection between a vertical panel and perimetral beam



(a) (b)

Figure 1.2.1.2: Schemes of connection between horizontal panel and columns: (a) example with anchor channel embedded on the top surface of the panel and (b) example with anchor channel embedded on the back side of the panel

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 connection kit for the intended use of 50 years when installed in the works (provided that the connection kit 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 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 2.1.1 shows how the performance of the connection kit is assessed in relation to the essential characteristics.

Table 2.1.1: 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			
Characteristic resistance under static and quasi-static tension loading			
1	Resistance to steel failure of anchors[1]	2.2.1 of EAD 330008-04-0601	Level $N_{Rk,s,a}$
2	Resistance to steel failure of the connection between anchors and channel[1]	2.2.2 of EAD 330008-04-0601	Level $N_{Rk,s,c}$
3	Resistance to steel failure of channel lips and subsequently pull-out of channel bolt[1]	2.2.3 of EAD 330008-04-0601	Level $N^0_{Rk,s,l}$; $s_{l,N}$
4	Resistance to steel failure of channel bolt[1]	2.2.4 of EAD 330008-04-0601	Level $N_{Rk,s}$
5	Resistance to steel failure by exceeding the bending strength of the channel[1]	2.2.5 of EAD 330008-04-0601	Level $M_{Rk,s,flex}$; s_{max}
6	Maximum installation torque moment to avoid damage during installation[1]	2.2.6 of EAD 330008-04-0601	Level $T_{inst,g}$; $(T_{inst,s})$
7	Resistance to pull-out failure of the anchor[1]	2.2.7 of EAD 330008-04-0601	Level $N_{Rk,p}$
8	Resistance to concrete cone failure[1]	2.2.8 of EAD 330008-04-0601	Level $k_{cr,N}$; $k_{ucr,N}$; h_{ef}
9	Minimum edge distances, spacing and member thickness to avoid concrete splitting during installation[1]	2.2.9 of EAD 330008-04-0601	Level s_{min}; c_{min}; h_{min}
10	Characteristic edge distance and spacing to avoid splitting of concrete under load[1]	2.2.10 of EAD 330008-04-0601	Level $s_{cr,sp}$; $c_{cr,sp}$
11	Resistance to blowout failure - bearing area of anchor head[1]	2.2.11 of EAD 330008-04-0601	Level A_h
Characteristic resistance under static and quasi-static shear loading			
12	Resistance to steel failure of anchor bolt under shear loading without lever arm[1]	2.2.12 of EAD 330008-04-0601	Level $V_{Rk,s}$

No	Essential characteristic	Assessment method	Type of expression of product performance
13	Resistance to steel failure by bending of the channel bolt under shear load with lever arm[1]	2.2.13 of EAD 330008-04-0601	Level $M^0_{Rk,s}$
14	Resistance to steel failure of channel lips, steel failure of connection between anchor and channel or steel failure of anchor (shear load in transverse direction) [1]	2.2.14 of EAD 330008-04-0601	Level $V^0_{Rk,s,l,y}$; $s_{l,V}$; $V_{Rk,s,c,y}$; $V_{Rk,s,a,y}$
15	Resistance to steel failure of connection between channel lips and channel bolt (shear load in longitudinal channel axis) [1]	2.2.15 of EAD 330008-04-0601	Level $V_{Rk,s,l,x}$
16	Factor for sensitivity to installation[1]	2.2.16 of EAD 330008-04-0601	Level γ_{inst}
17	Resistance to steel failure of the anchor[1]	2.2.17 of EAD 330008-04-0601	Level $V_{Rk,s,a,x}$
18	Resistance to steel failure of connection between anchor and channel[1]	2.2.18 of EAD 330008-04-0601	Level $V_{Rk,s,c,x}$
19	Resistance to concrete pry-out failure[1]	2.2.19 of EAD 330008-04-0601	Level k_8
20	Resistance to concrete edge failure[1]	2.2.20 of EAD 330008-04-0601	Level $k_{cr,V}$; $k_{ucr,V}$
Characteristic resistance under combined static and quasi-static tension and shear loading			
21	Resistance to steel failure of the anchor channel[1]	2.2.21 of EAD 330008-04-0601	Level k_{13}; k_{14}
Characteristic resistance under fatigue tension loading			
22	Fatigue resistance to steel failure of the whole system[1] (continuous or tri-linear function, assessment method A1, A2)	2.2.22 of EAD 330008-04-0601	Level $\Delta N_{Rk,s,0,n}$ (n = 1 to n = ∞)
23	Fatigue limit resistance to steel failure of the whole system[1]	2.2.23 of EAD 330008-04-0601	Level $\Delta N_{Rk,s,0,\infty}$
24	Fatigue resistance to steel failure of the whole system (linearized function, assessment method C)	2.2.24 of EAD 330008-04-0601	Level $\Delta N_{Rk,s,lo,n}$ $N_{lok,s,n}$ (n = 10^4 to n = ∞)
25	Fatigue resistance to concrete related failure[1] (exponential function, assessment method A1, A2)	2.2.25 of EAD 330008-04-0601	Level $\Delta N_{Rk,c,0,n}$ $\Delta N_{Rk,p,0,n}$ (n = 1 to n = ∞)
26	Fatigue limit resistance to concrete related failure[1] (assessment method B)	2.2.26 of EAD 330008-04-0601	Level $\Delta N_{Rk,c,0,\infty}$ $\Delta N_{Rk,p,0,\infty}$

No	Essential characteristic	Assessment method	Type of expression of product performance
27	Fatigue resistance to concrete related failure[1] ((linearized function, assessment method C)	2.2.27 of EAD 330008-04-0601	Level $\Delta N_{Rk,c,E,n}$ $\Delta N_{Rk,p,E,n}$ (n = 10^4 to n = ∞)
28	Displacements[1]	2.2.31 of EAD 330008-04-0601	Level δ_{N0}, $\delta_{N\infty}$, $\delta_{V,y,0}$, $\delta_{V,y,\infty}$, $\delta_{V,x,0}$, $\delta_{V,x,\infty}$
Characteristic mechanical resistance to cyclic quasi-static actions			
29	Shear strength after cyclic loads	2.2.1.1	Level $V_{res,k}$
30	In-plane behaviour	2.2.1.2	Level $\left(\Delta^{+}_{s,IP,DS1}; F_{\Delta^{+}_{s,IP,DS1}}\right)$ $\left(\Delta^{-}_{s,IP,DS1}; F_{\Delta^{-}_{s,IP,DS1}}\right)$ $\left(\Delta^{+}_{s,IP,DS2}; F_{\Delta^{+}_{s,IP,DS2}}\right)$ $\left(\Delta^{-}_{s,IP,DS2}; F_{\Delta^{-}_{s,IP,DS2}}\right)$ $\left(\Delta^{+}_{s,IP,DS3}; F_{\Delta^{+}_{s,IP,DS3}}\right)$ $\left(\Delta^{-}_{s,IP,DS3}; F_{\Delta^{-}_{s,IP,DS3}}\right)$
31	Out-of-plane behaviour	2.2.1.3	Level $\left(\Delta^{+}_{s,OOP,DS1}; F_{\Delta^{+}_{s,OOP,DS1}}\right)$ $\left(\Delta^{-}_{s,OOP,DS1}; F_{\Delta^{-}_{s,OOP,DS1}}\right)$ $\left(\Delta^{+}_{s,OOP,DS2}; F_{\Delta^{+}_{s,OOP,DS2}}\right)$ $(\Delta^{-}_{s,OOP,DS2}; F_{\Delta^{-}_{s,OOP,DS2}})$ $\left(\Delta^{+}_{s,OOP,DS3}; F_{\Delta^{+}_{s,OOP,DS3}}\right)$ $\left(\Delta^{-}_{s,OOP,DS3}; F_{\Delta^{-}_{s,OOP,DS3}}\right)$

