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EAD **332001-01-0602**

July 2023

European Assessment Document for

Clamping kits for connection of precast concrete members

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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).

Contents

1 SCOPE OF THE EAD

1.1 Description of the construction product

The EAD covers the assessment of clamping kits for connection of precast concrete members (from now on "clamping kit").

This EAD applies to the following two different clamping kits:

1) Turnbuckle with corresponding washers (from now on "turnbuckle clamping kit"). See clause 1.1.1.

2) Three metallic pieces (from now on "three metallic pieces clamping kit"). See clause 1.1.2.

The components of both clamping kits covered by this EAD (see clauses 1.1.1 and 1.1.2 below) are made of iron, steel, or stainless-steel, not in finely form, possibly coated with inorganic layer, but not containing organic material. No glue is used for assembling the components.

The assessment of the connection of the clamping kits to the concrete element is not covered by this EAD.

The products are not covered by a harmonized European standard (hEN).

The products are not fully covered by EAD 332001-00-0602. Compared to the previous version of the EAD, the following changes are introduced:

- A new product (three metallic pieces clamping kit) has been added.
- The assessment methods for resistance to seismic actions, expressed as functioning under pulsating tension load (see clause 2.2.7) and functioning under pulsating shear load (see clause 2.2.8), have been added.
- General structure of the EAD has been improved including the assessment description in annexes.

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.

1.1.1 Turnbuckle clamping kit

This clamping kit consists of a turnbuckle with corresponding washers, made from malleable iron, stainless-steel or galvanized steel.

The turnbuckle is fixed to concrete elements via a cast-in anchor with internal threaded socket. Alternatively, the connection can be done with anchor channels and hammer head screw, expansion anchors, etc.

Turnbuckle and washers are mandatory components of the turnbuckle clamping kit. Screws are optional components of the clamping kit.

Figures 1.1.1.1 to 1.1.1.5 detail the assembly of the turnbuckle clamping kit in two different examples.

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In the following, the reference to fasteners when dealing with turnbuckle clamping kits are referring to the fasteners specified by the MPII (Manufacturer Product Installation Instructions). The fasteners are cast in anchor with internal threaded socket assessed according to EAD 330012-01-0601, anchor channels assessed according to EAD 330008-04-0601 or expansion anchors according to EAD 330232-01-0601.

Nuts, cast-in anchors with internal threaded socket, anchor channels, hammer head screws or expansion anchors, are elements of the assembled connection that are not part of the turnbuckle clamping kits but their intended use (see clause 1.2.1.1).

Corrosion protection of metal parts of the turnbuckle clamping kit are defined in relation to the intended uses of the structures where they are installed:

(1) Clamping kits intended for use in structures subject to dry, internal conditions: no special corrosion protection is necessary for metal parts as coatings provided for preventing corrosion such as adding a zinc coating with a minimum thickness of 5 µm thickness) during storage prior to use and for ensuring proper functioning of the clamping kit.

(2) Clamping kits for use in structures subject to internal conditions with usual humidity (e.g., kitchen, bath- and laundry in residential buildings, exceptional permanently damp conditions and application under water): metal parts made of steel material 1.0038 or 1.0044 according to EN 10025-2[1], 1.0976 or 1.0979 according to EN 10149-1 and EN 10149-2, 1.0213, 1.0214, 1.1132, 1.5525 or 1.5535 according to EN 10263-2, EN 10263-3, and EN 10263-4, 1.5523 according to EN 10269, 1.0401 according to EN 10277 or hot dip galvanized according to EN ISO 1461 or EN ISO 10684 with at least 50 µm thickness.

(3) Clamping kits for use in structures subject to external atmospheric exposure (including industrial and marine environments), or exposure in permanently damp internal condition, if no particular aggressive conditions according to the below mentioned bullet (4) exists: metal parts made of stainless-steel material 1.4401, 1.4404, 1.4571, 1.4578, 1.4362, 1.4062, 1.4162, 1.4662, 1.4439, 1.4462 or 1.4539 according to EN 10088-4 and EN 10088-5.

(4) Clamping kits for use in structures subject to external atmospheric exposure or exposure in permanently damp internal conditions or particularly aggressive conditions such as permanent or alternate immersion in seawater or the splash zone of seawater, chloride atmosphere of indoor swimming pools or atmosphere with extreme chemical pollution (e.g., in desulfurization plants or road tunnels, where de-icing materials are used): metal parts made of stainless-steel with sufficient corrosion resistance to the media acting on it.

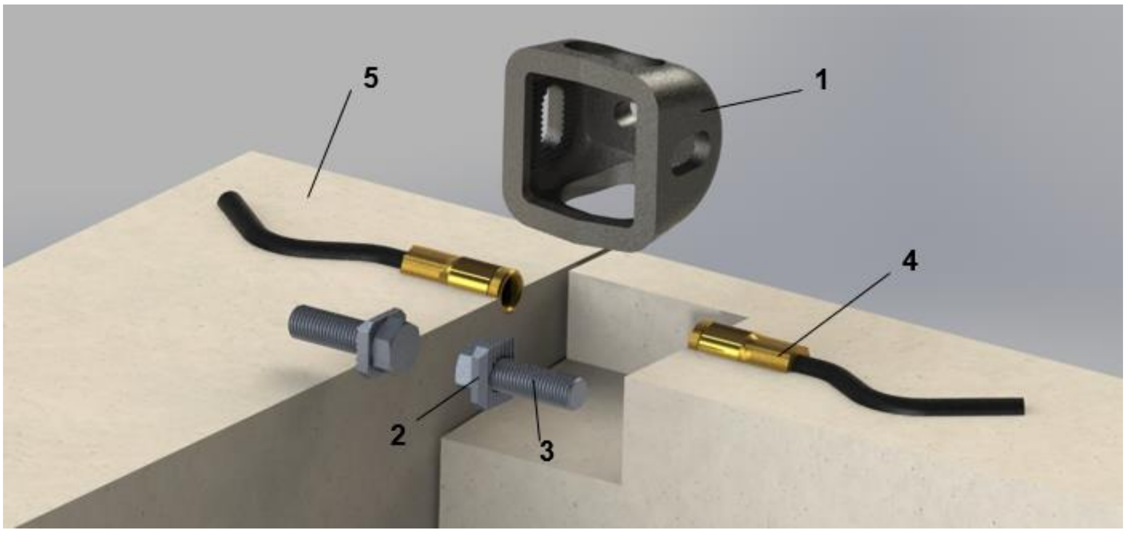


Figure 1.1.1.1: Exploded view of turnbuckle clamping kit assembled with cast-in anchors with internal threaded socket. Example nº 1.

Key for Figures 1.1.1.1 and 1.1.1.3:

1: Turnbuckle.

2: Washer.

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

3: Screw (optional).
4: Cast-in anchor with internal threaded socket (not part of the clamping kit).
5: Concrete element (not part of the clamping kit).

Figure 1.1.1.2: Assembled view of turnbuckle clamping kit assembled with cast-in anchors with internal threaded socket. Example nº 1.

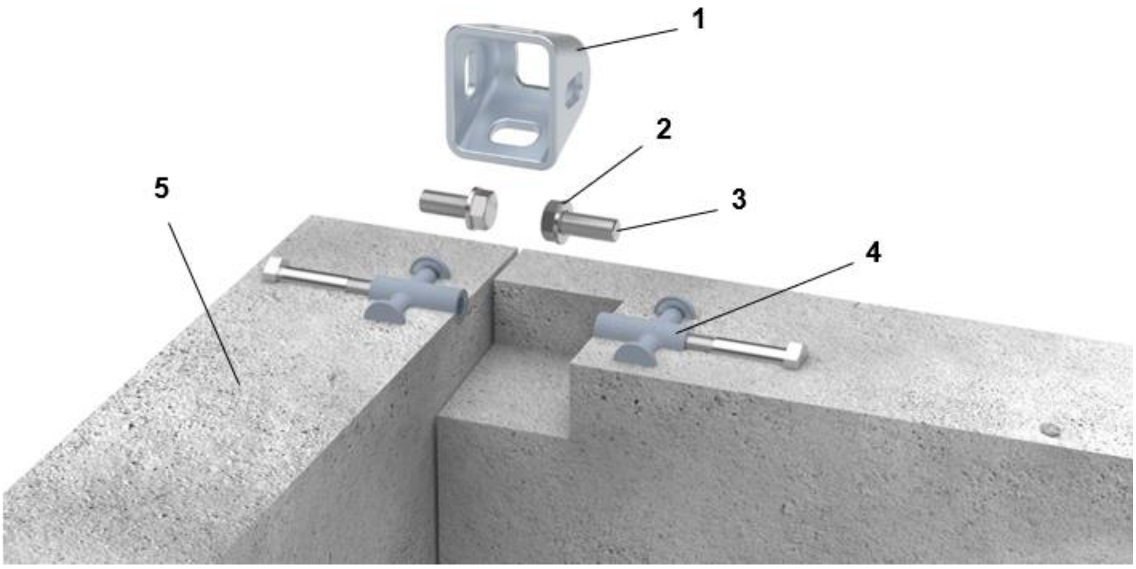


Figure 1.1.1.3: Exploded view of turnbuckle clamping kit assembled with cast-in anchors with internal threaded socket. Example nº 2.

Figure 1.1.1.4: Assembled view of turnbuckle clamping kit assembled with cast-in anchors with internal threaded socket. Example nº 2.

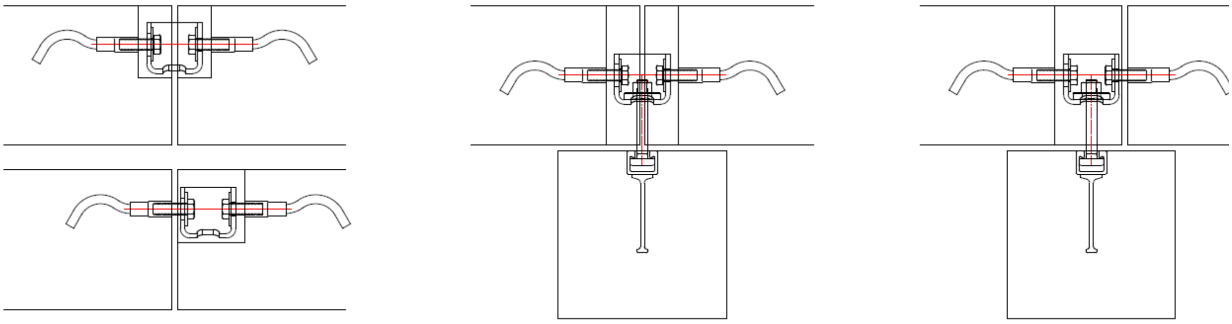


Figure 1.1.1.5: Connection options between concrete elements of turnbuckle clamping kits.

