EAD 330083-04-0601-v01

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European Assessment Document for

Variant:
Seismic performance for the connection of interior non-load-bearing drywall partition walls metal stud to concrete using multiple power actuated fasteners

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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

EAD 330083-04-0601[1], Clause 1.1 applies.

The product is not fully covered by EAD 330083-04-0601. Compared to EAD 330083-04-0601 the following changes are introduced:

- Additional assessment of seismic performance of fasteners used to attach metal tracks of interior non-load bearing metal stud drywall partitions to concrete. This has become necessary as drywall partitions are subject to increased scrutiny to reduce non-structural damage caused by earthquakes, and subsequently to increase community resilience.

The additional assessment proposed in this variant to EAD 330083-04-0601 only applies to Fastening Type 4 (attachment of drywall track to concrete).

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)

EAD 330083-04-0601, Clause 1.2.1 applies.

In addition, the intended use is defined by the following parameters related to seismic performance of the fasteners:

Wall types

- Interior non-load bearing metal stud drywall partitions.
- Up to 2 gypsum board layers per wall side, with up to 12,5 mm thickness per gypsum board.
- Metal stud spacing of approximately 62,5 cm.
- Wall height of 2,6 m up to 4,5 m.
- Metal stud and track widths of 50 to 150 mm.

Top and bottom connection to substructure (side connections are typically constructive)

- Metal track thickness from 0,5 to 1,25 mm.
- Material fastened between track and concrete can be none, gypsum strips up to 50 mm thickness, sound or fire insulation or levelling material of up to 3 mm installed thickness.
- Fixed connections.
- Deflection heads (Sliding connections) to the concrete ceiling, allowing for horizontal and/or vertical in-plane movement of the partition relative to the concrete ceiling (with and without gypsum strips below the track).

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

- "a" is the maximum gap between top of gypsum boards and concrete ceiling. a = 20 mm.

Earthquake motions

- The scope of this EAD variant is applicable to the ultimate limit state of the fastening to the structure in accordance with EN 1998-1 clause 4.3.5 for non-structural element.

1.2.2 Working life/Durability

EAD 330083-04-0601, Clause 1.2.2 applies.

1.3 Specific terms used in this EAD

In addition to EAD 330083-04-0601, Clause 1.3, the following applies.

1.3.1 Fixed connection

Top, side or bottom track fastened to concrete, where the wall boards and/or metal studs are screwed to the track.

Due to the nature of the connection, shear resistance shall be determined by performing tests with *a* = 0 mm for fixed track connections as illustrated in the schematic of the group test setup for fixed connections, given in Figure B.2.3.1.

Figure 1.3.1.1 provides an illustration of a transversal cross section of a fixed top connection.

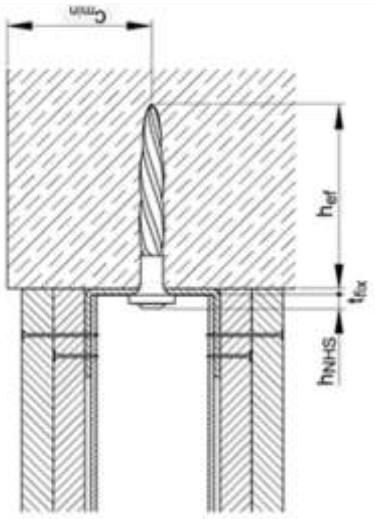


Figure 1.3.1.1: Examples of fixed top connection

1.3.2 Deflection head connection

Connection between the concrete substructure and partition wall, allowing horizontal and/or vertical movement of the wall relative to the substructure. The deflection head is typically located at the top of the partition wall and can include, but is not limited to, the fastening of tracks to the concrete and possibly including gypsum strips, but with no fastening to the metal studs or wall boards, allowing sliding.

Due to the nature of the connection, shear resistance shall be determined by performing tests with *a* = 20 mm for connection with deflection head, as illustrated in the schematic of the group test setup for deflection heads, given in Figure B.2.4.1.

Figure 1.3.2.1 provides an illustration of a transversal cross section of a deflection head.