32	Mechanical resistance to cyclic dynamic actions	2.2.2	Level $\left(F^{+}_{d,IP,DS1};\Delta_{F^{+}_{d,IP,DS1}}\right)$ $\left(F^{-}_{d,IP,DS1};\Delta_{F^{-}_{d,IP,DS1}}\right)$ $\left(F^{+}_{d,IP,DS2};\Delta_{F^{+}_{d,IP,DS2}}\right)$ $\left(F^{-}_{d,IP,DS2};\Delta_{F^{-}_{d,IP,DS2}}\right)$ $\left(F^{+}_{d,IP,DS3};\Delta_{F^{+}_{d,IP,DS3}}\right)$ $\left(F^{-}_{d,IP,DS3};\Delta_{F^{-}_{d,IP,DS3}}\right)$ $\left(\Delta^{+}_{d,IP,DS1};\mathrm{F}_{\Delta^{+}_{d,IP,DS1}}\right)$ $\left(\Delta^{-}_{d,IP,DS1};\mathrm{F}_{\Delta^{-}_{d,IP,DS1}}\right)$ $\left(\Delta^{+}_{d,IP,DS2};\mathrm{F}_{\Delta^{+}_{d,IP,DS2}}\right)$ $\left(\Delta^{-}_{d,IP,DS2};\mathrm{F}_{\Delta^{-}_{d,IP,DS2}}\right)$ $\left(\Delta^{+}_{d,IP,DS3};\mathrm{F}_{\Delta^{+}_{d,IP,DS3}}\right)$ $\left(\Delta^{-}_{d,IP,DS3};\mathrm{F}_{\Delta^{-}_{d,IP,DS3}}\right)$ $\left(F^{+}_{d,OOP,DS1};\Delta_{F^{+}_{d,OOP,DS1}}\right)$ $\left(F^{-}_{d,OOP,DS1};\Delta_{F^{-}_{d,OOP,DS1}}\right)$ $\left(F^{+}_{d,OOP,DS2};\Delta_{F^{+}_{d,OOP,DS2}}\right)$ $\left(F^{-}_{d,OOP,DS2};\Delta_{F^{-}_{d,OOP,DS2}}\right)$ $\left(F^{+}_{d,OOP,DS3};\Delta_{F^{+}_{d,OOP,DS3}}\right)$ $\left(F^{-}_{d,OOP,DS3};\Delta_{F^{-}_{d,OOP,DS3}}\right)$ $\left(\Delta^{+}_{d,OOP,DS1};\mathrm{F}_{\Delta^{+}_{d,OOP,DS1}}\right)$ $\left(\Delta^{-}_{d,OOP,DS1};\mathrm{F}_{\Delta^{-}_{d,OOP,DS1}}\right)$ $\left(\Delta^{+}_{d,OOP,DS2};\mathrm{F}_{\Delta^{+}_{d,OOP,DS2}}\right)$ $\left(\Delta^{-}_{d,OOP,DS2};\mathrm{F}_{\Delta^{-}_{d,OOP,DS2}}\right)$

No	Essential characteristic	Assessment method	Type of expression of product performance
			$\left(\Delta_{d,OOP,DS3}^{+}; F_{\Delta_{d,OOP,DS3}^{+}}\right)$ $\left(\Delta_{d,OOP,DS3}^{-}; F_{\Delta_{d,OOP,DS3}^{-}}\right)$
Basic Works Requirement 2: Safety in case of fire			
33	Reaction to fire	2.2.32 of EAD 330008-04-0601	Class
34	Resistance to fire	2.2.33 of EAD 330008-04-0601	Level $N_{Rk,s,fi}$; $V_{Rk,s,fi}$
Aspects of durability			
35	Durability	2.2.34 of EAD 330008-04-0601	Description
[1] The performance of the anchor channel is decisive for the performance of the connection kit with regard to this essential characteristic.			

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.

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 Characteristic mechanical resistance to cyclic quasi-static actions

The mechanical resistance to cyclic quasi-static actions of the connection kit shall be presented in terms of residual shear strength after cyclic loads, in-plane and out-of-plane behaviour of the connection kit evaluated through full-scale tests including precast panels.

2.2.1.1 Shear strength after cyclic loads

Purpose of the assessment

The purpose of the test herein presented is the evaluation of the residual shear strength of the connection kit after the application of cyclic loads.

Assessment method

The shear strength after cyclic loads of the connection kit shall be determined according to the test method included in ANNEX A.

Expression of results

The shear strength after cyclic loads of the connection kit shall be represented in the ETA by the level of the characteristic value of residual shear:

$$V_{res,k} \qquad [kN]$$

2.2.1.2 In-plane behaviour

Purpose of the assessment

The purpose of the test procedure herein included is the evaluation of the behaviour of precast panel connected to the main elements (beam or column) of a precast structure by means of the connection kit, object of this EAD, when subjected to in-plane cyclic quasi-static loads. In particular the in-plane behaviour shall be presented defining the recorded inter-story drift corresponding to the achievement of each connection kit damage level defined in Table 2.2.1.2.1.

Table 2.2.1.2.1: Connection kit performance level and damage

	Performance level		
	Operational level DS1	*Life safety level* DS2	*Collapse prevention level* DS3
Recorded damage	No damage	Detachment of concrete portions surrounding the anchor channels	- Yielding of bolts or steel plates of the connection kit - Connection kit failure with precast panel detachment

Assessment method

The in-plane behaviour of the panel-to-structure connection kit shall be evaluated according to the test procedure explained in ANNEX B and related to quasi-static tests.

Expression of results

The in-plane behaviour after cyclic loads of the connection kit shall be represented in the ETA by the level of the inter-story drift (positive or negative) corresponding to the achievement of DS1, DS2, DS3 (as defined in Table 2.2.1.2.1) and the corresponding value of the force. Also, the value of the inter-story drift and the corresponding force in the opposite direction of the same cycle shall be reported in the ETA, as shown in Figure 2.2.1.2.1.

- $\left(\Delta^{+}_{s,IP,DS1}; F_{\Delta^{+}_{s,IP,DS1}}\right)$ and $\left(\Delta^{-}_{s,IP,DS1}; F_{\Delta^{-}_{s,IP,DS1}}\right)$ [%; kN]
- $\left(\Delta^{+}_{s,IP,DS2}; F_{\Delta^{+}_{s,IP,DS2}}\right)$ and $\left(\Delta^{-}_{s,IP,DS2}; F_{\Delta^{-}_{s,IP,DS2}}\right)$ [%; kN]
- $\left(\Delta^{+}_{s,IP,DS3}; F_{\Delta^{+}_{s,IP,DS3}}\right)$ and $\left(\Delta^{-}_{s,IP,DS3}; F_{\Delta^{-}_{s,IP,DS3}}\right)$ [%; kN]

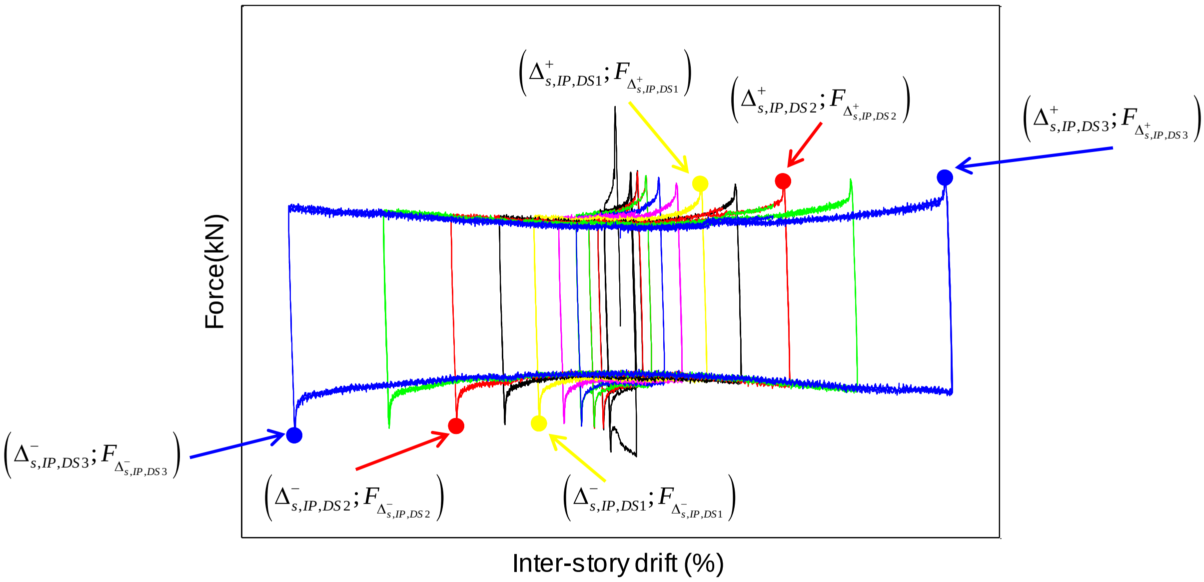


Figure 2.2.1.2.1: Example of total force-drift recorded during the test: identification of inter-story drift and force values corresponding to the achievement of DS1, DS2 and DS3

2.2.1.3 Out-of-plane behaviour

Purpose of the assessment

The purpose of the test procedure herein included is the evaluation of the behaviour of precast panel connected to the main elements (beam or column) of a precast structure by means of the connection kit, object of this EAD, when subjected to out-of-plane cyclic quasi-static loads.