1.1.2 Three metallic pieces clamping kit

This clamping kit consists of three metallic pieces (see Figure 1.1.2.1) made of:

- an internally threaded upper bushing,
- a hexagonal nut, and
- an internally and externally threaded bottom sleeve.

The internally threaded upper bushing, the hexagonal nut and the internally and externally threaded bottom sleeve are mandatory components of the clamping kit.

Steel grades according to EN 10025-2[2] or EN ISO 683-1 are used in the upper bushing, the bottom sleeve, and the hexagonal nut. They are not coated because they are completely embedded in concrete during their working life.

The bottom sleeve is internally threaded to a steel threaded bar from the bottom precast concrete structure. The threaded steel bar from the upper precast concrete structure is threaded to the hexagonal nut. The upper bushing of the splice is threaded to the bottom sleeve, clamping the hexagonal nut.

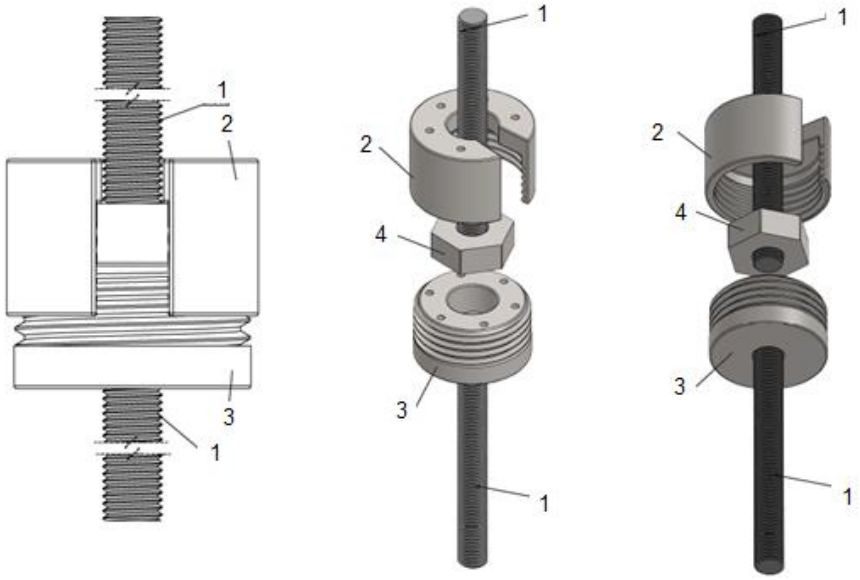
2 All undated references to standards in this EAD are to be understood as references to the dated versions listed in chapter 4.

The column-beam-column is made by means of the threaded steel bars from the bottom column which pass through the precast concrete beam and are connected to the threaded bars from the upper column by the clamping kit on top of the precast concrete beam (see Figure 1.1.2.2).

The connection is completed with concrete poured on site on top of the longitudinal groove of the precast concrete beam.

The clamping kit supports all loads generated by the upper column during installation. All loads generated in service are supported by the clamping kit and by the concrete poured on site.

The embedded threaded steel bars and the concrete poured on site on top of the longitudinal groove of the precast concrete beams are elements of the assembled connection that are not part of the three metallic pieces clamping kits but their intended use (see clause 1.2.1.2).



Key:

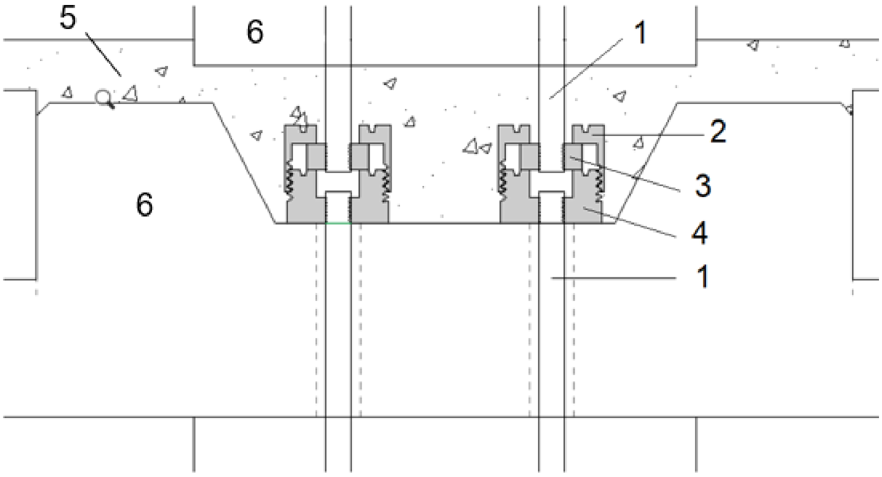
1: Threaded bar (not part of the clamping kit).

2: Internally threaded upper bushing.

3: Internally and externally threaded bottom sleeve.

4: Hexagonal nut.

Figure 1.1.2.1: Clamping kit consisting of three metallic pieces.



Key:

1: Threaded bar (not part of the clamping kit).

2: Upper bushing.

3: Hexagonal nut.

4: Bottom sleeve.

5: Concrete poured on site (not part of the clamping kit).

6: Concrete elements (not part of the clamping kit)

Figure 1.1.2.2: Cross-section of the joint between precast concrete beam and columns using three metallic pieces clamping kit.

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

1.2.1 Intended use(s)

1.2.1.1 Turnbuckle clamping kit

The clamping kit that consists of the turnbuckle is used for connecting either two or three concrete elements. The connection can be made between precast-to-precast structures, precast to situ concrete structures or between precast to already existing structures.

The turnbuckle clamping kit is fastened to cast-in anchors embedded in precast concrete elements (see Figure 1.1.1.1).

The applicable general use conditions are given in clause 6.3 of EN 1992-1-1.

The turnbuckle clamping kit is subjected to static, quasi-static, and seismic actions.

The turnbuckle clamping kit is intended to be used together with other connection elements such as nuts, cast-in anchors with internal threaded socket (according to EAD 330012-01-0601), anchor channels (according to EAD 330008-04-0601), hammer head screws or expansion anchors (according to EAD 330232-01-0601), these elements are to be defined (e.g., in the MPII) in relation to the turnbuckle clamping kit.

1.2.1.2 Three metallic pieces clamping kit

The clamping kit that consists of three metallic pieces is used to connect load bearing precast reinforced concrete structures (e.g., column-beam-column, foundation-column or beam-column).

The three metallic pieces clamping kit is fastened to threaded bars of the concrete structures transferring axial (tension or compression) and shear forces between the connected threaded bars. Threaded steel bars are embedded in precast concrete structures and are made of steel according to EN ISO 898-1.

The applicable general use conditions are given in clause 6.3 of EN 1992-1-1.

The concrete structures are subjected to static, quasi-static, and seismic actions.

The three metallic pieces clamping kit that consists of three metallic pieces is enclosed by concrete in service (for concrete covering see clause 6.5 of EN 1992-1-1) and is only exposed to the environment during installation.

The three metallic pieces clamping kit is intended to be used together with other elements of the connection such as the threaded bar and concrete poured on site, these elements are to be defined (e.g., in the MPII) in relation to the three metallic pieces clamping kit.

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 clamping kits for the intended use of 50 years when installed in the works (provided that the clamping kits are subject to appropriate installation (see 1.1)). 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[3].

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.

3 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 the assumed working life.

1.3 Specific terms used in this EAD

1.3.1 Symbols

$F_{u,m}$ [kN] = mean value of a test series.
k_S [-] = coefficient used to calculate characteristic properties.
c_{vF} [-] = coefficient of variation [%] related to loads.
$F_{u,5\%}$ [kN] = 5% fractile value with a confidence level of 90 % of a test series.
N_{eq} [kN] = equivalent cyclic load level under pulsating tension load (N_{eq} = 0,5 x $N_{u,m}$).
$N_{eq,red}$ [kN] = reduced equivalent cyclic load level under pulsating tension load.
$\alpha_{N,C1}$ [-] = seismic reduction factor for tension loading.
N_{min} [kN] = minimum cyclic load level under pulsating tension load testing.
N_{C1} [kN] = cyclic load level under pulsating tension load to be applied in the cycles 1 to 10 (N_{C1} = N_{eq} = 0,5 x $N_{u,m}$).
$N_{C1,red}$ [kN] = reduced cyclic load level under pulsating tension load to be applied in the cycles 1 to 10 ($N_{C1,red}$ = $N_{eq,red}$).
N_i [kN] = cyclic load level under pulsating tension load to be applied in the cycles 11 to 30 (N_i = 0,75 x N_{eq}).
$N_{i,red}$ [kN] = reduced cyclic load level under pulsating tension load to be applied in the cycles 11 to 30 ($N_{i,red}$ = 0,75 x $N_{eq,red}$).
N_m [kN] = cyclic load level under pulsating tension load to be applied in the cycles 31 to 100 (N_m = 0,50 x N_{eq}).
$N_{m,red}$ [kN] = reduced cyclic load level under pulsating tension load to be applied in the cycles 31 to 100 ($N_{m,red}$ = 0,50 x $N_{eq,red}$).
$N_{u,m}$ [kN] = reference load to be used in the pulsating tension load testing ($N_{u,m}$ = $F_{u,m}$ of the tensile strength in service).
$N_{Rk,C1}$ [kN] = characteristic resistance of functioning under pulsating tension load.
$V_{eq,red}$ [kN] = reduced equivalent cyclic load level under pulsating shear load.
V_{eq} [kN] = equivalent cyclic load level under pulsating shear load (V_{eq} = 0,5 x $V_{u,m}$).
$\alpha_{V,C1}$ [-] = seismic reduction factor for shear loading.
V_{min} [kN] = minimum cyclic load level under pulsating shear load testing.
V_{C1} [kN] = cyclic load level under pulsating shear load to be applied in the cycles 1 to 10 (V_{C1} = V_{eq} = 0,5 x $V_{u,m}$).
$V_{C1,red}$ [kN] = cyclic load level under pulsating shear load to be applied in the cycles 1 to 10 ($V_{C1,red}$ = $V_{eq,red}$).
V_i [kN] = cyclic load level under pulsating shear load to be applied in the cycles 11 to 30 (V_i = 0,75 x V_{eq}).
$V_{i,red}$ [kN] = reduced cyclic load level under pulsating shear load to be applied in the cycles 11 to 30 ($V_{i,red}$ = 0,75 x $V_{eq,red}$).
V_m [kN] = cyclic load level under pulsating shear load to be applied in the cycles 31 to 100 (V_m = 0,50 x V_{eq}).
$V_{m,red}$ [N] = reduced cyclic load level under pulsating shear load to be applied in the cycles 31 to 100 ($V_{m,red}$ = 0,50 x $V_{eq,red}$).
$V_{u,m}$ [kN] = reference load to be used in the pulsating shear load testing ($V_{u,m}$ = $F_{u,m}$ of the shear strength).
$V_{Rk,C1}$ [kN] = characteristic resistance of functioning under pulsating shear load.f_{cm} [MPa] = mean concrete compressive strength at the age t.
f_{ck} [MPa] = characteristic concrete compressive strength at age t_{ref}.