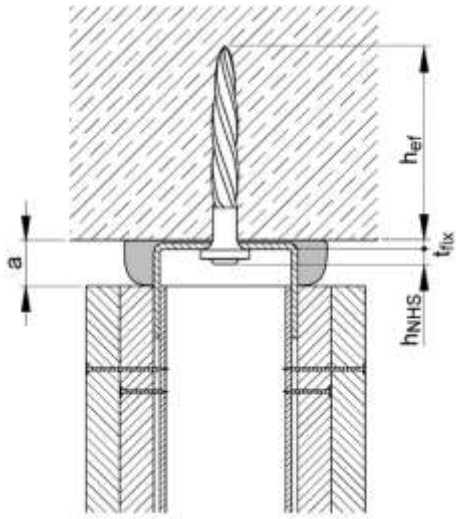


Figure 1.3.2.1: Example of a deflection head

1.3.3 Fasteners

The notations and symbols frequently used in this EAD are given below. Further particular notation and symbols are given in the text.

a	=	maximum gap between top of gypsum boards and concrete ceiling allowing vertical deflection of structural member (deflection head), corresponding to the cantilever distance for performing the tests
A_{s1}	=	stressed cross-section of the fastener, based on the nominal diameter in the area of the steel adapter
h_{ef}	=	effective anchorage depth
h_{NHS}	=	nail head standoff
t_{fix}	=	thickness of fixture

1.3.4 Base material (concrete) and metal parts of fastener

f_{uk}	=	nominal characteristic steel ultimate strength
$f_{u,test}$	=	steel ultimate tensile strength in the test

1.3.5 Loads / Forces

V	=	shear force

1.3.6 Tests / Assessment

V_{um}	=	mean ultimate shear load in a test series
$V_{u,Group}^{t}$	=	ultimate shear load in a group test
$V_{u,Group,m}$	=	mean ultimate shear load in a group test series
n	=	number of tests of a test series
n_{red}	=	number of fasteners in the fastener group
v	=	coefficient of variation
α_{seis}	=	reduction factor under seismic loading
V_{Rk}	=	characteristic fastener resistance under shear force

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 product 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	Characteristic resistance of Fastening type 1 and 2	EAD 330083-04-0601, clause 2.2.1	Level F_{Rk} [kN], $M^0_{Rk,s}$ [Nm], c_{min} [mm], s_{min} [mm], h_{min} [mm], h_{ef} [mm] N_{Rk} [kN] (only for fasteners and ceiling hangers made of metal under tension loading)
2	Displacements of Fastening type 1 and 2	EAD 330083-04-0601, clause 2.2.2	Level δ_{N0}, δ_{V0}. $\delta_{N\infty}$, $\delta_{V\infty}$ [mm]
3	Maximum service load of Fastening type 3	EAD 330083-04-0601, clause 2.2.3	Level $N_{s,max}$ [kN], $V_{s,max}$ [kN], h_{ef} [mm], n_1 [-], span [mm], number of gaps for local failure, number of gaps for serviceability limit state.
4	Characteristics resistance of Fastening type 4	EAD 330083-04-0601, clause 2.2.4	Level V_{Rk} [kN], c_{min} [mm], s_{min} [mm], h_{min} [mm], h_{ef} [mm], $\min t_{fix}$ [mm].
5	Characteristic out of plane seismic shear resistance of Fastening type 4	2.2.1	Level $V_{Rk,s,eq}$ [kN], $V_{Rk,c,eq,20/25}$ [kN], $V_{Rk,c,eq,max}$ [kN], $V_{Rk,p,eq,20/25}$ [kN], $V_{Rk,c,eq,max}$ [kN]
Basic Works Requirement 2: Safety in case of fire			
6	Reaction to fire	EAD 330083-04-0601, clause 2.2.5	Class
7	Resistance to fire Fastening types 1 and 2	EAD 330083-04-0601, clause 2.2.6	Level Fasteners and fixtures made of metal: $F_{Rk,fi}$ [kN], $M^0_{Rk,s,fi}$ [N·m], $c_{min,fi}$ [mm], $s_{min,fi}$ [mm] Fixtures made of plastic: not specified in this version of EAD
8	Resistance to fire Fastening type 4	EAD 330083-04-0601, clause 2.2.7	Level Fasteners and fixtures made of metal: $V_{Rk,fi}$ [kN], $c_{min,fi}$ [mm] Insulation made of PE-Foam or other specific material: not specified in this version of EAD
Aspects of durability			
9	Durability	EAD 330083-04-0601, clause 2.2.8	Description

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

EAD 330083-04-0601, Clause 2.2 applies.

2.2.1 Characteristic out of plane seismic shear resistance of Fastening type 4

Assessment method

Characteristic out of the plane seismic shear resistance of Fastening type 4 shall be assessed applying both of the following tests:

- Static out of plane reference shear tests in low and high strength concrete (see clause 2.2.1.1) and
- Seismic out of plane shear resistance in low and high strength concrete (see clause 2.2.1.2).