Assessment method

The out-of-plane behaviour of the panel-to-structure connection kit shall be evaluated according to the test procedure explained in ANNEX B and related to quasi-static tests.

Expression of results

The out-of-plane behaviour after cyclic loads of the connection kit shall be represented in the ETA by the level of the inter-story drift (positive or negative) corresponding to the achievement of DS1, DS2, DS3 (as defined in Table 2.2.1.2.1) and the corresponding value of the force. Also, the value of the inter-story drift and the corresponding force in the opposite direction of the same cycle shall be reported in the ETA (as reported in Figure 2.2.1.2.1 for in-plane behaviour).

- $\left(\Delta^{+}_{s,OOP,DS1};F_{\Delta^{+}_{s,OOP,DS1}}\right)$ and $\left(\Delta^{-}_{s,OOP,DS1};F_{\Delta^{-}_{s,OOP,DS1}}\right)$ [%; kN]
- $\left(\Delta^{+}_{s,OOP,DS2};F_{\Delta^{+}_{s,OOP,DS2}}\right)$ and $(\Delta^{-}_{s,OOP,DS2};F_{\Delta^{-}_{s,OOP,DS2}})$ [%; kN]
- $\left(\Delta^{+}_{s,OOP,DS3};F_{\Delta^{+}_{s,OOP,DS3}}\right)$ and $\left(\Delta^{-}_{s,OOP,DS3};F_{\Delta^{-}_{s,OOP,DS3}}\right)$ [%; kN]

2.2.2 Mechanical resistance to cyclic dynamic actions

Purpose of the assessment

The purpose of the test procedure herein included is the evaluation of the seismic behaviour of the connection kit precast panel connected to the main elements (beam or column) of a precast structure by means of the connection kit, object of this EAD, when subjected to dynamic actions.

Assessment method

The mechanical resistance of the connection kit to dynamic actions shall be evaluated according to the test procedure according to ANNEX B and, with regard to Clause B.3, especially according to Clause B.3.2 related to dynamic tests.

Expression of results

The mechanical resistance to cyclic dynamic loads of the connection kit shall be represented in the ETA by the level of:

- the maximum positive and negative in-plane forces recorded in the connection kit and the corresponding displacements, corresponding to the achievement of DS1, DS2, DS3 (Table 2.2.1.2.1):
  - $\left(F^{+}_{d,IP,DS1};\Delta_{F^{+}_{d,IP,DS1}}\right)$ and $\left(F^{-}_{d,IP,DS1};\Delta_{F^{-}_{d,IP,DS1}}\right)$ [kN; %]
  - $\left(F^{+}_{d,IP,DS2};\Delta_{F^{+}_{d,IP,DS2}}\right)$ and $\left(F^{-}_{d,IP,DS2};\Delta_{F^{-}_{d,IP,DS2}}\right)$ [kN; %]
  - $\left(F^{+}_{d,IP,DS3};\Delta_{F^{+}_{d,IP,DS3}}\right)$ and $\left(F^{-}_{d,IP,DS3};\Delta_{F^{-}_{d,IP,DS3}}\right)$ [kN; %]
- the maximum positive and negative in-plane displacement recorded in the connection kit and the corresponding forces, corresponding to the achievement of DS1, DS2, DS3 (Table 2.2.1.2.1):
  - $\left(\Delta^{+}_{d,IP,DS1};\mathrm{F}_{\Delta^{+}_{d,IP,DS1}}\right)$ and $\left(\Delta^{-}_{d,IP,DS1};\mathrm{F}_{\Delta^{-}_{d,IP,DS1}}\right)$ [%; kN]
  - $\left(\Delta^{+}_{d,IP,DS2};\mathrm{F}_{\Delta^{+}_{d,IP,DS2}}\right)$ and $\left(\Delta^{-}_{d,IP,DS2};\mathrm{F}_{\Delta^{-}_{d,IP,DS2}}\right)$ [%; kN]
  - $\left(\Delta^{+}_{d,IP,DS3};\mathrm{F}_{\Delta^{+}_{d,IP,DS3}}\right)$ and $\left(\Delta^{-}_{d,IP,DS3};\mathrm{F}_{\Delta^{-}_{d,IP,DS3}}\right)$ [%; kN]

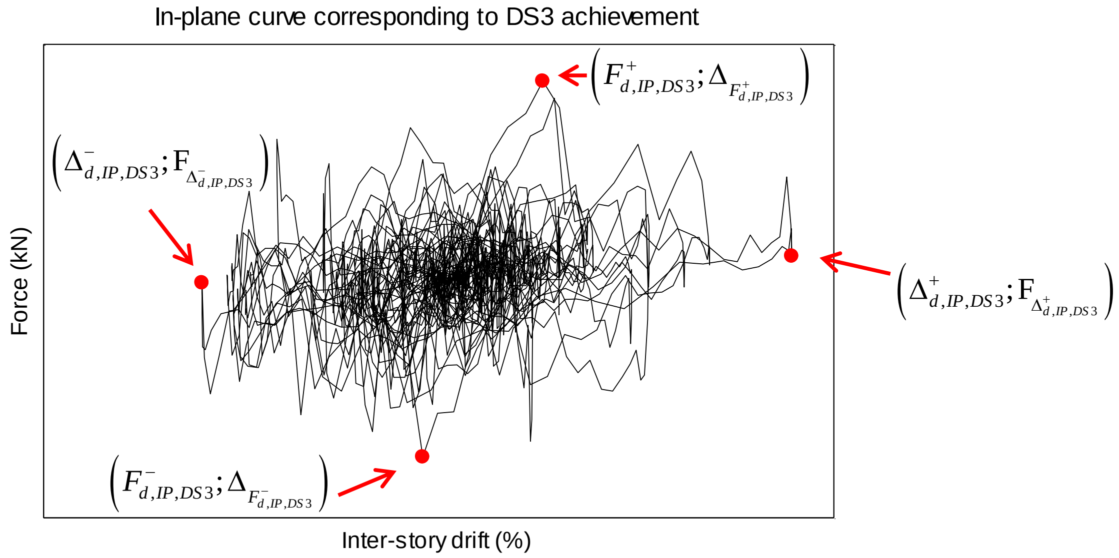


Figure 2.2.2.1: Example of in-plane force-drift resulting curve corresponding to the achievement of DS3

- the maximum positive and negative out-of-plane forces recorded in the connection kit and the corresponding displacements, corresponding to the achievement of DS1, DS2, DS3 (Table 2.2.1.2.1):
  - $\left(F^+_{d,OOP,DS1};\Delta_{F^+_{d,OOP,DS1}}\right)$ and $\left(F^-_{d,OOP,DS1};\Delta_{F^-_{d,OOP,DS1}}\right)$ [kN; %]
  - $\left(F^+_{d,OOP,DS2};\Delta_{F^+_{d,OOP,DS2}}\right)$ and $\left(F^-_{d,OOP,DS2};\Delta_{F^-_{d,OOP,DS2}}\right)$ [kN; %]
  - $\left(F^+_{d,OOP,DS3};\Delta_{F^+_{d,OOP,DS3}}\right)$ and $\left(F^-_{d,OOP,DS3};\Delta_{F^-_{d,OOP,DS3}}\right)$ [kN; %]
- the maximum positive and negative out-of-plane displacement recorded in the connection kit and the corresponding forces, corresponding to the achievement of DS1, DS2, DS3 (Table 2.2.1.2.1):
  - $\left(\Delta^+_{d,OOP,DS1};F_{\Delta^+_{d,OOP,DS1}}\right)$ and $\left(\Delta^-_{d,OOP,DS1};F_{\Delta^-_{d,OOP,DS1}}\right)$ [%; kN]
  - $\left(\Delta^+_{d,OOP,DS2};F_{\Delta^+_{d,OOP,DS2}}\right)$ and $\left(\Delta^-_{d,OOP,DS2};F_{\Delta^-_{d,OOP,DS2}}\right)$ [%; kN]
  - $\left(\Delta^+_{d,OOP,DS3};F_{\Delta^+_{d,OOP,DS3}}\right)$ and $\left(\Delta^-_{d,OOP,DS3};F_{\Delta^-_{d,OOP,DS3}}\right)$ [%; kN]