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

Table 2.1.1 shows how the performance of the clamping kits for connection of precast concrete members 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			
1	Tensile strength in service	2.2.1	Level
2	Tensile strength during installation (i)	2.2.2	Level
3	Shear strength (iii)	2.2.3	Level
4	Compression strength in service (i)	2.2.4	Level
5	Compression strength during installation (i)	2.2.5	Level
6	Strength of T-connection (ii)	2.2.6	Level
7	Functioning under pulsating tension load	2.2.7	Level
8	Functioning under pulsating shear load	2.2.8	Level
9	Durability against corrosion (ii)	2.2.9	Level
Basic Works Requirement 2: Safety in case of fire			
10	Reaction to fire	2.2.10	Class
(i) This characteristic is only applicable to three metallic pieces clamping kits (see clause 1.1.2). (ii) This characteristic is only applicable to turnbuckle clamping kits (see clause 1.1.1). (iii) There is no need to differentiate between shear strength in service and during installation.			

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.

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.

2.2.1 Tensile strength in service

Purpose of this assessment

The purpose of the assessment is to determine the characteristic tensile strength of the clamping kits in service.

Assessment method

Tensile strength in service of the clamping kits shall be tested according to:

- Clause A.1 for turnbuckle clamping kits.
- Clause A.2 for three metallic pieces clamping kits.

Expression of results

The characteristic value ($F_{u,5\%}$) [kN], calculated according to clause A.3, of tensile strength in service for each material and size shall be stated in the ETA.

In addition, for three metallic pieces clamping kits, the load-displacement diagram shall be stated in the ETA.

2.2.2 Tensile strength during installation

Purpose of this assessment

This characteristic is only applicable to the three metallic pieces clamping kits.

The purpose of this assessment is to determine the characteristic tensile strength of the product. The product is not embedded in concrete during installation unlike in service when it is embedded in concrete.

Assessment method

Tensile strength during installation of the three metallic pieces clamping kits shall be tested according to clause B.1.

Expression of results

The characteristic value ($F_{u,5\%}$) [kN], calculated according to clause A.3, of tensile strength during installation for each material and size shall be stated in the ETA.

In addition, the load-displacement diagram shall be stated in the ETA.

2.2.3 Shear strength

Purpose of this assessment

The purpose of the assessment is to determine the characteristic shear strength of the clamping kits.

Assessment method

Shear strength of the clamping kits shall be tested according to:

- Clause C.1 for turnbuckle clamping kits.
- Clause C.2 for three metallic pieces clamping kits.

Expression of results

The characteristic value ($F_{u,5\%}$) [kN], calculated according to clause A.3, of shear strength for each material and size shall be stated in the ETA.

In addition, for three metallic pieces clamping kits, the load-displacement diagram shall be stated in the ETA.

2.2.4 Compression strength in service

Purpose of this assessment

This characteristic is only applicable to clamping kits that consist of three metallic pieces.

The purpose of the assessment is to determine the characteristic compression strength of the product in service.

Assessment method

Compression strength in service of the three metallic pieces clamping kits shall be tested according to clause D.1.

Expression of results

The characteristic value ($F_{u,5\%}$)[kN], calculated according to clause A.3, of compression strength in service for each material and size shall be stated in the ETA.

In addition, the load-displacement diagram shall be stated in the ETA.

2.2.5 Compression strength during installation

Purpose of this assessment

This characteristic is only applicable to three metallic pieces clamping kits.

The purpose of the assessment is to determine the characteristic compression strength of the product during installation. The product is not embedded in concrete during installation unlike in service when it is embedded in concrete.

Assessment method

Compression strength during installation of the three metallic pieces clamping kits shall be tested according to clause E.1.

Expression of results

The characteristic value ($F_{u,5\%}$)[kN], calculated according to clause A.3, of compression strength during installation for each material and size shall be stated in the ETA.

In addition, the load-displacement diagram shall be stated in the ETA.

2.2.6 Strength of T-connection

Purpose of this assessment

This characteristic is only applicable to turnbuckle clamping kits.

The purpose of the assessment is to determine the characteristic strength of T-connection.

Assessment method

Strength of T-connection of the turnbuckle clamping kits shall be tested according to clause F.1.

Expression of results

The characteristic value ($F_{u,5\%}$)[kN], calculated according to clause A.3, of the T-connection for each material and size shall be stated in the ETA.

2.2.7 Functioning under pulsating tension load

Purpose of this assessment

The purpose of the assessment is to determine the functioning under pulsating tension load of clamping kits.

Assessment method

Functioning under pulsating tension load of the clamping kits shall be tested according to:

- Clause G.1 for turnbuckle clamping kits.
- Clause G.2 for three metallic pieces clamping kits.

Expression of results

The characteristic value ($N_{Rk,C1}$) [kN] according to clause G.1.4, of the tensile strength under pulsating tension load for each material and size shall be stated in the ETA.

2.2.8 Functioning under pulsating shear load

Purpose of this assessment

The purpose of the assessment is to determine the functioning under pulsating shear load of clamping kits.

Assessment method

Functioning under pulsating shear load of the clamping kits shall be tested according to:

- Clause H.1 for turnbuckle clamping kits.
- Clause H.2 for three metallic pieces clamping kits.

Expression of results

The characteristic value ($V_{Rk,C1}$) [kN] according to clause H.1.4, of the shear strength under pulsating shear load for each material and size shall be stated in the ETA.

2.2.9 Durability against corrosion

For clamping kits that consist of a turnbuckle and are made from hot dip galvanized malleable iron, the thickness of the coating shall be determined in accordance with Annex A of EN 10346.

The coating mass [grams], the steel quality and thickness of the coating shall be stated in the ETA.

2.2.10 Reaction to fire

The turnbuckle clamping kit and the three metallic pieces clamping kit, as defined in clause 1.1, are considered to satisfy the requirements of class A1 of the reaction-to-fire performance in accordance with the Commission Decision 96/603/EC as amended by Decision 2000/605/EC and Decision 2003/424/EC without the need for testing on the basis of it fulfilling the conditions set out in that Decision and its intended use being covered by that Decision.

Therefore, when the conditions referred to above are fulfilled, the performance of the products is A1 which shall be given in the ETA.

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 98/214/EC as amended by Decision 2001/596/EC.

The system is 2+

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.

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]**					
Incoming materials					
1	Type of material	Checking of supplier certificates or supplier tests	Conformity with the order	---	Each delivery
2	Dimensions and tolerances	Mechanical or optical measurement	Laid down in control plan	3 samples for each size and for each material	Each batch/ production week 10000 anchors
3	Material properties: - tensile strength, elastic limit and elongation at rupture - hardness.	- tensile test, - hardness testing Brinell or Vickers	Laid down in control plan	3 samples for each size and for each material	Each batch/ production week 10000 anchors
4	Coating (i)	Measuring of coating thickness (see clause 2.2.9)	Laid down in control plan	3 samples for each size and for each material	Each batch/ production week 10000 anchors
Final product					
5	Tensile test	2.2.1	Laid down in control plan	3 samples for each size and for each material	Each batch/ production week 10000 anchors
(i)	Only applicable to turnbuckle clamping kits made of galvanized steel.				

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 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	Notified Body will ascertain that the factory production control with the staff and equipment are suitable to ensure a continuous and orderly manufacturing of the Clamping kits.	Verification of the complete FPC as described in the control plan agreed between the TAB and the manufacturer	According to Control plan	According to Control plan	When starting the production or a new line
Continuous surveillance, assessment and evaluation of factory production control					
2	The Notified Body will ascertain that the system of factory production control and the specified manufacturing process are maintained taking account of the control plan.	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	According to Control plan	According to Control plan	1/year

4 REFERENCE DOCUMENTS

EN 10025-2:2019	Hot rolled products of structural steels – Part 2: Technical delivery conditions for non-alloy structural steels.
EN ISO 683-1:2018	Heat-treatable steels, alloy steels and free-cutting steels – Part 1: Non-alloy steel for quenching and tempering.
EN ISO 898-1:2013 EN ISO 898-1:2013/AC:2013	Mechanical properties of fasteners made of carbon steel and alloy steel – Part 1: Bolts, screws and studs with specific property classes – Coarse thread and fine pitch thread.
EAD 330012-01-0601	Cast-in anchor with internal threaded socket.
EAD 330008-04-0601	Anchor channels.
EAD 330232-01-0601	Mechanical fasteners for use in concrete.
EAD 332001-00-0602	Clamping systems for connection of precast concrete members.
EN 1992-1-1:2023	Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings, bridges and civil engineering structures.
EN 10149-1:2013	Hot rolled flat products made of high yield strength steels for cold forming – Part 1: General technical delivery conditions.
EN 10149-2:2013	Hot rolled flat products made of high yield strength steels for cold forming – Part 2: Technical delivery conditions for thermomechanically rolled steels.
EN 10263-2:2017	Steel rod, bars and wire for cold heading and cold extrusion – Part 2: Technical delivery conditions for steels not intended for heat treatment after cold working.
EN 10263-3:2017	Steel rod, bars and wire for cold heading and cold extrusion – Part 3: Technical delivery conditions for case hardening steels.
EN 10263-4:2017	Steel rod, bars and wire for cold heading and cold extrusion – Part 4: Technical delivery conditions for steels for quenching and tempering.
EN 10269:2013	Steels and nickel alloys for fasteners with specified elevated and/or low temperature properties.
EN 10277:2018	Bright steel products – Technical delivery conditions.
EN ISO 1461:2022	Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods.
EN ISO 10684:2004 EN ISO 10684:2004/AC:2009	Fasteners – Hot dip galvanized coatings.
EN 10088-4:2009	Stainless-steels – Part 4: Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for construction purposes.
EN 10088-5:2009	Stainless-steels – Part 5: Technical delivery conditions for bards, rods, wire, sections and bright products of corrosion resisting steels for construction purposes.
EN 12390-1:2021	Testing hardened concrete – Part 1: Shape, dimensions and other requirements for specimens and moulds.
EN 12390-2:2019	Testing hardened concrete – Part 2: Making and curing specimens for strength tests.
EN 12390-3:2019	Testing hardened concrete – Part 3: Compressive strength of test specimens.
EN 10346:2015	Continuously hot-dip coated steel flat products for cold forming – Technical delivery conditions.