Expression of results

$V_{Rk,s,eq}\ [kN], V_{Rk,c,eq,C20/25}\ [kN], V_{Rk,c,eq,max}\ [kN], V_{Rk,p,eq,C20/25}\ [kN], V_{Rk,p,eq,max}\ [kN]$ shall be stated in the ETA.

2.2.1.1 Static out of plane reference shear tests in low and high strength concrete (basic test series A21 and A22)

Purpose of the assessment

These tests are performed to determine the force V_{max} for use in A23 and A24 cyclic tests under out of plane shear loading in drywall partition tracks without edge influence.

Test series A21 and A22 may be omitted if tests A17 and A18 according to EAD 330083-04-0601, Table 2.2.4.2.1 are performed in slabs coming from the same concrete batch as slabs used for performing test series A23 and A24. In this case and if the condition on the minimum number of fasteners in the fastener group n_{red} is fulfilled, test series A17 and A18 can replace test series A21 and A22 respectively.

Test conditions

Tests shall be performed according to Annex B.2.2.

The tests shall be performed in cracked concrete with the minimum strength class C20/25 and the maximum strength class as defined in the Manufacturer's Product Installation Instructions (MPII), as given in Annex A, Table A.1.1, lines A21 to A22.

If several track thicknesses are considered in the MPII, tests in low and high strength concrete shall be performed with at least the minimum track thickness.

In case of single fastener failure at installation in a group of fasteners, the test may be performed with a reduced number of fasteners in this group n_{red} ≥ 4.

Assessment method

The following assessment shall be made for each fastener size, for each embedment depth and track thickness:

Failure Loads:

- Determine $V^t_{u,A21,group}$ or $V^t_{u,A22,group}$, for the group of fasteners
- Determine $V^t_{u,A21}$ or $V^t_{u,A22}$, per fasteners as:

$$V^t_{u,A21} = V^t_{u,A21,group} \,/\, n_{red} \quad (2.2.1.1.1)$$

$$V^t_{u,A22} = V^t_{u,A22,group} \,/\, n_{red} \quad (2.2.1.1.2)$$

- Determine the mean ultimate failure load $V^t_{u,A21,m}$ or $V^t_{u,A22,m}$ [kN], from the group of fasteners.

- Verify the coefficient of variation of failure loads. If the coefficient of variation exceeds 20% ($v_u[\%]$ > 20), determine the reduction factor for large scatter $\alpha_{v,A21}$ or $\alpha_{v,A22}$ according to A.2.1.

Where:

$V^t_{u,A21,group}$	mean ultimate shear capacity of a group of fasteners from reference test series A21	[N]
$V^t_{u,A22,group}$	mean ultimate shear capacity of a group of fasteners from reference test series A22	[N]
$V^t_{u,A21,m}$	mean ultimate shear capacity per fasteners from reference test series A21	[N]
$V^t_{u,A22,m}$	mean ultimate shear capacity per fasteners from reference test series A22	[N]
n_{red}	number of fasteners in the group, minus fasteners clearly identified as an installation failure prior to the test (i.e., the fastener was removed by hand)	[-]

2.2.1.2 Seismic out of plane shear resistance in low and high strength concrete (test series A23 and A24)

Purpose of the assessment

These tests are performed to determine the mean ultimate out of plane seismic shear capacity of power actuated fasteners for use in drywall partition track without edge influence and thereby to establish the influence factor α_{seis} ≤ *1,0* to be applied to the characteristic static load stated in the ETA and determined according to EAD 330083-04-0601, Clause 2.2.4.4.

Test conditions

Tests shall be performed according to Annex B.2.3

Seismic tests A23 and A24 shall be carried out with the same minimum number of fasteners in the fastener group n_{red} and the same testing conditions as the reference tests described in 2.2.1.1.
If several track thicknesses are considered in the MPII, tests in low and high strength concrete shall be performed at least with the minimum thickness.

The tests shall be performed in cracked concrete with the minimum strength class C20/25 and the maximum strength class as defined in the Manufacturer's Product Installation Instructions (MPII), as given in Annex A, Table A.1.1, lines A23 and A24.