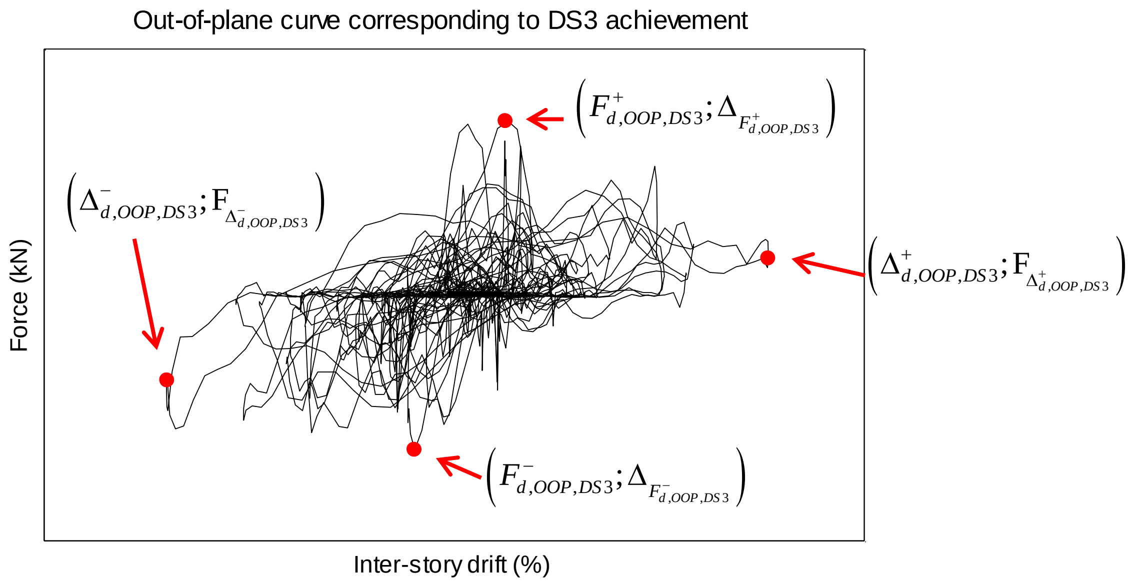


Figure 2.2.2.2: **Example of out-of-plane force-drift resulting curve corresponding to the achievement of DS3**

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System of assessment and verification of constancy of performance to be applied

For the products covered by this EAD the applicable European legal act is Commission Decision 2000/273/EC, as amended by Decision 2001/596/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 3.2.1.

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 3.2.1: 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	*Raw material* / Material and material properties of channel	Inspection certificate 3.1 according to EN 10204	Control plan	1	Each manufac-turing batch
2	*Raw material* / Material and material properties of anchor	Test report 2.2 according to EN 10204	Control plan	1	Each manufac-turing batch
3	*Raw material* / Dimensions and material properties of channel bolts, steel plates and sliding nuts	Inspection certificate 3.1 according to EN 10204 [1)]	Control plan	1	Each manufac-turing batch
For the welding of the anchors on the channel back the manufacturer shall possess the corresponding recognition for the intended welding process. [1)] This does not apply, if tension tests with channel bolts according to line 7 are carried out					

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
4	*Tests after production steps* / Determination of the functional measurements (thickness, width, height and opening) of the channels and dimensions of the anchors, ribbed steel plates and sliding nuts	Gauge	Control plan	3 [2)]	2000 consecutive meter of the anchor channels respectively per 10000 short anchor channels respectively once per production week
5	*Tests after production steps* / Checking the thickness of the weld, lengths of the weld, anchor widths	Gauge	Control plan	3 [2)]	
6	*Tests after production steps* / Determination of the ultimate load of the anchor channels not cast into concrete by centric tension tests loaded in the line of the axis of the anchor via anchor and channel. The load shall be transferred into the channel by a load-carrying device with the corresponding geometry of appropriate heads of channel bolts.	Clause A2 of EAD 330008-04-0601	Control plan	3 [2)]	
7 [3)]	*Tests after production steps* / Determination of the ultimate load of the channel bolts by centric tension tests loaded in the line of the axis of the channel bolt. The load shall be transferred into the head of the bolt by a load-carrying device with the corresponding geometry of appropriate channel profiles. The test shall be carried out for each channel bolt, each channel profile and each type of material of the channel bolt.	Clause A2 of EAD 330008-04-0601	Control plan	3	
8	*Tests after production steps* / Determination of the ultimate load of the anchor channel not cast into concrete and channel bolts by shear tests loaded in the line of the axis of the channel profile. The load shall be transferred into the bolt by a fixture. The test shall be carried out for each channel bolt, each channel profile and each type of material of the channel bolt only if shear load acting in the direction of the longitudinal channel axis is assessed.	Clause A2 of EAD 330008-04-0601	Control plan	3	
9	*Tests after production steps* / Determination of the thickness of the corrosion protection	Visual, measurement	Control plan	3 [2)]	
10	*Tests after production steps* / Characteristic steel fatigue resistance for test methods A1 and A2 reported in Annex C and Annex D of EAD 330008-04-0601, respectively.	tests under different fatigue cyclic load levels [4) 7)]	[5)]	3 (1 per load level)	1 size per year and All sizes, types and materials in 5 years
11	*Tests after production steps* / Characteristic steel fatigue resistance for test method B reported in Annex E of EAD 330008-04-0601	tests on load level ΔS_D [7)]	[6)]	3	
12	*Tests after production steps* / Characteristic steel fatigue resistance for test method C reported in Annex H of EAD 330008-04-0601			3 (1 per load level)	

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control

2) for each channel profile, each anchor and each type of material of channel profile and anchor

3) if inspection certificate 3.1 is not available respectively the characteristic resistance due to steel failure of the channel bolts does not comply to material properties according to EN ISO 898-1 and EN ISO 3506-1

4) The load levels are determined as follows:

Load level a: $$\Delta S_a = \left(S_k - \frac{1}{3}\left(S_k - \Delta S_{D,k}\right)\right) \quad (3.2.1)$$

Load level b: $$\Delta S_b = \left(S_k - \frac{2}{3}\left(S_k - \Delta S_{D,k}\right)\right) \quad (3.2.2)$$

Load level c: $$\Delta S_c = \Delta S_{D,k} \quad (3.2.3)$$

where S_k and $\Delta S_{D,k}$ are defined in EAD 330008-04-0601.

5) The constancy of performance is verified if the number of cycles of the first two specimens exceeds the characteristic resistance. The number of cycles of the third specimen shall reach the limit number of cycles n_{lim} and pass the run-out test on the load level a. The definition of n_{lim} is reported in EAD 330008-04-0601.

6) The constancy of performance is verified if the number of cycles of tested specimens reaches the limit number of cycles n_{lim} and pass the run-out test on the load level ΔS_{RT}. ΔS_{RT} is defined in EAD 330008-04-0601.

7) Tests shall be performed with the smallest channel bolt.

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body in the procedure of assessment and verification of constancy of performance for the connection kit are laid down in Table 3.3.1.

Table 3.3.1: 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 connection kit.	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	At the beginning of the contract between Notified Body and Manufacturer
Continuous surveillance, assessment and evaluation of factory production control					
2	The notified body shall ascertain 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.	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 3.2.1	As defined in the control plan	As defined in the control plan	Once per year

4 REFERENCE DOCUMENTS

EN 1990:2023	Eurocode - Basis of structural and geotechnical design
EN 10204:2004	Metallic products - Types of inspection documents
EN ISO 898-1:2013+Cor 1:2013	Mechanical properties of fasteners made of carbon steel and alloy steel - Part 1: Bolts, screws and studs with specified property classes - Coarse thread and fine pitch thread (ISO 898-1:2013+Cor 1:2013)
EN ISO 3506-1:2020	Fasteners - Mechanical properties of corrosion-resistant stainless steel fasteners - Part 1: Bolts, screws and studs with specified grades and property classes (ISO 3506-1:2020)
EAD 330008-04-0601	Anchor Channels

ANNEX A SHEAR STRENGTH AFTER CYCLIC LOADS

A.1 Test specimen, test setup and equipment

The test specimen shall be made up of (Figure A.1.1):

- an anchor channel, embedded in a concrete element or in a steel frame specifically designed to simulate the confinement effect of the surrounding concrete;
- a nut, pre-inserted in the anchor channels;
- a ribbed steel plate and bolt that will be connected to the loading system.