ANNEX A: TENSILE STRENGTH IN SERVICE

This annex describes the assessment methods for tensile strength in service to be applied depending on the product to be assessed:

- Turnbuckle clamping kit assessment method is described in clause A.1.

- Three metallic pieces clamping kit assessment method is described in clause A.2.

In addition, clause A.3 describes the test results calculations to be carried out for obtaining the characteristic values.

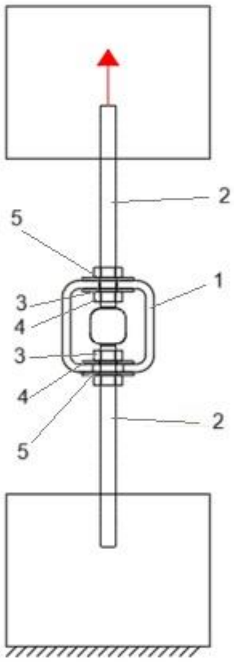
A.1 – Turnbuckle clamping kits

A.1.1 – Test setup and equipment (see Figure A.1.1.1)

The specimen shall be clamped into a tensile testing machine by means of threaded bars (with strength classification 8.8 according to EN ISO 898-1) and hexagon nuts (strength classification 8 according to EN ISO 898-1), the threaded bars shall be placed in the two slotted holes of the specimen. Here, the washers that belong to the specimen shall be applied. If necessary, counter nuts with washers shall be attached to the outside of the specimen so that the specimen does not slip before the load is applied. Installation torque shall be the minimum value defined in the MPII.

Due to the two slotted holes, the threaded bars shall be arranged differently with different expected failure loads. Clauses A.1.2 and A.1.3 shall be considered.

Figure A.1.1.1: Test setup for clamping kits that consist of a turnbuckle.



Key:
1: Test specimen.
2: Threaded bar.
3: Interlocking washer.
4: Hexagonal nut.
5: Counter nut and washer.

The specimen shall be subjected to a load application along the axis of the threaded bar until fracture. If the fracture occurs in the threaded bar, the test shall be repeated using a strongest threaded bar (with a highest strength classification in accordance with EN ISO 898-1) until the failure occurs in the specimen.

Displacements (in the axis of the applied load) shall be recorded continuously (e.g., by means of electrical displacement transducers of the tensile testing machine crosshead) with a measuring bias not greater than

0,020 mm or 2,0% for displacements > 1 mm. Possible slips of the grips shall be subtracted from the measures.

The load shall be increased at a constant speed in such a way that the peak load occurs after (1,5 ± 0,5) minutes from commencement. Load and displacement shall be recorded continuously. The tests shall be carried out with load control. The test shall be continued beyond the peak of the load/displacement curve to at least 75% of the maximum load to be measured (to allow the drop of the load/displacement curve).

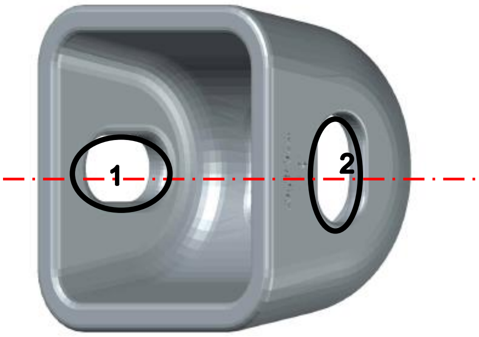
The data shall be collected with a frequency of 3 Hz – 5 Hz.

A.1.2 - Pilot test (critical bolt position)

The specimen shall consist of two slotted holes – one horizontal and one vertical (see Figure A.1.2.1). The arrangement of the threaded bars in these slotted holes may lead to different failure loads. The combination of slotted holes 1 or 2 with 3 (perpendicular to read dash dot axis) shall not be considered.

For the tensile test, the arrangement with the lowest failure loads shall be considered. To determine the arrangement, the specimen with the possible bolt positions (see Table A.1.2.1) shall be tested with the below mentioned setup. The measured values shall be included in the evaluation of the tensile load testing.

Figure A.1.2.1: Slotted holes



Key:
1: Horizontal slotted hole.
2: Vertical slotted hole.

Table A.1.2.1: Bolt positions.

1 – Horizontal slotted hole	Front
	Centre
	Rear
2 – Vertical slotted hole	Top (*)
	Centre
	Bottom (*)
(*) Since the specimen has a mirror symmetry along the shown red line, the bolt positions “top” and “bottom” provide identical results. For this reason, 3 x 2 = 6 bolt positions shall be taken into account.	

Number of tests:

Table A.1.2.2: Number of pilot tests for clamping kits that consist of a turnbuckle.

Possible bolt positions	x	Minimum number of tests (*)	=	**Total**
6		3		**18**
(*) Per material and size.				

A.1.3 – Tensile load testing

The setup according to clause A.1.1 shall be assembled with the critical bolt position according to clause A.1.2. Taking into account relevant results from the pilot tests, a total of at least 10 tests per material and size shall be carried out.

The ultimate load ($F_{u,m}$) and the load-displacement diagram of each test shall be registered. These data shall be processed in accordance with clause A.3 in order to obtain the 5% fractile value with a confidence level of 90 % of the test series ($F_{u,5\%}$).

Number of tests:

Table A.1.3.1: Number of tensile tests for clamping kits that consist of a turnbuckle.

Minimum total number (*)	-	Results from pilot test	=	**Total**
10		3		**7**
(*) Per material and size.				

A.2 – Three metallic pieces clamping kits

A.2.1 - Test setup (see Figure A.2.1.1)

The specimen shall be clamped into a tensile testing machine by means of the threaded bars. The specimen shall consist of two threaded bars (with strength classification 10.9 according to EN ISO 898-1) connected by a clamping kit embedded in a concrete block (see Figure A.2.1.1).

Concrete block shall be made with concrete resistance C25/30 unless is explicitly excluded by MPII. Additionally, any other concrete resistance according to the range taken from the MPII may be used.

The full threaded length of the hexagonal nut shall be threaded to the steel upper bar, and the full threaded length of the bottom sleeve shall be threaded to the steel bottom bar. Afterwards, the upper bushing shall be threaded to the bottom sleeve provided the depth of the hexagonal nut is clamped. Installation torque shall be the minimum value defined in the MPII.

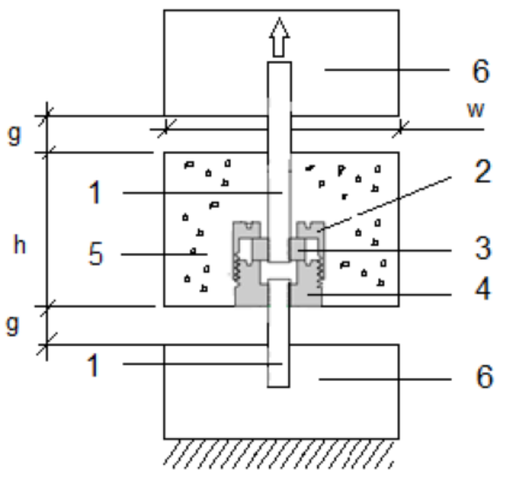
The specimen shall be completed by concrete poured and compacted around the clamping kit within a mould 200 mm x 200 mm x 200 mm. At the same time three concrete cubes or cylinders according to EN 12390-1 shall be moulded and cured according to EN 12390-2. These concrete cubes or cylinders shall be tested according to EN 12390-3 at the same time with the specimen to identify the mean compressive strength. Additional concrete cubes or cylinders shall be tested at 7 days, 14 days, 21 days, etc., in order to identify the progress of the concrete compressive strength for deciding the time to test the specimens. I.e., the specimens shall be tested when the measured compressive strength is closer to but not higher than the mean compressive strength corresponding to the characteristic compressive strength for the relevant class, in accordance with Table 5.1 of EN 1992-1-1 ($f_{cm} \leq f_{ck}$ + 8 MPa).

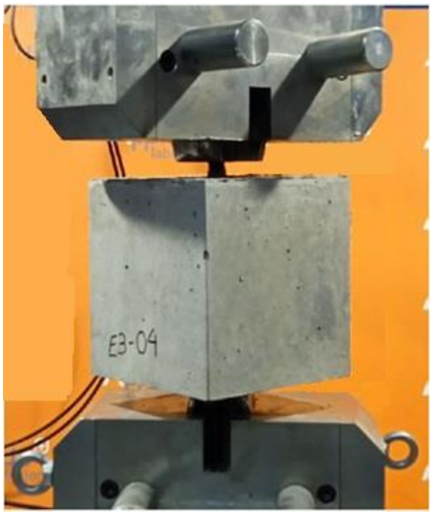
The clamping kit shall be centred within the concrete block. When the concrete reaches the prescribed mean compressive strength, the specimen shall be connected to the test rig and loaded to failure. Concrete or hexagonal nut failure is expected.

The concrete surface of the specimen shall not be in contact with the tensile testing machine: a minimum clearance of 10 mm shall be considered.

The load shall be applied at a constant rate not exceeding 25 mm/min.

Figure A.2.1.1: Test setup for clamping kits that consist of three metallic pieces.





Key:
1: Threaded bar.
2: Threaded upper bushing.
3: Hexagonal nut.
4: Bottom sleeve.
5: Concrete.
6: Clamping system of the test machine (wedge grips are usually used).
h: Height of the concrete block (200 mm).
w: Width of the concrete block (200 mm x 200 mm).
g: Gap between the concrete block and the load plates (≥ 10 mm).

The specimen shall be subjected to a load application along the axis of the threaded bar until fracture.

Displacements (in the axis of the applied load) shall be recorded continuously (e.g., by means of the electrical displacement transducers of the tensile testing machine crosshead). Possible slips of the grips shall be subtracted from the measures.

Failure of the clamping kit or concrete shall be sought. If the threaded bar fails, the test shall be repeated using a more resistant threaded bar.

The load-displacement diagram shall be continuously recorded during the test.