Depending on the failure mode observed in tests A21 or A22, value for V_{max} shall be determined as follows:

Track / steel or mixed failure:

$$V_{max,A23,group} = 0{,}50 \cdot n_{red} \cdot V^t_{u,A21,m} \cdot \left(\frac{f_{u,A23}}{f_{u,A21}}\right) \quad (2.2.1.2.1)$$

$$V_{max,A24,group} = 0{,}50 \cdot n_{red} \cdot V^t_{u,A22,m} \cdot \left(\frac{f_{u,A24}}{f_{u,A22}}\right) \quad (2.2.1.2.2)$$

Concrete or pull-out failure:

$$V_{max,A23,group} = 0{,}50 \cdot n_{red} \cdot V^t_{u,A22,m} \quad (2.2.1.2.3)$$

$$V_{max,A24,group} = 0{,}50 \cdot n_{red} \cdot V^t_{u,A21,m} \quad (2.2.1.2.4)$$

Where:

$f_{u,A21}$	mean ultimate steel strength of tracks used in the test series A21	[N/mm²]
$f_{u,A22}$	mean ultimate steel strength of tracks used in the test series A22	[N/mm²]
$f_{u,A23}$	mean ultimate steel strength of tracks used in the test series A23	[N/mm²]
$f_{u,A24}$	mean ultimate steel strength of tracks used in the test series A24	[N/mm²]
n_{red}	number of fasteners in the group, minus fasteners clearly identified as an installation failure prior to the test (i.e., the fastener was removed by hand)	[-]

Assessment method

The following assessment shall be done for each tested fastener size and for each tested embedment depth:

Failure Loads:

- Determine the mean ultimate failure load $V^t_{u,A23,m}$ or $V^t_{u,A24,m}$ [kN], from the group of fasteners.
- Verify the coefficient of variation of failure loads. If the coefficient of variation exceeds 20% (v_u[%] > 20), determine the reduction factor for large scatter $\alpha_{v,A23}$ or $\alpha_{v,A24}$ according to equation (A.2.1.1).
- Determine the reduction factor $\alpha_{seis,A23}$ according to equation (2.2.1.2.5) or $\alpha_{seis,A24}$ according to equation (2.2.1.2.6). Test series A21 and A22 or A17 and A18 are used as the corresponding reference test series, see Table A.1.1.
- After the cyclic tests, the fastener group shall not fail, and the mean ultimate residual shear capacity after the cyclic shear test shall be 160% of V_{max}. If the fastener group fails, the test series shall be repeated with a reduced value $V_{max,red}$ until no failure is observed after cycles, and 160% of $V_{max,red}$ are achieved.

$$\alpha_{seis,A23} = \frac{V_{max,red,A23}}{V_{max,A23}} \leq 1{,}0 \qquad (2.2.1.2.5)$$

$$\alpha_{seis,A24} = \frac{V_{max,red,A24}}{V_{max,A24}} \leq 1{,}0 \qquad (2.2.1.2.6)$$

- Steel failure of the fastener under seismic shear load without lever arm:

The characteristic resistance $V_{Rk,s,eq}$ shall be determined for the cross-section of fastener as follows:

$$V_{Rk,s,eq} = \alpha_{steel} \cdot A_{s1} \cdot f_{uk} \qquad (2.2.1.2.7)$$

Where

α_{steel}	0,5	[-]
A_{s1}	Stressed cross-section of the fastener	[mm²]
f_{uk}	Characteristic tensile strength of the fastener	[N/mm²]

- Concrete failure or pull-out failure under shear load:

In case test series A21 and A22 are omitted, the characteristic resistances of single fasteners under shear loading shall be calculated as follows:

$$V_{Rk,c,eq,C20/25} = V_{Rk,p,eq,C20/25} = min\,(;V_{Rk,0,20}) \cdot min\,\alpha_v \cdot \alpha_{v,A23} \cdot \alpha_{seis,A23} \qquad (2.2.1.2.8)$$

$$V_{Rk,c,eq,max} = V_{Rk,p,eq,max} = min\,(V_{Rk,0,18}; V_{Rk,0,20}) \cdot min\,\alpha_v \cdot \alpha_{v,A24} \cdot \alpha_{seis,A24} \qquad (2.2.1.2.9)$$

In case test series A21 and A22 are carried out, the characteristic resistances of single fasteners under shear loading shall be calculated as follows:

$$V_{Rk,c,eq,C20/25} = V_{Rk,p,eq,C20/25} = \min\left(V_{Rk,0,21}; V_{Rk,0,20}\right) \cdot min\,\alpha_v^* \cdot \min\,(\alpha_{v,A21}; \alpha_{v,A23}) \cdot \alpha_{seis,A23} \qquad (2.2.1.2.10)$$

$$V_{Rk,c,eq,max} = V_{Rk,p,eq,max} = \min\,(V_{Rk,0,22}; V_{Rk,0,20}) \cdot min\,\alpha_v^* \cdot \min\,(\alpha_{v,A22}; \alpha_{v,A24}) \cdot \alpha_{seis,A24} \qquad (2.2.1.2.11)$$

Where

$V_{Rk,0,17}$ shear capacity per fastener under static loading in C20/25 concrete determined according to EAD 330083-04-0601, clause 2.2.4.4.