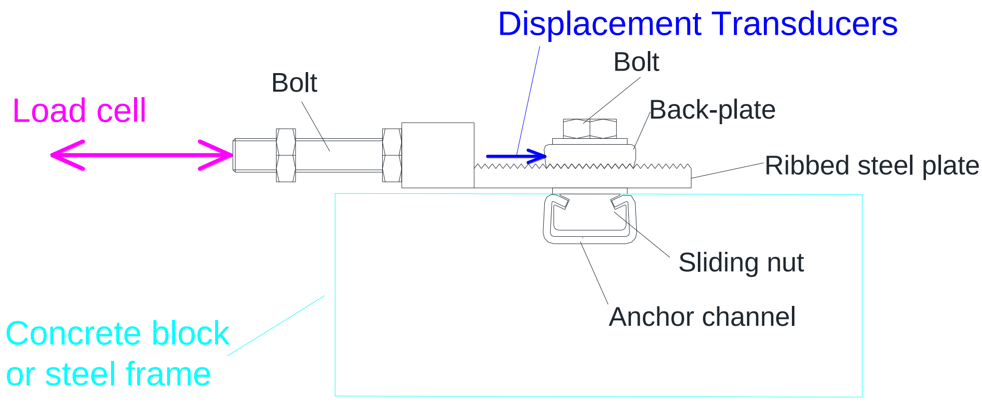


Figure A.1.1: Test setup for the evaluation of shear strength after cyclic loads

Tests shall be carried out using measuring equipment having a documented calibration according to international standards. The load application equipment shall be designed to avoid sudden increase in load especially at the beginning of the test. The measurement bias of the measuring chain of the load shall not exceed 2% of the measured quantity value.

The displacement of the back-plate shall be monitored and recorded. Displacements shall be recorded continuously (e.g., by means of electrical displacement transducers) with a measuring bias not greater than 0,020 mm or 2,0 % for displacements > 1 mm.

A.2 Test procedure

The test shall be performed with the loading protocol according to Figure A.2.1. After the application of the cyclic loads, a monotonic shear test shall be carried out up to the specimen failure.

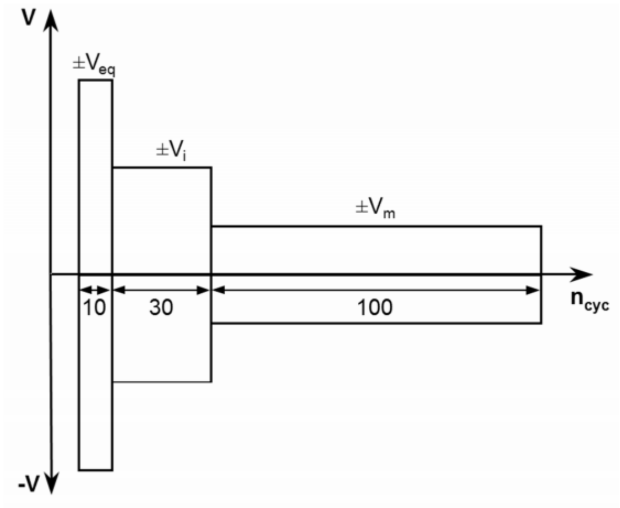


Figure A.2.1: Loading history

Where:

- V_{eq} shall be evaluated according to the following equation:

$$V_{eq} = 0{,}5 V_{u,m,test} \left(\frac{f_{u,k}}{f_{u,test}} \right)$$

with:

- $V_{u,m,test}$ = mean value of the failure loads applied to one anchor measured in test series C2 of Table A.1.1of EAD 330008-04-0601 $[N]$ (see Clause 2.2.20 of EAD 330008-04-0601)
- $f_{u,k}$ = nominal characteristic steel ultimate tensile strength of channel $\left[N/mm^2 \right]$
- $f_{u,test}$ = actual steel ultimate tensile strength of channel back $\left[N/mm^2 \right]$

- $V_i = 0{,}75 V_{eq}$ $[N]$
- $V_m = 0{,}5 V_{eq}$ $[N]$
- n_{cyc} is the number of the cycles to be performed for each shear level, according to Figure A.2.1.

The cycling frequency shall be between 0,1 and 2 Hz.

A minimum of 5 tests shall be carried out.

A.3 Test records

At least the following shall be recorded:

1) Complete description of the test specimen and its components.

2) Description of the test equipment:

   - A detailed sketch of the testing apparatus (front and lateral view) including the specimen geometry and the position of each sensor adopted (e.g., accelerometers and LVDTs) to measure the test results;
   - A description of the specimen and of each sensor depicted in the sketch;
   - A description of the equipment (hardware and software) adopted for data acquisition and processing.

3) Results:

   - Shear-displacement cyclic curves;
   - Shear-displacement monotonic curves;
   - Maximum value of residual shear for each test: $V_{Ru,s,I}$;
   - Medium value of residual shear, $V_{Ru,m}$;
   - Characteristic value of residual shear, $V_{Res,k}$, determined according to equation D.3 in clause D.7.2 of Annex D of EN 1990.

ANNEX B IN-PLANE AND OUT-OF-PLANE BEHAVIOUR TO CYCLIC QUASI-STATIC AND DYNAMIC ACTIONS

B.1 Test specimen, setup and equipment

Tests shall be carried out by using a test equipment capable to replicate both, dynamic and quasi-static loading protocols with at least two degrees of freedom in the horizontal plane. The test equipment shall provide, at least, one hydraulic actuator capable to move the specimen (e.g., movable beams in Figure B.1.1) in the in-plane direction, i.e., in the plane of the panel, horizontally (see green arrow in Figure B.1.1), and one hydraulic actuator capable to move the specimen in the out-of-plane direction, i.e., in the direction perpendicular to panel plane (see blue arrow in Figure B.1.1). Hydraulic actuators shall be commanded by a digital controller, where the control panel allows applying the desired displacement amplitudes, frequencies, displacement waveforms, and number of cycles.

The specimen shall be made up of a full scale horizontal or vertical panel attached to main elements of precast structures (columns or beams) by means of connection kits.

The anchor channels of the connection kit shall be embedded in the precast panel and in perimetral precast concrete elements (beams or columns), according to manufacturer product installation instructions in order to reproduce the real installation conditions.

An example of specimen configuration is reported in Figure B.1.3: In this example the seismic test is carried out on a vertical precast panel, that in real conditions at the base is connected to the foundation by means of L-shaped steel connectors, and at the top is connected to a precast beam by means of two connection kits. The test setup shall reproduce the real installation conditions, i.e., by providing fixed connection between the panel and the laboratory floor and two connection devices at the top, each of them constituted by one anchor channel embedded in the precast panel, while a second one, usually embedded in a perimetral precast concrete beam, shall be inserted in a setup supporting apparatus *ad hoc* designed (setup supporting pieces in Figure B.1.3 (b)) in order to rigidly connect the anchor channel to the test rig and transfer the input actions to the connection kit.

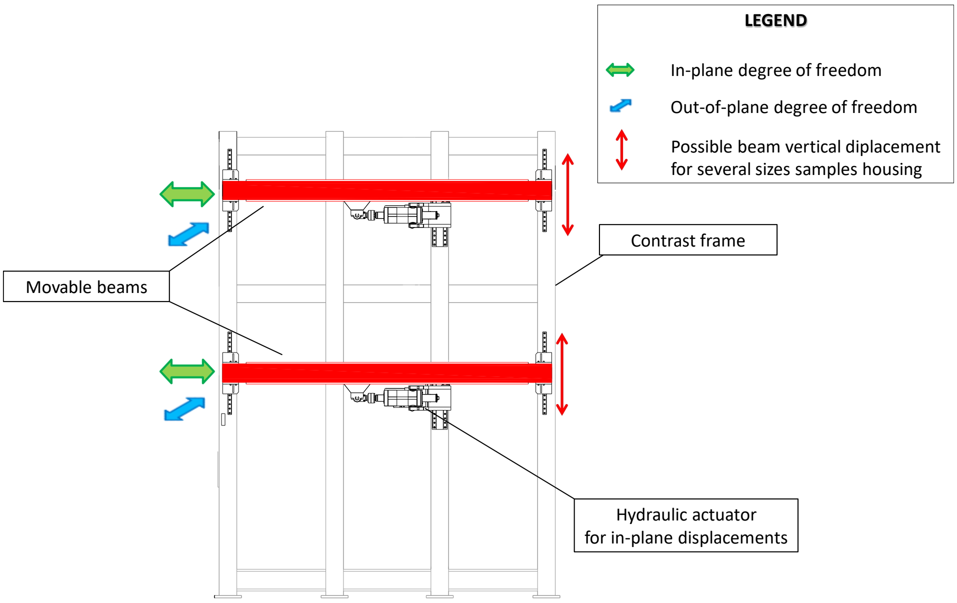


Figure B.1.1: Example of test equipment (frontal view)