A.2.2 - Tensile testing

At least 10 tests per material and size shall be carried out.

To reduce the test program, the worst case of each size (the lowest steel strength class of the hexagonal nut, bottom sleeve and the upper bushing) shall be tested, and the value shall be assigned to higher steel strength classes.

The ultimate load ($F_{u,m}$) and the load-displacement diagram of each test shall be registered. These data shall be processed in accordance with clause A.3 in order to obtain the 5% fractile value with a confidence level of 90 % of the test series ($F_{u,5\%}$).

A.3 – Calculation of the characteristic values

The measured failure loads shall be recorded and stated in the test report.

From these values the 5% fractile value with a confidence level of 90% (according to EAD 330232-01-0601 clause A2.3) shall be calculated:

$F_{u,5\%} = F_{u,m} \times (1 – k_S \times c_{vF})$ (A.3.1)

with k_S = 2,57 (for n = 10 tests)

ANNEX B: TENSILE STRENGTH DURING INSTALLATION

This annex describes the assessment methods for tensile strength during installation of the three metallic pieces clamping kits.

B.1 – Three metallic pieces clamping kits

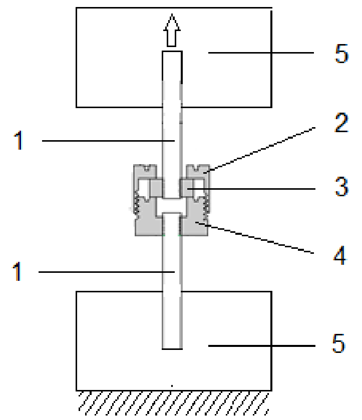
B.1.1 - Test setup (see Figure B.1.1.1)

The specimen shall be clamped into a tensile testing machine by means of the threaded bars. The specimen consists of two threaded bars (with strength classification 10.9 according to EN ISO 898-1) connected by a clamping kit that consists of three metallic pieces (see Figure B.1.1.1).

The full threaded length of the hexagonal nut shall be threaded to the steel upper bar, and the full threaded length of the bottom sleeve shall be threaded to the steel bottom bar. Afterwards, the upper bushing shall be threaded to the bottom sleeve provided the depth of the hexagonal nut is clamped. Installation torque shall be the minimum value defined in the MPII.

The load shall be applied at a constant rate not exceeding 25 mm/min.

Figure B.1.1.1: Test setup for clamping kits that consist of three metallic pieces.



Key:
1: Threaded bar.
2: Threaded upper bushing.
3: Hexagonal nut.
4: Bottom sleeve.
5: Clamping system of the test machine (wedge grips are usually used).

The specimen shall be subjected to a load application along the axis of the threaded bar until fracture.

Displacements (in the axis of the applied load) shall be recorded continuously (e.g., by means of the electrical displacement transducers of the tensile testing machine crosshead). Possible slips of the grips shall be subtracted from the measures.

Failure of the clamping kit shall be sought. If the threaded bar fails, the test shall be repeated using a more resistant threaded bar.

The load-displacement diagram shall be continuously recorded during the test.

B.1.2 - Tensile testing

At least 10 tests per material and size shall be carried out.

The ultimate load ($F_{u,m}$) and the load-displacement diagram of each test shall be registered. These data shall be processed in accordance with clause A.3 in order to obtain the 5% fractile value with a confidence level of 90 % of the test series ($F_{u,5\%}$).

To reduce the test program, the worst case of each size (the lowest steel strength class of the hexagonal nut, bottom sleeve and the upper bushing) shall be tested, and the value shall be assigned to higher steel strength classes.

After testing, calculation according to clause A.3 shall be applied.

ANNEX C: SHEAR STRENGTH

This annex describes the assessment methods for shear strength to be applied depending on the product to be assessed:

- Turnbuckle clamping kit assessment method is described in clause C.1.

- Three metallic pieces clamping kit assessment method is described in clause C.2.

C.1 – Turnbuckle clamping kits

C.1.1 - Test setup and equipment (see Figure C.1.1.1)

The specimen shall be connected to the test device (using a tensile/compression testing machine) with hexagonal head bolts (strength classification 8.8 according to EN ISO 898-1), the hexagonal head bolt shall be placed in the two slotted holes of the specimen. The specimen shall be attached on both sides of the test device. Here, the washers that belong to the specimen shall be applied. Installation torque shall be the minimum value defined in the MPII.

The testing device shall consist of a rigid immovable part and a movable part. The movable part shall be provided with a guide rail to prevent undesirable torsion.

Due to the two slotted holes, different arrangements of the hexagonal head bolts are arising with different expected failure loads. Clauses C.1.2 and C.1.3 shall be considered.

Two different setups during shear load testing:

1. Test setup: The opening of the specimen shall be directed forwards.
2. Test setup: The opening of the specimen shall be directed downwards.

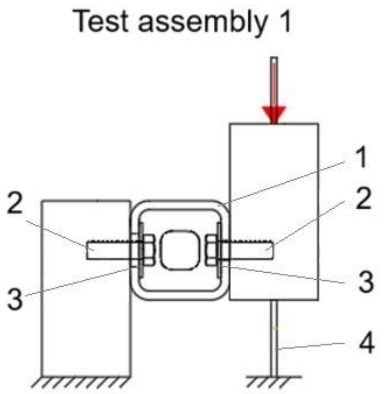
The specimen shall be subjected to a load application perpendicular to the axis of the hexagonal head bolts until fracture. If the fracture occurs in the hexagonal head bolt, the test shall be repeated using a strongest hexagonal head bolt (with a highest strength classification in accordance with EN ISO 898-1) until the failure occurs in the specimen.

Displacements (in the axis of the applied load) shall be recorded continuously (e.g., by means of electrical displacement transducers of the tensile/compression testing machine crosshead) with a measuring bias not greater than 0,020 mm or 2,0% for displacements > 1 mm. Possible slips of the grips shall be subtracted from the measures.

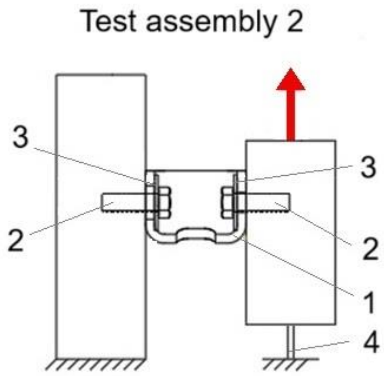
The load shall be increased at a constant speed in such a way that the peak load occurs after 1 to 2 minutes from commencement. Load and displacement shall be recorded continuously. The tests shall be carried out with load control. The test shall be continued beyond the peak of the load/displacement curve to at least 75% of the maximum load to be measured (to allow the drop of the load/displacement curve).

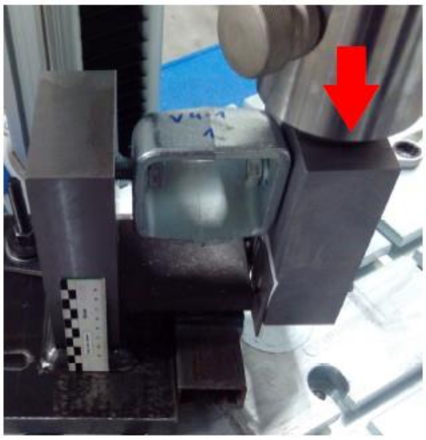
The data shall be collected with a frequency of 3 Hz – 5 Hz.

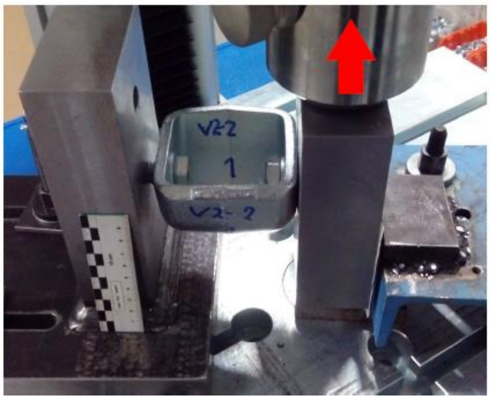
Figure C.1.1.1: Test setup for clamping kits that consist of a turnbuckle.



Key:
1: Test specimen.
2: Hexagonal head bolt.
3: Interlocking washer.
4: Guide rail.





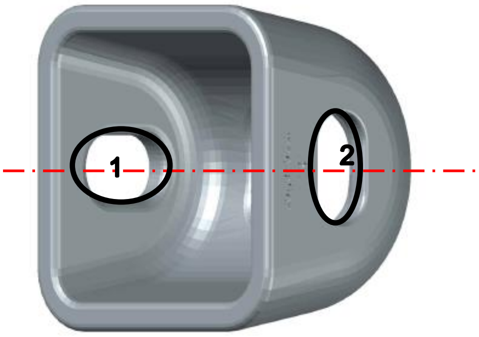


C.1.2 - Pilot test (critical bolt position)

The specimen shall consist of two slotted holes – one horizontal and one vertical (see Figure C.1.2.1). The arrangement of the hexagonal head bolts in these slotted holes can lead to different failure loads. The combination of slotted holes 1 or 2 with 3 (perpendicular to read dash dot axis) shall not be considered.

For the shear testing, the arrangement with the lowest failure loads shall be considered. To determine this arrangement, the specimen with the possible bolt positions (see Table C.1.2.1) shall be tested with the below mentioned setup. The measured values shall be included in the evaluation of the shear load testing (see clause C.1.3).

Figure C.1.2.1: Slotted holes



Key:
1: Horizontal slotted hole.
2: Vertical slotted hole.

Table C.1.2.1: Bolt position.

1 - Horizontal slotted hole	Front
	Centre
	Rear
2 - Vertical slotted hole	Top (*)
	Centre
	Bottom (*)
(*) Since the specimen has a mirror symmetry along the shown red line, the bolt positions "top" and "bottom" provide identical results. For this reason, 3 x 2 = 6 bolt positions shall be taken into account.	

Number of tests:

Table C.1.2.2: Number of tests for clamping kits that consist of a turnbuckle.

Possible bolt positions	x	Possible bolt positions	x	Minimum number of tests (*)	=	**Total**
2		6		3		**36**
(*) Per material and size.						

C.1.3 - Shear load testing

The setup according to clause C.1.1 shall be assembled with the critical bolt position according to clause C.1.2. Taking into account relevant results from the pilot tests, a total of at least 10 tests per material and size shall be carried out.