$V_{Rk,0,18}$ shear capacity per fastener under static loading in maximum concrete class concrete determined according to EAD 330083-04-0601, clause 2.2.4.4.

$V_{Rk,0,20}$ shear capacity per fastener under static loading in case of metal track failure determined according to EAD 330083-04-0601, clause 2.2.4.4.

$min\ \alpha_v$ minimum α_v to consider a coefficient of variation of the ultimate loads in the functioning and basic tests larger than 20% according to EAD 330083-04-0601, clause 2.2.4.4.

$min\ \alpha_v^*$ minimum α_v to consider a coefficient of variation of the ultimate loads in the functioning and basic tests larger than 20% according to EAD 330083-04-0601, clause 2.2.4.4, excluding reduction due to respectively test series 17 or test series 18.

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

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

EAD 3300083-04-0601, Clause 3.1 applies.

3.2 Tasks of the manufacturer

EAD 3300083-04-0601, Clause 3.2 applies.

3.3 Tasks of the notified body

EAD 3300083-04-0601, Clause 3.3 applies.

4 REFERENCE DOCUMENTS

[1]	EAD 330083-04-0601	Power-actuated fastener in concrete and fixtures for redundant non-structural applications
[2]	EN 1998-1:2004 + A1:2013	Eurocode 8 – Design of structures for earthquake resistance - Part 1: General rules, seismic actions and rules for buildings
[3]	EAD 330232-01-0601	Mechanical fasteners for use in concrete

ANNEX A: TEST PROGRAM AND GENERAL ASPECTS OF ASSESSMENT

A.1 Test program

The test programme presented in this Annex is applicable only to essential characteristic “Characteristic out of plane seismic shear resistance of fastening type 4”.

Table A.1.1: Test program for fixed track connections or deflection heads[1)]

No	Purpose of test	Concrete	Crack width Δw (mm)	Track thickness (mm)	Load direction	Number of tests	Clause	Reference test
Basic shear tests								
A21	Static out of plane reference shear tests in low strength concrete	C20/25	0,2	$\min t_{fix}$	V	5/20[3)]	2.2.1.1	-
A22	Static out of plane reference shear tests in high strength concrete	max[2)4)]	0,2	$\min t_{fix}$	V	5/20[3)]	2.2.1.1	-
Seismic shear tests								
A23	Seismic out of plane shear resistance in low strength concrete (cyclic test)	C20/25	0,5	$\min t_{fix}$	V	5/20[3)]	2.2.1.2	A21
A24	Seismic out of plane shear resistance in high strength concrete (cyclic test)	max[2)4)]	0,5	$\min t_{fix}$	V	5/20[3)]	2.2.1.2	A22

1) In case of testing deflection heads, the shear force shall be introduced at a maximum distance “a” from the concrete.

2) If there is an application for anchorage in concrete strength class less than C50/60 only; tests are required in concrete with a compressive strength $f_{ck,test} \geq f_{ck,used}$ + 20 N/mm² (in case of C20/25) and $f_{ck,test} \geq f_{ck,used}$ + 10 N/mm² (in case of C40/50), $f_{ck,test} \geq f_{ck,used}$ + 5 N/mm² (in case of C50/60), interim values can be interpolated linear.

3) 5 fastener group tests or 20 single fastener tests shall be tested.

4) Highest concrete strength class (not larger than C50/60) for which the assessment is done.

A.2 General assessment methods

A.2.1 Criteria regarding scatter of failure loads

The calculated coefficient of variation of the ultimate load shall be smaller than 20%, otherwise a reduction factor α_v for each test series shall be calculated according to Equation (A.2.1.1).

$$\alpha_v = {}^{1}/_{(1 + 0{,}03 \cdot (v_u[\%] - 20))} \quad \text{(A.2.1.1)}$$

with:

$v_u[\%]$ = coefficient of variation of ultimate load

The smallest value of α_v shall be considered for the assessment of the characteristic resistance, clause 2.2.4.