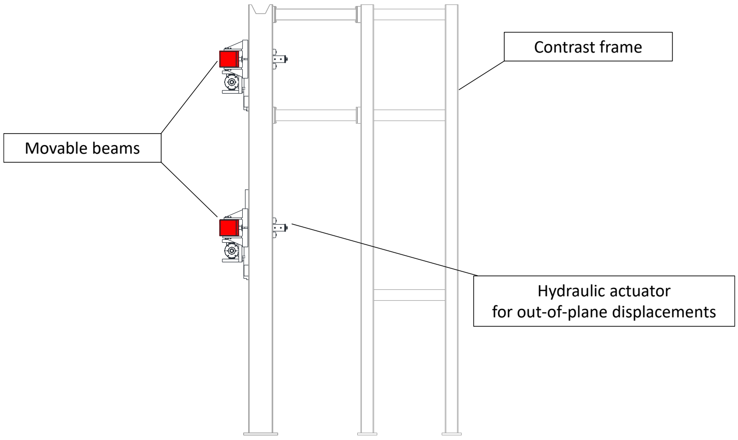
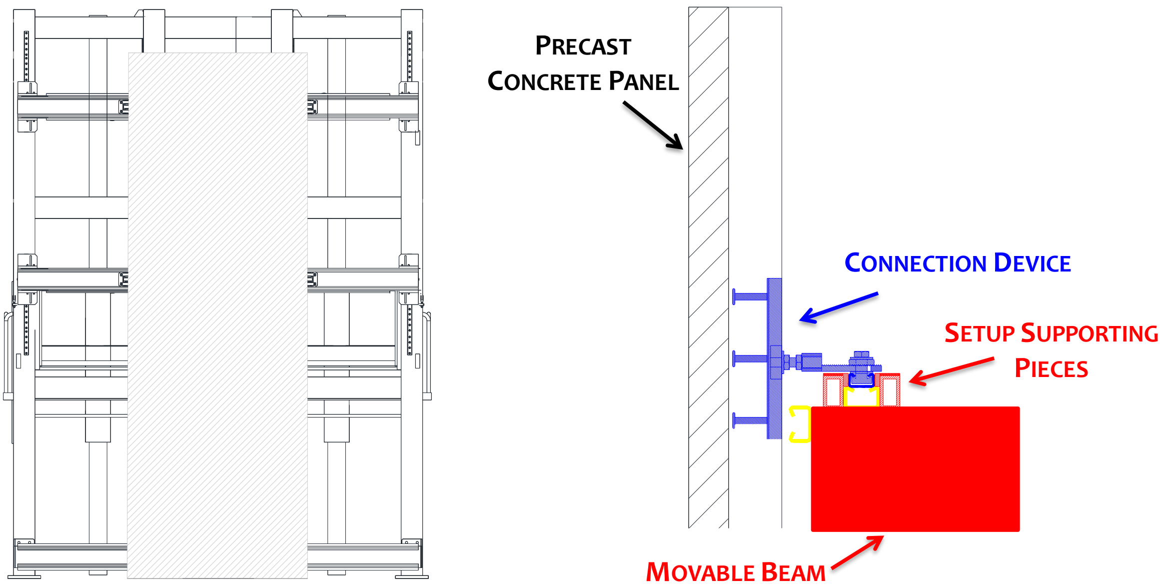


Figure B.1.2: Example of test equipment. Lateral view



(a) (b)

Figure B.1.3: Example of a full test specimen: (a) frontal view of a vertical panel connected to a dynamic machine and (b) particular of the connection between panel and a movable beam by means of the connection kit

The main features of the connected panel, in terms of height, width, thickness and total mass shall be reported in the ETA.

The number of connection kits used to link the panel to the main structure elements shall be reported in the ETA.

The monitoring system shall be constituted by displacement transducers, located as shown Figure B.1.4:

- One of them shall be used to monitor the in-plane movement of the panel with respect the beam (linear variable displacement transducers (LVDT) no. 1), i.e., it shall be rigidly connected to the movable beam and with the push rod pointing on the lateral face of the precast panel.
- Another one shall be used to control the out-of-plane displacement of the panel with respect to the beam (LVDT no. 2), i.e., it shall be rigidly connected to the movable beam and with the push rod pointing on the back face of the precast panel.
- The local displacements of the connection devices with respect to the beam, for the in-plane direction, shall be controlled by LVDT allocated in position 3, i.e., rigidly connected to the beam and with the push road pointing on a plate fixed to the bolt of the connection device sliding in the anchor channel on the beam.

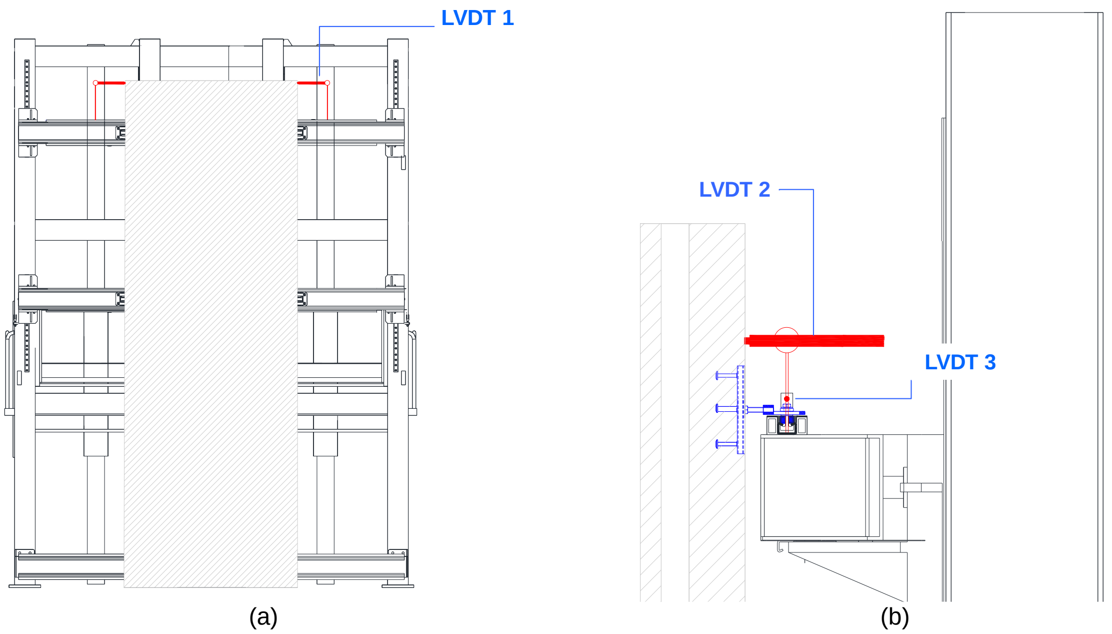


Figure B.1.4: **Example of linear variable displacement transducers (LVDT) positioning: (a) frontal view with in-plane displacement transducers (no.1) and (b) lateral view (left side of the panel) with out-of-plane displacement transducer (no.2) and local displacement transducer (no. 3)**

B.2 Number of tests

At least the following tests shall be carried out:

- One specimen shall be subjected to a quasi-static test, according to the procedure included in clause B.3.1;
- One specimen shall be subjected to the sequence of a dynamic test, according to the procedure included in clause B.3.2.

B.3 Test procedure

B.3.1 Quasi-static tests

The in-plane and out-of-plane quasi-static cyclic tests shall be performed by applying to the specimen a displacement-controlled loading protocol as reported in Figure B.3.1.1.