The ultimate load ($F_{u,m}$) and the load-displacement diagram of each test shall be registered. These data shall be processed in accordance with clause A.3 in order to obtain the 5% fractile value with a confidence level of 90 % of the test series ($F_{u,5\%}$).

Number of tests:

Table C.1.3.1: Number of tests for clamping kits that consist of a turnbuckle.

Test setups	x	Minimum total number	x	Results from pilot tests	=	**Total (*)**
2		6		3		**36**
(*) Per material and size.						

C.2 - Three metallic pieces clamping kits

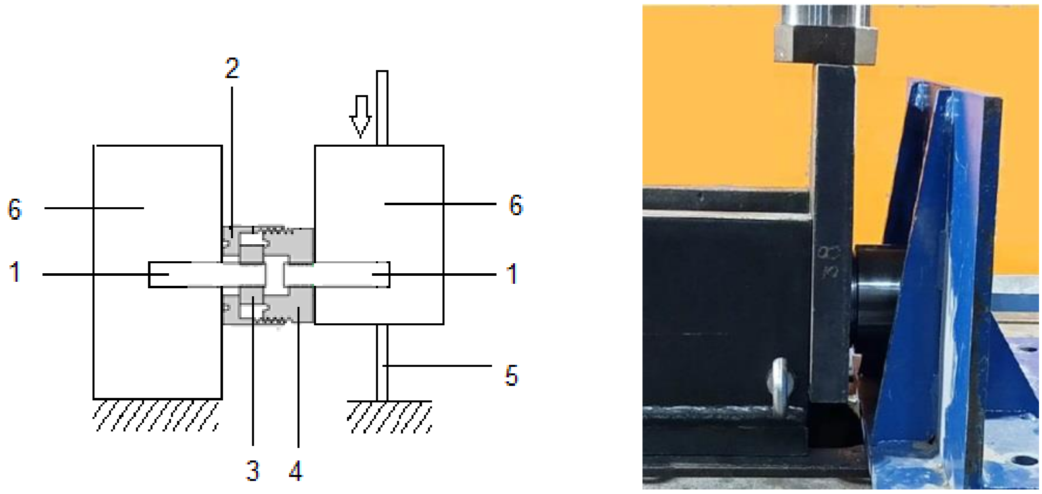
C.2.1 - Test setup (see Figure C.2.1.1)

The specimen shall be connected to the test device (using a tensile/compression testing machine) with the threaded bars. The specimen consists of two threaded bars (with strength classification 10.9 according to EN ISO 898-1) connected by a clamping kit that consists of three metallic pieces (see Figure C.2.1.1).

The full threaded length of the hexagonal nut shall be threaded to the steel upper bar, and the full threaded length of the bottom sleeve shall be threaded to the steel bottom bar. Afterwards, the upper bushing shall be threaded to the bottom sleeve provided the depth of the hexagonal nut is clamped. Installation torque shall be the minimum value defined in the MPII.

The load shall be applied at a constant rate not exceeding 25 mm/min.

Figure C.2.1.1: Test setup for clamping kits that consist of three metallic pieces.



Key:
1: Threaded bar.
2: Threaded upper bushing.
3: Hexagonal nut.
4: Bottom sleeve.
5: Guide rail.
6: Clamping system of the test machine. (wedge grips are usually used).

The specimen shall be subjected to a load application perpendicular to the axis of the threaded bar until fracture. Friction of the kit between the 2 rigid blocks of the clamping system shall be avoided.

Displacements (in the axis of the applied load) shall be recorded continuously (e.g., by means of the electrical displacement transducers of the tensile/compression testing machine crosshead). Possible slips of the grips shall be subtracted from the measures.

Failure of the clamping kit shall be sought. However, if the threaded bar described above fails before the clamping kit, the test shall be considered valid.

The load-displacement diagram shall be continuously recorded during the test.

C.2.2 – Shear load testing

At least 10 tests per material and size shall be carried out.

The ultimate load ($F_{u,m}$) and the load-displacement diagram of each test shall be registered. These data shall be processed in accordance with clause A.3 in order to obtain the 5% fractile value with a confidence level of 90 % of the test series ($F_{u,5\%}$).

To reduce the test program the worst case of each size (the lowest steel strength class of the hexagonal nut, bottom sleeve and the upper bushing) shall be tested, and the value shall be assigned to higher steel strength classes.

After testing, calculation according to clause A.3 shall be applied.

ANNEX D: COMPRESSION STRENGTH IN SERVICE

This annex describes the assessment methods for compression strength in service of the three metallic pieces clamping kits.

D.1 – Three metallic pieces clamping kits

D.1.1 - Test setup (see Figure D.1.1.1)

The specimen shall be clamped into a compression testing machine by means of the threaded bars. The specimen shall consist of two threaded bars (with strength classification 10.9 according to EN ISO 898-1) connected by a clamping kit embedded in a concrete block. (see Figure D.1.1.1).

Concrete block shall be made with concrete resistance C25/30 unless is explicitly excluded by MPII. Additionally, any other concrete resistance according to the range taken from the MPII may be used.

The full threaded length of the hexagonal nut shall be threaded to the steel upper bar, and the full threaded length of the bottom sleeve shall be threaded to the steel bottom bar. Afterwards, the upper bushing shall be threaded to the bottom sleeve provided the depth of the hexagonal nut is clamped. Installation torque shall be the minimum value defined in the MPII.

The specimen shall be completed by concrete poured and compacted around the clamping kit within a mould 200 mm x 200 mm x 200 mm. At the same time 3 concrete cubes or cylinders according to EN 12390-1 shall be moulded and cured according to EN 12390-2. These concrete cubes or cylinders shall be tested according to EN 12390-3 at the same time with the specimen to identify the mean compressive strength. Additional concrete cubes or cylinders shall be tested at 7 days, 14 days, 21 days, etc., in order to identify the progress of the concrete compressive strength and decide the appropriate time to test the specimens. The specimens shall be tested when the measured compressive strength is closer to but not higher than the mean compressive strength corresponding to the characteristic compressive strength for the relevant class, in accordance with Table 5.1 of EN 1992-1-1 ($f_{cm} \leq f_{ck}$ + 8 MPa).

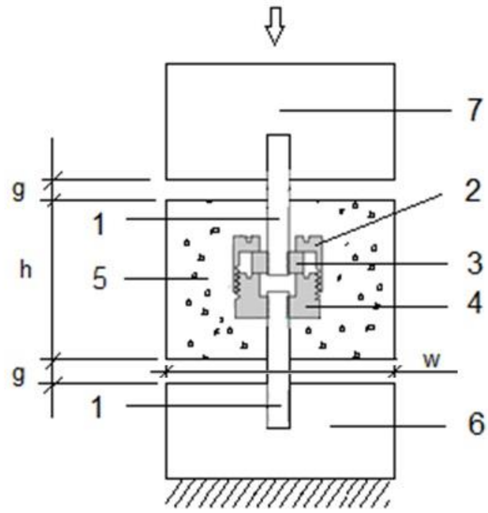
The clamping kit shall be centred within the concrete block. When the concrete reaches the prescribes mean compressive strength, the specimen shall be connected to the test rig and loaded to failure. Concrete or hexagonal nut failure is expected. If the threaded bar fails, the test shall be repeated using a more resistant threaded bar.

The concrete surface of the specimen shall not be in contact with the compression testing machine: a minimum clearance of 10 mm shall be considered.

The load shall be applied at a constant rate not exceeding 25 mm/min.

Figure D.1.1.1: Test setup for clamping kits that consist of three metallic pieces.

Key:
1: Threaded bar.
2: Threaded upper bushing.
3: Hexagonal nut.
4: Bottom sleeve.
5: Concrete block.
6: Clamping system of the test machine (wedge grips are usually used).
7: Load application device.
h: Height of the concrete block (200 mm).
w: Width of the concrete block (200 mm x 200 mm).
g: Gap between the concrete block and the load plates.



The specimen shall be subjected to a compressive load parallel to the axis of the threaded bar until fracture. The load shall be applied on the threaded bar.

Displacements (in the axis of the applied load) shall be recorded continuously (e.g., by means of the electrical displacements transducers of the compression testing machine crosshead). Possible slips of the grips shall be subtracted from the measures.

Failure of the clamping kit or concrete shall be sought. If the threaded bar fails, the test shall be repeated using a more resistant threaded bar.

The load-displacement diagram shall be continuously recorded during the test.

D.1.2 - Compression testing

At least 10 tests per material and size shall be carried out.

The ultimate load ($F_{u,m}$) and the load-displacement diagram of each test shall be registered. These data shall be processed in accordance with clause A.3 in order to obtain the 5% fractile value with a confidence level of 90 % of the test series ($F_{u,5\%}$).

To reduce the test program, the worst case of each size (the lowest steel strength class of the hexagonal nut, bottom sleeve and the upper bushing) shall be tested, and the values shall be assigned to higher steel strength classes.

After testing, calculation according to clause A.3 shall be applied.

ANNEX E: COMPRESSION STRENGTH DURING INSTALLATION

This annex describes the assessment methods for compression strength during installation of the three metallic pieces clamping kits.

E.1 – Three metallic pieces clamping kits

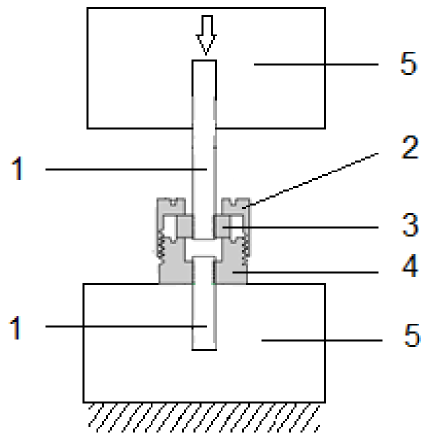
E.1.1 - Test setup (see Figure E.1.1.1)

The specimen shall be clamped into a compression testing machine by means of the threaded bars. The specimen shall consist of two threaded bars (with strength classification 10.9 according to EN ISO 898-1) connected by a clamping kit that consists of three metallic pieces (see Figure E.1.1.1).

The full threaded length of the hexagonal nut shall be threaded to the steel upper bar, and the full threaded length of the bottom sleeve shall be threaded to the steel bottom bar. Afterwards, the upper bushing shall be threaded to the bottom sleeve provided the depth of the hexagonal nut is clamped. Installation torque shall be the minimum value defined in the MPII.

The load shall be applied at a constant rate not exceeding 25 mm/min.

Figure E.1.1.1: Test setup for clamping kits that consist of three metallic pieces.