ANNEX B: DETAILS OF TESTS FOR POWER ACTUATED FASTENERS

B.1 Scope

This Annex provides details for tests with power actuated fasteners in concrete. It is applicable only to essential characteristic “Characteristic out of plane seismic shear resistance of fastening type 4”.

B.2 Details of tests

B.2.1 Test members

B.2.1.1 General

Provisions for all test series

Tests shall be performed on groups of 5 or in case of installation failure at least n_{red} fasteners. Metal tracks with a tensile strength of R_m ≥ 260 N/mm², fixture thickness t_{fix} representative for the intended application shall be used.
Before installing a group test, the friction force due to the weight of the test frame needs to be measured and detracted from the test result.

The anchorage depth of each fastener shall be measured in all tests of each test series.

B.2.2 Shear tests under static loading

The shear tests shall be carried out on concrete members according to EAD 330232-01-0601, B.3.1.2. In addition, the following applies:
After installation of the fasteners, track is connected to the test rig and is then tested. The crack widths shall be measured at a distance of 2 x h_{ef} behind the fastener. The load shall be applied in the direction of the cracks.
If the fastener is assessed for different embedment depths for a specific diameter, the most unfavourable condition leading to the lowest assessed characteristic resistance according to EAD 330083-04-0601, clause 2.2.4.4, shall be tested. If the most unfavourable condition cannot be determined all embedment depths shall be tested.
Fastener installation for group tests with metal tracks shall be executed one after the other as follows:

- Position of the fixture to the intended location of concrete cracks;
- Drive power-actuated fasteners: The power-actuated fastening tool shall be positioned such, that the fastener is driven into the line of expected cracks in the middle of the fixture. The spacing between the fasteners shall be reported.
- Identified installation failure shall be reported and fastener shall be removed;
- Develop 5 continuous unidirectional hair-cracks e.g., by means of steel wedges;

After fastener installation, the test set up shall be continued as follows:

- Displacement sensors to measure the crack width shall be attached both sides of every fastener, with the fastener located in the middle between the displacement transducers.
- Zero sensors for crack width measurement.
- Open of the crack e.g., by means of steel wedges till the target crack-width Δw is reached. The crack width shall be determined per fastener and calculated as the average crack width of the readings from the displacement sensors located left and right of the power-actuated fastener.

The cross beam of the test frame shall be fixed by screws and free of clearance to the metal track. Free movement of the fasteners shall be ensured, see Figure B.2.3.1 for fixed connections or B.2.4.1 for deflection heads, Detail A-A.

For deflection heads, the shear forces shall be applied to the track with *a* = 20 mm.

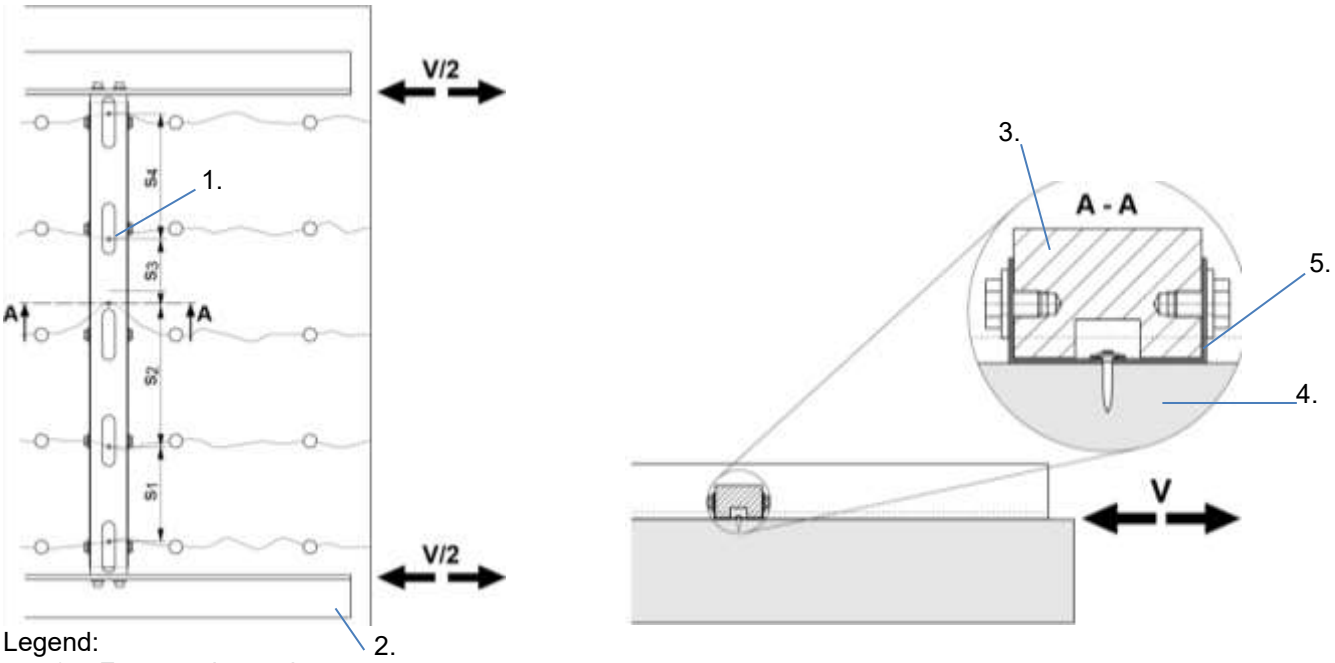
Test shall be performed until maximum load is reached.