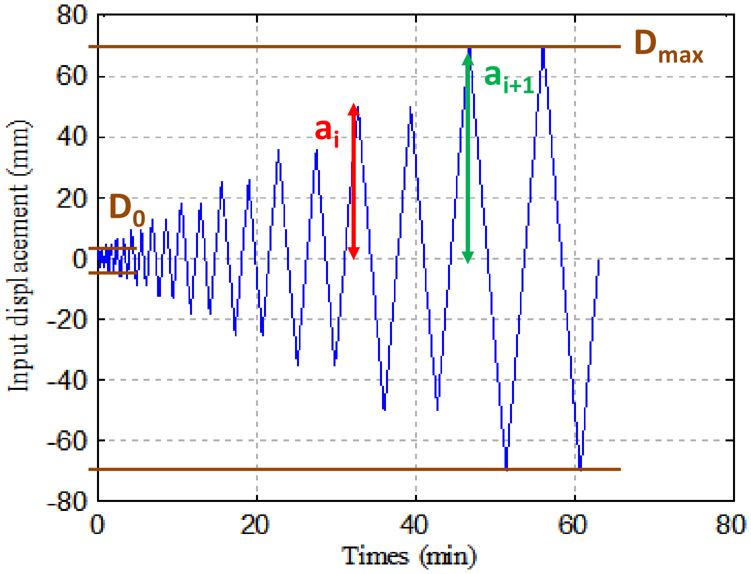


Figure B.3.1.1: Example of the recommended displacements loading history

The displacement amplitude shall be evaluated as numeric succession on two successive steps a_i and a_{i+1} as highlighted in Equation B.3.1.1,

$$a_{i+1} = 1{,}39 \cdot a_i \tag{B.3.1.1}$$

The loading history is defined by the following parameters:

- D_0 = the targeted smallest displacement amplitude of the loading history. It shall be safely smaller than the amplitude at which the lowest damage state is first observed. At the lowest damage state at least six cycles shall be executed. If no data exists regarding what amplitude of displacement is likely to initiate damage, a recommended value for D_0 shall correspond to around 0,0015 in terms of inter-story drift.
- D_{max} = the targeted maximum displacement amplitude of the loading history. It is an estimated value of the imposed displacement at which the most severe damage level is expected to initiate. This value shall be estimated prior to the test (it can be estimated from a monotonic test). A recommended value for this amplitude, lacking other evidence such as the results of a prior monotonic test, shall correspond to 0,03 in terms of inter-story drift.
- n = the number of steps (or increments) in the loading history, 10 or larger.
- a_i = the amplitude of the cycles, as they increase in magnitude, i.e., the first amplitude, a_1, is D_0 (or a value close to it), and the last planned amplitude, a_n, is D_{max} (or a value close to it). Whenever possible, the test shall be continued beyond D_{max} even if the most severe damage state has been attained. Tests shall be terminated only when the capabilities of the test setup have been reached, e.g., the available stroke of the loading ram has been reached, or the test specimen has degraded so severely that no relevant additional information about performance can be acquired.

The displacement rate shall be set at minimum equal to 0,5 mm/sec and at maximum equal to 1 mm/sec.

The displacement time history shall be applied to the specimen, first in the in-plane direction (y), then the two connection devices shall be replaced and a new test in the out-of-plane direction (x) shall be carried out.

B.3.2 Dynamic tests

Dynamic tests shall be performed by applying artificial acceleration time-histories with increasing intensity in two horizontal directions. The procedure is reported in steps, as explained below.

Step 1. At first, the *input acceleration time-history* shall be obtained according to the procedure explained in clause B.3.2.1. The maximum acceleration value of the *input acceleration time history* is defined as $a_{x,max}$ (see Figure B.3.2.1).

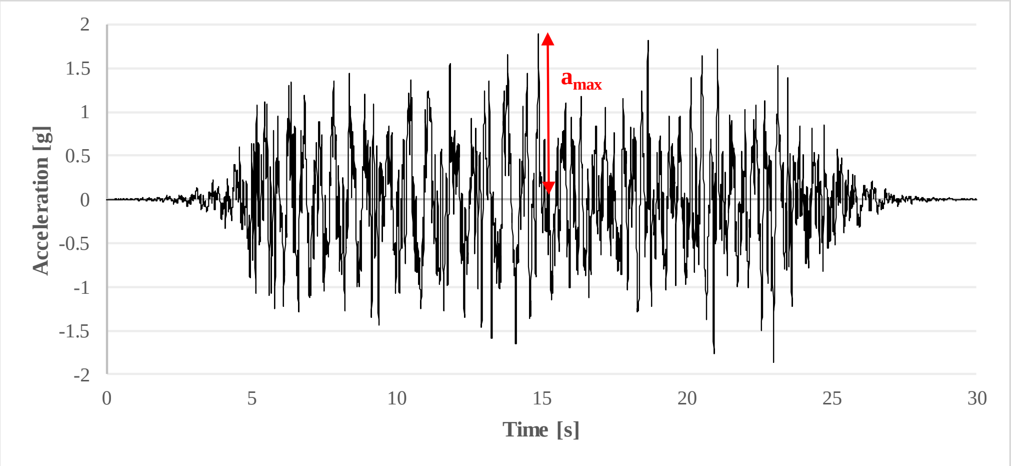


Figure B.3.2.1: Example of *input acceleration time-history*

Step 2. The specimen and the corresponding equipment is installed on the testing apparatus.

Step 3. Several acceleration time-histories shall be obtained by linearly scaling down the input acceleration time-history of step 1, starting from 5%·$a_{x,max}$ up to 100% $a_{x,max}$, in 5% steps. Each acceleration time-history corresponds to a sub-step of the x-direction dynamic out-of-plane test (see Table B.3.2.1). If it is expected that accelerations lower than 5%·$a_{x,max}$ can affect the integrity of the component, lower initial accelerations can be considered. The test shall continue up to either the failure of the specimen or the attainment of the test facility limits.

Table B.3.2.1: Definition of the dynamic test sub-steps

Step of the dynamic test [-]	**Maximum applied acceleration [m/s²]**
3.1	0,05 · a_{max}
3.2	0,10 · a_{max}
3.3	0,15 · a_{max}
3.4	0,20 · a_{max}
…	…
3.i	0,05 · i · a_{max}
…	…
3.n	1,00 · a_{max}

During each sub-step of the test, the corresponding acceleration time-histories shall be applied simultaneously in the in-plane and in out-of-plane directions and damage of the connection kit, eventually occurred, shall be recorded by filling out a damage scheme.

At the end of the i-th sub-step the test equipment shall be stopped and the specimen shall be observed for further damage identification.

The level of the damage recorded in each sub-step shall be compared with Table 2.2.1.2.1 in order to identify the achievement of one of the three damage states.

If, due to facility limitations, a damage state is not attained during the test, the seismic performance parameter corresponding to that damage state is the maximum recorded during the test.

B.3.2.1 Procedure for the selection of the input acceleration time-history

In order to define the input acceleration time history, it is necessary to firstly define a Reference Response Spectrum (herein after RRS).

The Required Response Spectrum (RRS) shall be evaluated according to Equation B.3.2.1.1 in time domain (see Figure B.3.2.1.1) or according to Equation B.3.2.1.2 in frequency domain (see Figure B.3.2.1.2).

$$\begin{cases} \frac{S_a}{(\alpha \cdot S)} = \left[\frac{10}{1+4\left(1-\frac{T_a}{T_0}\right)^2}\right] & T_a < T_0 \\ \frac{S_a}{(\alpha \cdot S)} = 10 & T_0 \leq T_a < T_1 \\ \frac{S_a}{(\alpha \cdot S)} = 8 + \frac{2}{(T_1 - T_2)}(T_a - T_2) & T_a \geq T_1 \end{cases} \quad \text{(B.3.2.1.1)}$$

Where:

- S_a is spectral acceleration used to calculate the horizontal equivalent static force to be applied to the non-structural elements.
- α is the ratio between the reference peak ground acceleration on stiff soil for the considered limit state and the acceleration of gravity.
- S is the soil amplification factor.
- T_a is the fundamental vibration period of the non-structural elements.
- T_0 is the starting period of the RRS and is equal to 0,08·s.
- T_1 is the period corresponding to the beginning of the constant acceleration branch of RRS and is equal to 0,714 s.
- T_2 is the period corresponding to the last descending brunch of RRS and is equal to 1,33 s.