Key:
1: Threaded bar.
2: Threaded upper bushing.
3: Hexagonal nut.
4: Bottom sleeve.
5: Clamping system of the test machine (wedge grips are usually used)..

The specimen shall be subjected to a compressive load parallel to the axis of the threaded bar until fracture.

Displacements (in the axis of the applied load) shall be recorded continuously (e.g., by means of the electrical displacement transducers of the compression testing machine crosshead). Possible slips of the grips shall be subtracted from the measures.

Failure of the clamping kit shall be sought. If the threaded bar fails, the test shall be repeated using a more resistant threaded bar.

If a buckling failure of the threaded bar is observed, the distance between upper clamping system and threaded upper bushing shall be reduced until it is avoided.

The load-displacement diagram shall be continuously recorded during the test.

E.1.2 - Compression testing

At least 10 tests per material and size shall be carried out.

The ultimate load ($F_{u,m}$) and the load-displacement diagram of each test shall be registered. These data shall be processed in accordance with clause A.3 in order to obtain the 5% fractile value with a confidence level of 90 % of the test series ($F_{u,5\%}$).

To reduce the test program, the worst case of each size (the lowest steel strength class of the hexagonal nut, bottom sleeve and the upper bushing) shall be tested, and the values shall be assigned to higher steel strength classes.

After testing, calculation according to clause A.3 shall be applied.

ANNEX F: STRENGTH OF T-CONNECTION

This annex describes the assessment methods for strength of T-connection of the turnbuckle clamping kits.

F.1 – Turnbuckle clamping kits

F.1.1 - Test setup and equipment (see Figure F.1.1.1)

The specimen shall be connected to the lower part of the test device (using a tensile testing machine) by means of hexagonal head bolts (with strength classification mentioned in clause F.1.2), the hexagonal head bolt shall be placed in the two slotted holes of the specimen. The specimen shall be attached on both sides of the test device. Here, the washers that belong to the specimen need to be applied. Installation torque shall be the minimum value defined in the MPII.

Due to the two slotted holes, different arrangements of the hexagonal head bolts are arising with different expected failure loads. Clauses F.1.2 and F.1.3 shall be considered.

The specimen shall be connected to the upper part of the test device by means of threaded bars and hexagon nuts (with strength classification mentioned in clause F.1.2), the threaded bars shall be placed in the rearward bolt holes. Here, the washers and adapter plates that belong to the specimen need to be applied. If necessary, counter nuts with washers shall be attached to the outside of the specimen so that the specimen does not slip before the load is applied.

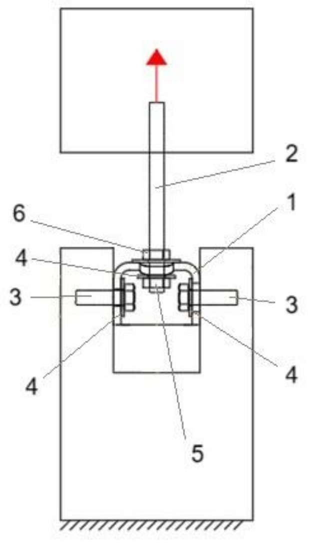
The specimen shall be subjected to a load application along the axis of the threaded bar until fracture. If a fracture occurs in the threaded bar, the test shall be repeated using a strongest threaded bar (with a highest strength classification in accordance with EN ISO 898-1) until the failure occurs in the specimen.

Displacements (in the axis of the applied load) shall be recorded continuously (e.g., by means of electrical displacement transducers of the tensile testing machine crosshead) with a measuring bias not greater than 0,020 mm or 2,0% for displacements > 1 mm. Possible slips of the grips shall be subtracted from the measures.

The load shall be increased at a constant speed in such a way that the peak load occurs after 1 to 2 minutes from commencement. Load and displacement shall be recorded continuously. The tests shall be carried out with load control. The test shall be continued beyond the peak of the load/displacement curve to at least 75% of the maximum load to be measured (to allow the drop of the load/displacement curve).

The data shall be collected with a frequency of 3 Hz – 5 Hz.

Figure F.1.1.1: Test setup for characteristic strength of T-connection of clamping kits that consist of a turnbuckle.



Key:
1: Test specimen.
2: Threaded bar.
3: Hexagonal head bolt.
4: Interlocking washer.
5: Hexagonal nut.
6: Counter nut and washer.

F.1.2 - Pilot test (strength classification of hexagonal head bolt)

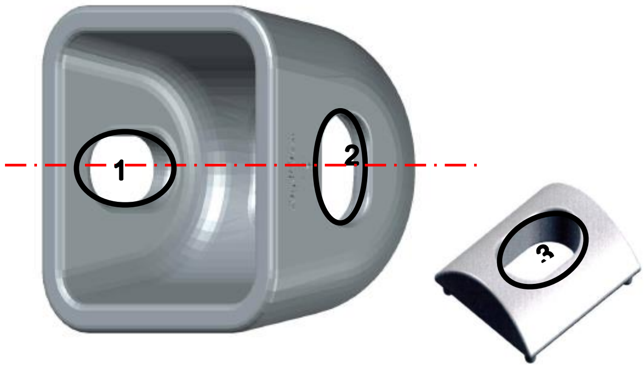
The specimen shall be tested on steel failure. To prevent premature failure of the hexagonal head bolts, it shall be necessary to determine which strength classification shall be selected. Therefore, the below mentioned test setup shall be performed. During the first test, the hexagonal head bolts of strength classification 8.8 and 8 in accordance with EN ISO 898-1 shall be used. If these hexagonal head bolts fail prematurely, the strength classification of the hexagonal head bolts shall be increased in the next test, until their failure no longer occurs before the steel failure of the specimen itself. Here, all hexagonal head bolts shall be arranged in the middle of the slotted holes.

F.1.3 - Pilot test (critical bolt position)

The specimen shall consist of two slotted holes – one horizontal and one vertical (see Figure F.1.3.1). By application of the adapter plate in the rearward bolt hole a third slotted hole shall be created. The arrangement of the hexagonal head bolts and threaded bars in these slotted holes can lead to different failure loads.

For the shear testing, the arrangement with the lowest failure loads shall be considered. To determine this arrangement, the specimen with the possible bolt positions (see Table F.1.3.1) shall be tested with the below mentioned setup. The measured values shall be included in the evaluation of the shear load testing (see clause F.1.4).

Figure F.1.3.1: Slotted holes and adapter plate.



Key:
1: Horizontal slotted hole.
2: Vertical slotted hole.
3: Rearward slotted hole.

Table F.1.3.1: Bolt positions.

<table>
<tr><td rowspan="3">1 - Horizontal slotted hole</td><td>Front</td></tr>
<tr><td>Centre</td></tr>
<tr><td>Rear</td></tr>
<tr><td rowspan="3">2 - Vertical slotted hole</td><td>Top (*)</td></tr>
<tr><td>Centre</td></tr>
<tr><td>Bottom (*)</td></tr>
<tr><td rowspan="3">3.- Rearward slotted hole</td><td>Left</td></tr>
<tr><td>Centre</td></tr>
<tr><td>Right</td></tr>
<tr><td colspan="2">(*) Since the specimen has a mirror symmetry along the shown red line, the bolt positions "top" and "bottom" provide identical results. For this reason, 3x3x2=18 bolt positions shall be taken into account.</td></tr>
</table>

Number of tests:

Table F.1.3.2: Number of pilot tests for clamping kits that consist of a turnbuckle.

Possible bolt positions	x	Minimum number of tests (*)	=	**Total**
18		3		**54**
(*) Per material and size.				

F.1.4 - Shear stress testing

The setup according to clause F.1.1 shall be assembled with the critical bolt position according to clause F.1.3 and strength classification according to clause F.1.2. Taking into account relevant results from the pilot tests, a total of at least 10 tests per material and size shall be carried out.

Number of tests:

Table F.1.4.1: Number of tensile tests for clamping kits that consist of a turnbuckle.

Minimum total number (*)	-	Results from pilot test	=	**Total**
10		3		**7**
(*) Per material and size.				

The ultimate load ($F_{u,m}$) and the load-displacement diagram of each test shall be registered. These data shall be processed in accordance with clause A.3 in order to obtain the 5% fractile value with a confidence level of 90 % of the test series ($F_{u,5\%}$).

ANNEX G: FUNCTIONING UNDER PULSATING TENSION LOAD

This annex describes the assessment methods for functioning under pulsating tension load to be applied depending on the product to be assessed:

- Turnbuckle clamping kit assessment method is described in clause G.1.

- Three metallic pieces clamping kit assessment method is described in clause G.2.

G.1 – Turnbuckle clamping kits

The purpose of this assessment method is to obtain the seismic reduction factor for tension loading ($\alpha_{N,C1}$).

G.1.1 - Test setup and equipment

The general test setup is given in clause A.1.1.

G.1.2 - Pilot test (critical bolt position)

The critical positions shall be determined analogously to clause A.1.2 and adopted for the tests.

G.1.3 - Pulsating tension load testing

The setup according to clause G.1.1 shall be assembled with the critical bolt position according to clause G.1.2.

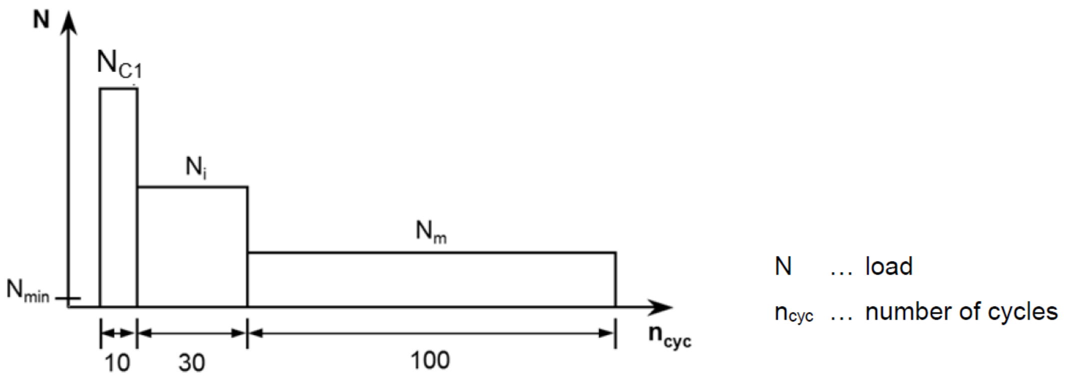
The cycling frequency shall be between 0,1 and 2,0 Hz. The bottom of the tension load pulses shall be taken to be slightly greater than zero to avoid servo control problems but shall not exceed N_{min}, with N_{min} being the maximum between 3% of N_{eq} and 200 N.