The orientation of the shear force shall be parallel to the cracks.

B.2.3 Shear tests under cyclic out of plane loading for fixed connections

Fastener installation, set up and crack opening shall be performed in the same way as described in clause B.2.2.

The test set up is shown in Figure B.2.3.1.



Legend:
1. Fastener in crack
2. Loading rail
3. Cross head / adapter
4. Concrete
5. Track

Figure B.2.3.1 Group test setup (schematic) for fixed connections

Test shall be performed as cyclic tests with the following test protocol, with a cycling frequency between 0,1 and 2,0 Hz, according to Figure B.2.3.2 and Table B.2.3.1.

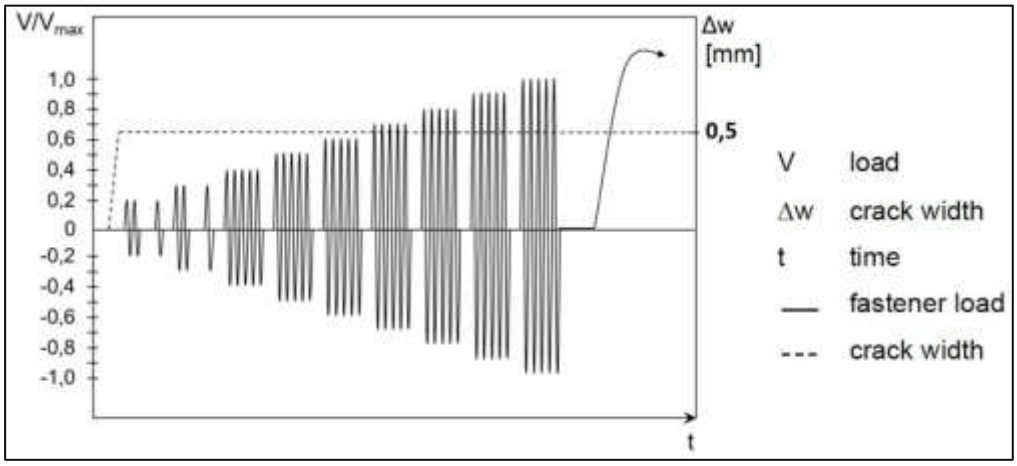


Figure B.2.3.2 Schematic test procedure, test series A23 and A24

Table B.2.3.1 Schematic test procedure, test series A23 and A24

$\pm V / V_{max}$	Number of cycles	Crack width Δw [mm]
0,2	25	0,5
0,3	15	0,5
0,4	5	0,5
0,5	5	0,5
0,6	5	0,5
0,7	5	0,5
0,8	5	0,5
0,9	5	0,5
1,0	5	0,5
SUM	75	0,5