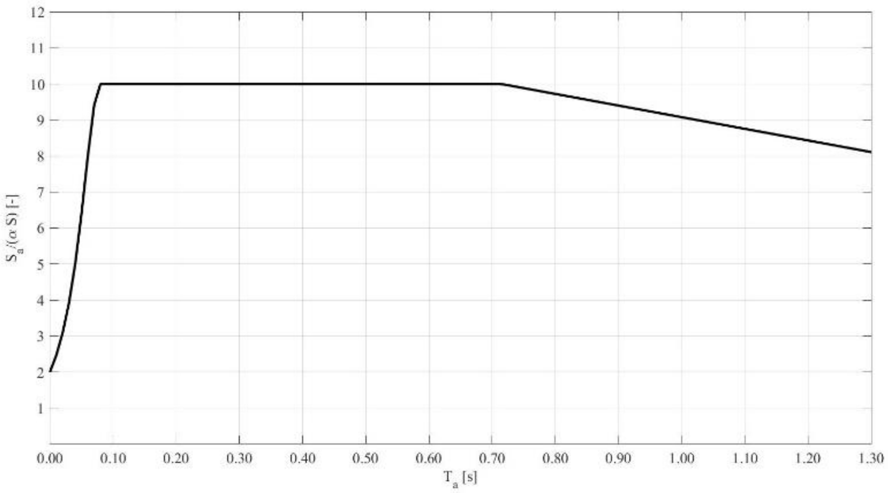


Figure B.3.2.1.1: Required response spectrum (RRS), 5% damping in time domain

$$\begin{cases} \frac{S_a}{(\alpha \cdot S)} = 8 + \frac{2}{(f_1 - f_0)}(f_a - f_0) & f_a < f_1 \\ \frac{S_a}{(\alpha \cdot S)} = 10 & f_1 \leq f_a < f_2 \\ \frac{S_a}{(\alpha \cdot S)} = \left[\frac{10}{1+4\left(1-\frac{f_2}{f_a}\right)^2}\right] & f_a \geq f_2 \end{cases} \qquad \text{(B.3.2.1.2)}$$

where f_0 = 0,75·Hz; f_1 = 1,4 Hz and f_2 = 12,5 Hz.

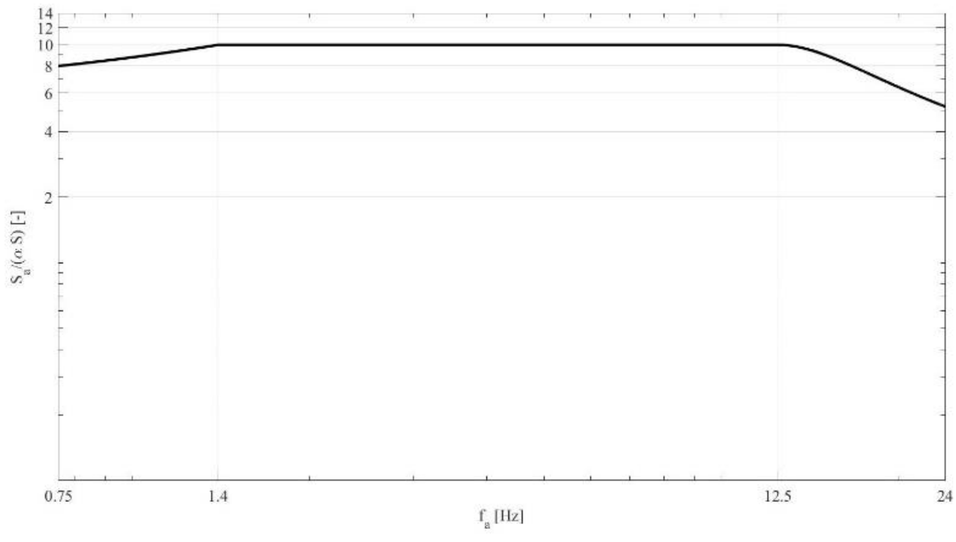


Figure B.3.2.1.2: Required response spectrum (RRS), 5% damping in frequency domain

Starting from this Required Response Spectrum, an acceleration time-history shall be chosen in a manner that the relative spectrum (also defined as Test Response Spectrum-TRS) shall be compatible with the RRS defined assuming $\alpha \cdot S_a$ = 0,40 g, over the frequency range from 1,4 to 24 Hz.

The starting acceleration time-history shall be non-stationary broadband random excitations having an energy content ranging from 1 to 32 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 amplitude of the narrowband signal shall be adjusted until the TRS envelops the RRS. It is recommended that the TRS shall be between 90% (lower limit) and 130% (upper limit) of RRS. Figure B.3.2.1.3 shows TRS example spectrum enveloping a RRS "target" spectrum.

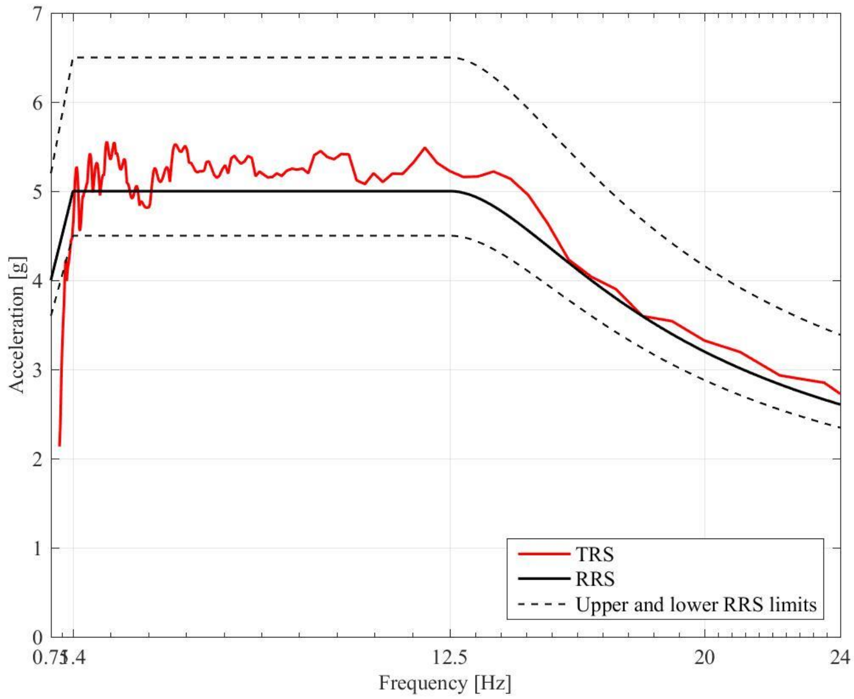


Figure B.3.2.1.3: Example of TRS spectrum enveloping RRS spectrum

In the performance of a test program, the TRS may not fully envelop the RRS. The general requirement for a retest shall be exempted if the following criterion is met: a maximum of two of the one-sixth octave analysis points may be below the RRS by than 10% or less, provided that, for each point, the adjacent one-sixth-octave points are at least equal to RRS.

The obtained acceleration time-history shall be also compatible with the test equipment limitations. For this purpose, a "filter tool" can be used in order to generate a signal compatible with the maximum displacements applicable by the test equipment. In particular, the signal can be filtered through high-pass filters considering a maximum frequency threshold equal to 0,75 f_a if 0,75 f_a does not exceed 3,5 Hz, whereas if 0,75 f_a exceeds 3,5 Hz, this latter frequency should be considered as maximum frequency threshold for high-pass filters.

B.4 Test records

B.4.1 Quasi – static tests

At least the following shall be recorded:

1) Complete description of the test specimen and its components.

2) Description of the test equipment.

   - A detailed sketch of the testing apparatus (front and lateral view) including the specimen geometry and the position of each sensor adopted (e.g., accelerometers and LVDTs) to measure the test results;

   - A description of the specimen and of each sensor depicted in the sketch;

   - A description of the equipment (hardware and software) adopted for data acquisition and processing.

3) Results:

- Damage occurred during the test related to applied inter-story drift;
- Force – inter-story drift curves, both in-plane and out-of-plane direction, where the force is the value recorded in correspondence of the connection kit and the inter-story drift is obtained by the displacement recorded during the test at the level of the connection kit.

B.4.2 Dynamic tests

At least, the following shall be recorded:

1) Complete description of the test specimen and its components.

2) Description of the test equipment.

- A detailed sketch of the testing apparatus (front and lateral view) including the specimen geometry and the position of each sensor adopted (e.g., accelerometers and LVDTs) to measure the test results;
- A description of the specimen and of each sensor depicted in the sketch;
- A description of the equipment (hardware and software) adopted for data acquisition and processing.

3) Results:

- Damage occurred during the test related to the applied acceleration time-history;
- Force – inter-story drift curves, where the force is the value recorded in correspondence of the connection kit and the inter-story drift is obtained by the displacement recorded during the test at the level of the connection kit.