The cyclic load level shall be carried out according to the following scheme:

Table G.1.3.1: Cyclic load level under pulsating tension load.

Load level	N_{C1}	N_i	N_m
Number of cycles (n_{cyc})	10	30	100

Figure G.1.3.1: cyclic load level under pulsating tension load.



The mean failure load from the respective reference test $F_{u,m}$ (clause A.1) shall be used as the reference load $N_{u,m}$.

$N_{C1} = N_{eq} = 0{,}50 \times N_{u,m}$ (G.1.3.1)
$N_i = 0{,}75 \times N_{eq}$ (G.1.3.2)
$N_m = 0{,}50 \times N_{eq}$ (G.1.3.3)

where
$N_{u,m}$ = [kN] reference load to be used in the pulsating tension load testing ($N_{u,m} = F_{u,m}$ of the tensile strength in service)

A total of at least 10 tests per material and size shall be carried out.

G.1.4 - Assessment

1. After completion of the cyclic loading history (using the equivalent load (N_{eq}) according to the equations G.1.3.1 to G.1.3.2) without any failure, the residual tension capacity shall be tested according to the method defined in clause A.1.

2. If the residual tension capacity after the cyclic loading history is equal or greater than the 160% of the equivalent load (N_{eq}), the seismic reduction factor for tension loading is $\alpha_{N,C1} = 1{,}0$.

3. If one of the following aspects occur:

   - the mean value of the residual tension capacity after the cyclic loading history is less than the 160% of the equivalent load (N_{eq}), or

   - any failure is observed in any cycle prior to completing the loading history,

   the cyclic loading according to clause G.1.3 shall be repeated with a reduced equivalent loading ($N_{eq,red}$) (e.g., applying reducing steps such as ($0{,}9 \times N_{eq}$), ($0{,}8 \times N_{eq}$), etc.). The loading history specified in Table G.1.3.1 and the Figure G.1.3.1 shall be applied, where $N_{eq,red}$, $N_{i,red}$ and $N_{m,red}$ are substituted for N_{C1}, N_i and N_m, respectively.

   Failure of the clamping kit in any cycle prior to completing the loading history given in Table G.1.3.1 and Figure G.1.3.1 shall be recorded related to the load values applied (N_{C1}, N_i and N_m).

4. After completing of the cyclic loading history with the reduced equivalent loading without any failure, the residual tension capacity shall be tested according to the method defined in clause A.1.

5. If the mean value of the residual tension capacity after the cyclic loading history with the reduced equivalent loading is equal or greater than the 160% of the equivalent reduced load ($N_{eq,red}$), the seismic reduction factor for tension loading shall be calculated according to Equation G.1.4.1.

   $$\alpha_{N,C1} = \frac{N_{eq,red}}{N_{eq}} \quad \text{(G.1.4.1)}$$

6. If the mean value of the residual tension capacity after the cyclic loading history with the reduced equivalent loading is less than the 160% of the equivalent reduced load ($N_{eq,red}$), or any failure is observed in any cycle prior to completing the loading history, iterative new reductions of the loads shall be considered applying bullets 3) and 4) above until the condition given in bullet 5) is met.

Finally, the characteristic resistance for functioning under pulsating tension load shall be calculated as follow:

$$N_{Rk,C1} = F_{u,5\%} \times \alpha_{N,C1} \quad \text{(G.1.4.2)}$$

where

$F_{u,5\%}$ = [kN] – 5% fractile value from static tension load tests (clause A.1).

G.2 – Three metallic pieces clamping kits

G.2.1 – Test setup

The test setup given in clause A.2.1 applies.

G.2.2 – Pilot test

It does not apply.

G.2.3 – Pulsating tension load testing

The specifications given in clause G.1.3 shall apply, except for the reference to clause G.1.2 and clause A.1 that shall be replaced by clause G.2.2 and clause A.2, respectively.

G.2.4 – Assessment

The specifications given in clause G.1.4 shall apply, except for the reference to clause A.1 that shall be replaced by clause A.2.

ANNEX H: FUNCTIONING UNDER PULSATING SHEAR LOAD

This annex describes the assessment methods for functioning under pulsating shear load to be applied depending on the product to be assessed:

- Turnbuckle clamping kit assessment method is described in clause H.1.

- Three metallic pieces clamping kit assessment method is described in clause H.2.

H.1 – Turnbuckle clamping kits

The purpose of this assessment method is to obtain the seismic reduction factor for shear loading ($\alpha_{V,C1}$).

H.1.1 – Test setup and equipment

The general test setup is given in clause C.1.1, both test assemblies.

H.1.2 – Pilot test (critical bolt position)

The critical positions shall be determined analogously to clause C.1.2 and adopted for the tests.

H.1.3 – Pulsating shear load testing

The setup according to clause H.1.1 shall be assembled with the critical bolt position according to H.1.2.

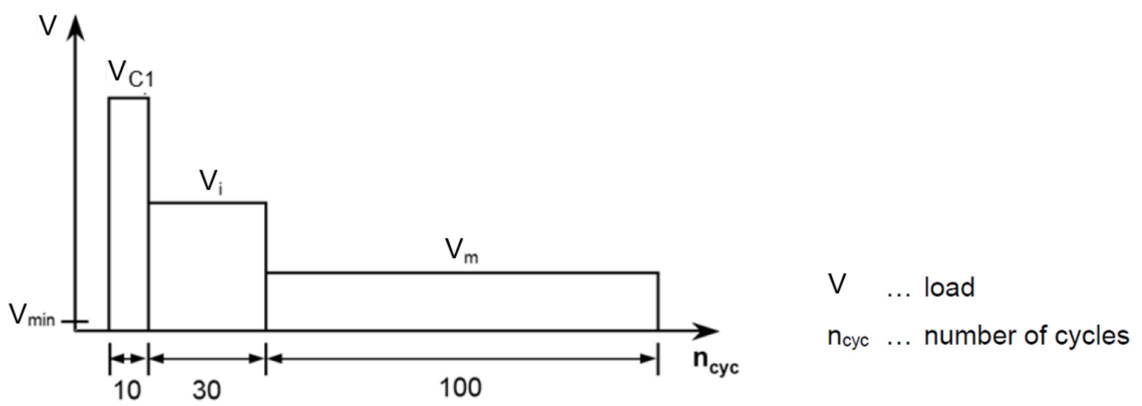
The cycling frequency shall be between 0,1 and 2 Hz. The bottom of the shear load pulses shall be taken to be slightly greater than zero to avoid servo control problems but shall not exceed V_{min}, with V_{min} being the maximum between 3% of V_{eq} and 200 N.

The cyclic load level shall be carried out according to the following scheme:

Table H.1.3.1: Cyclic load level under pulsating shear load.

Load level	V_{C1}	V_i	V_m
Number of cycles (n_{cyc})	10	30	100

Figure H.1.3.1: Cyclic load level under pulsating shear load.



The mean failure load from the respective reference test $F_{u,m}$ (clause C.1) shall be used as the reference load $V_{u,m}$.

$V_{C1} = V_{eq} = 0,50 \times V_{u,m}$ (H.1.3.1)
$V_i = 0,75 \times V_{eq}$ (H.1.3.2)
$V_m = 0,50 \times V_{eq}$ (H.1.3.3)

where
$V_{u,m}$ = [kN] – mean ultimate shear load

A total of at least 10 tests per material and size shall be carried out.

H.1.4 – Assessment

1. After completion of the cyclic loading history (using the equivalent load (V_{eq}) according to the equations H.1.3.1 to H.1.3.2) without any failure (mainly failure in the hexagonal head bolt), the residual shear capacity shall be tested according to the method defined in clause C.1.

2. If the mean value of the residual shear capacity after the cyclic loading history is equal or greater than the 160% of the equivalent load (V_{eq}), the seismic reduction factor for shear loading is $\alpha_{V,C1} = 1,0$.

3. If one of the following aspects occur:

   - the mean value of the residual shear capacity after the cyclic loading history is less than the 160% of the equivalent load (V_{eq}), or

   - any failure is observed in any cycle prior to completing the loading history (mainly failure in the hexagonal head bolt),

   the cyclic loading according to clause H.1.3 shall be repeated with a reduced equivalent loading ($V_{eq,red}$). (e.g., applying reducing steps such as ($0,9 \times V_{eq}$), ($0,8 \times V_{eq}$), etc.). The loading history specified in Table H.1.3.1 and the Figure H.1.3.1 shall be applied, where $V_{eq,red}$, $V_{i,red}$ and $V_{m,red}$ are substituted for V_{C1}, N_i and N_m, respectively.

   Failure of the clamping kit in any cycle prior to completing the loading history given in Table H.1.3.1 and Figure H.1.3.1 shall be recorded related to the load values applied (V_{C1}, V_i and V_m).

4. After completing of the cyclic loading history with the reduced equivalent loading without any failure, the residual shear capacity shall be tested according to the method defined in clause C.1.

5. If the mean value of the residual shear capacity after the cyclic loading history with the reduced equivalent loading is equal or greater than the 160% of the equivalent reduced load ($N_{eq,red}$), the seismic reduction factor for shear loading shall be calculated according to Equation H.1.4.1.

   $$\alpha_{V,C1} = \frac{V_{eq,red}}{V_{eq}} \quad \text{(H.1.4.1)}$$

6. If the mean value of the residual shear capacity after the cyclic loading history with the reduced equivalent loading is less than the 160% of the equivalent reduced load ($V_{eq,red}$), or any failure is observed in any cycle prior to completing the loading history, iterative new reductions of the loads shall be considered applying bullets 3) and 4) above until the condition given in bullet 5) is met.

Finally, the characteristic resistance for functioning under pulsating shear load shall be calculated as follow:

$$V_{Rk,C1} = F_{u,5\%} \times \alpha_{V,C1} \quad \text{(H.1.4.2)}$$

where

$F_{u,5\%}$ = [kN] – 5% fractile value from static shear load tests (clause C.1).

H.2 – Three metallic pieces clamping kits

H.2.1 - Test setup

The test setup given in clause C.2.1 applies.

H.2.2 - Pilot test

It does not apply.

H.2.3 – Pulsating shear load testing

The specifications given in clause H.1.3 shall apply, except for the reference to clause H.1.2 and clause C.1 that shall be replaced by clause H.2.2 and clause C.2, respectively.

H.2.4 - Assessment

The specifications given in H.1.4 shall apply, except for the reference to clause C.1 that shall be replaced by clause C.2.