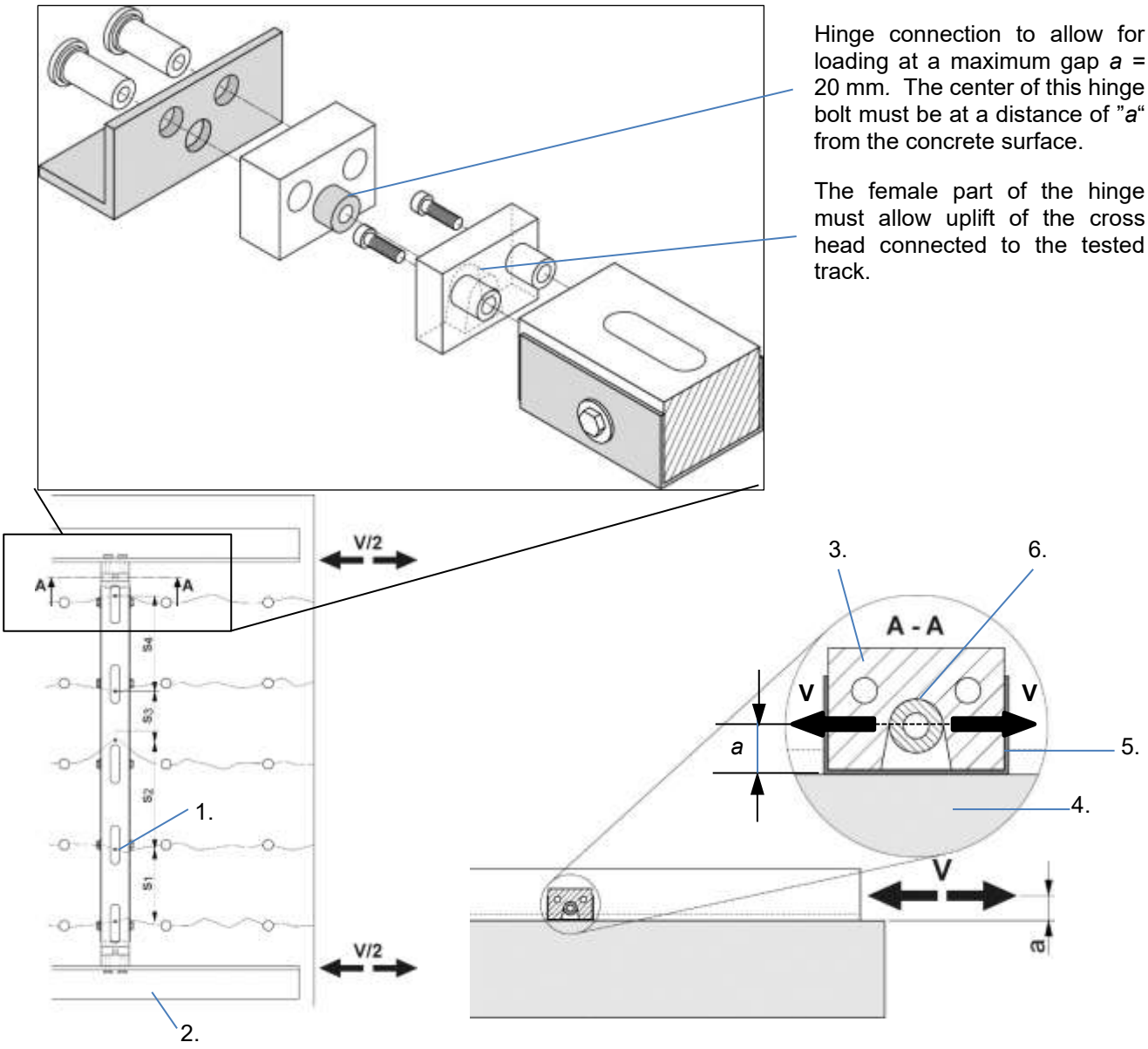
Upon completion of the required 75 cycles, the test shall be stopped, and the cross head shall be unloaded and moved to the initial position.
After that, the displacement measurement shall be zeroed and a monotonic test shall be carried out, testing the specimen to failure. The ultimate failure load after the monotonic test shall be recorded and the mean ultimate failure load $V^t_{u,m,A23}$ or $V^t_{u,m,A24}$ shall be determined. Maintain a crack width of 0,5 mm throughout the cyclic and monotonic tests.

B.2.4 Shear tests under cyclic out of plane loading for deflection heads with *a* = 20 mm .

Fastener installation, set up and crack opening shall be performed in the same way as described in clause B.2.2.

Test shall be performed as cyclic tests in accordance with clause B.2.3. but on deflection heads with *a* = 20 mm.

The test set up is shown in Figure B.2.4.1. The test set up shall be designed to introduce forces at a distance a from the concrete surface, allow for rotation of the track and cross head, and minimize the vertical forces caused by weight of the set up on the track connection.



Legend:

1. Fastener in crack
2. Loading rail
3. Cross head / adapter
4. Concrete
5. Track
6. Hinge connection

Figure B.2.4.1 Group test setup (schematic) for deflection heads