HILTI HST4-R Expansion Anchor

MFPA Fire Assessment

GS 6.1/22-065-3-r1 (30.11.2023)

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Object:	Assessment of the load bearing behaviour of Hilti HST4-R expansion anchors under tensile load and one-sided fire loading according to the ZTV-ING curve - abbreviated version
Client:	**Hilti Corporation** Feldkircherstraße 100 9494 Schaan Liechtenstein
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This document covers 10 pages, including 0 appendices.

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1 Objective and request

MFPA Leipzig GmbH was ordered by Hilti Corporation to assess the load bearing behaviour of Hilti HST4-R expansion anchors under tensile load and one-sided fire loading according to the ZTV-ING curve (see [N1]) basing on experimental results.
The assessment covers the failure mode "steel failure".
The present document includes a summary of the design concept for fire design and the associated characteristic load-bearing capacities. For a detailed derivation of the performance properties, please refer to [G1].

2 Description of the construction

Hilti HST4 and HST4-R expansion anchors are metal fasteners for anchorage in concrete structures, consisting of a bolt, expansion sleeve, hexagon nut or dome nut and washer with or without additional filling set. With ETA-21/0878 [P1] a current European Technical Assessment is available for Hilti expansion anchors HST4-R.
Anchorage is produced by means of force-controlled expansion of the expansion sleeve within the zylindrical drilled hole. According to the manufacturer, Hilti HST4 and HST4-R expansion anchors are intended for use under static and quasi-static loading in reinforced and unreinforced normal concrete of the strength class of at least C20/25 and at most C50/60 according to [N2].
The geometry of the expansion anchors is specified in Figure 1. Figure 2 shows the installation parameters for the different anchor versions of expansion anchors HST4-R.

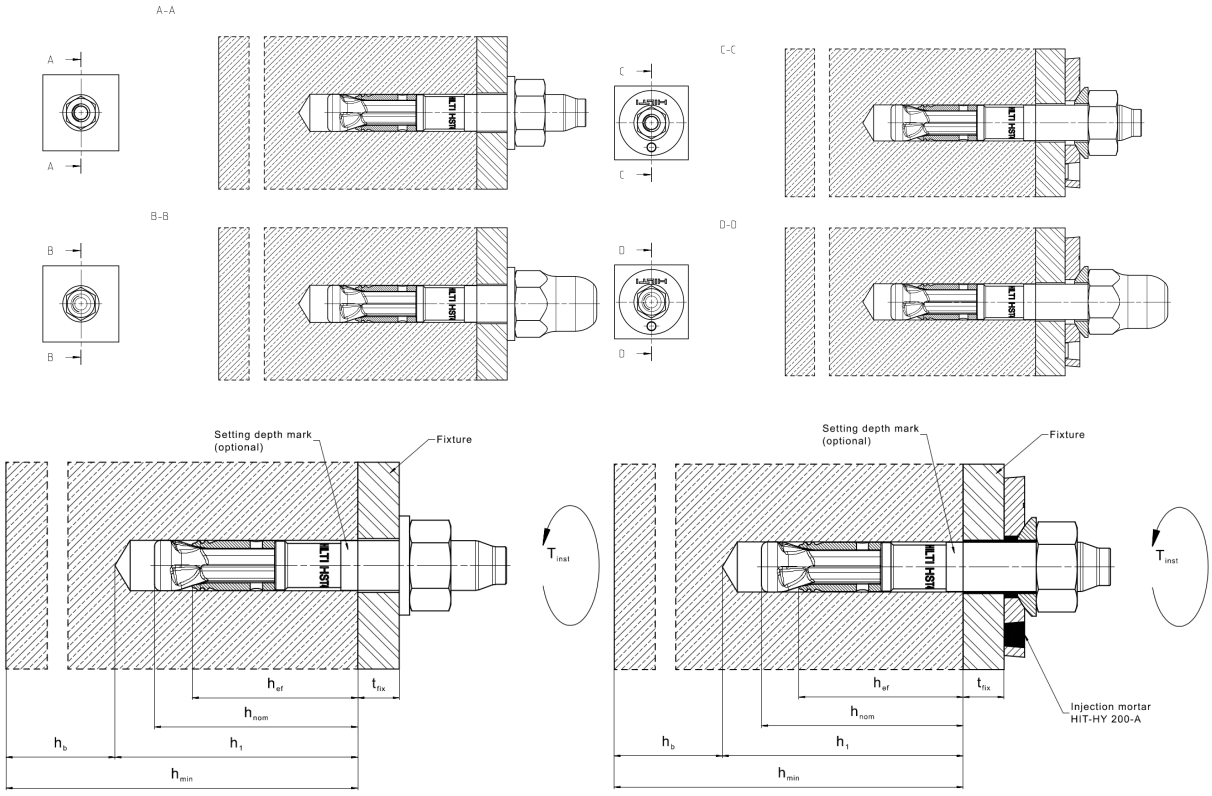

Figure 1: Hilti expansion anchors HST4 and HST4-R: Geometry in the installed state; left: without additional filling set, right: with additional filling set, provided by the client

Table B5: Installation parameters HST4-R

HST4-R			M8	M10	M12	M16	M20
Nominal diameter of drill bit	d_0	[mm]	8	10	12	16	20
Max. cutting diameter of drill bit	d_{cut}	[mm]	8,45	10,45	12,50	16,50	20,55
Max. diameter of clearance hole in the fixture	d_f	[mm]	9	12	14	18	22
Effective anchorage depth	h_{ef}	[mm]	30 - 90	30 - 100	40 - 125	65 - 160	101 - 180
Nominal embedment depth	h_{nom}	[mm]	h_{ef} + 6	h_{ef} + 8	h_{ef} + 9	h_{ef} + 12	h_{ef} +15
Min. depth of drill hole (hammer drilled, not cleaned)	$h_1 \geq$	[mm]	h_{ef} + 26	h_{ef} + 28	h_{ef} + 29	h_{ef} + 32	h_{ef} +35
Min. depth of drill hole (hammer drilled, cleaned)	$h_1 \geq$	[mm]	h_{ef} + 9	h_{ef} + 12	h_{ef} + 13	h_{ef} + 18	h_{ef} +23
Min. depth of drill hole (hollow drill bit drilled boreholes)	$h_1 \geq$	[mm]	-	-	h_{ef} + 13	h_{ef} + 18	h_{ef} +23
Min. depth of drill hole (diamond cored boreholes)	$h_1 \geq$	[mm]	h_{ef} + 16	h_{ef} + 18	h_{ef} + 19	h_{ef} + 22	h_{ef} +25
Min. thickness of concrete member [2]	$h_{min} \geq$	[mm]	max (80; 1,5 · h_{ef})	max (80; 1,5 · h_{ef})	max (100; 1,5 · h_{ef})	max (120; 1,5 · h_{ef})	max (160; 1,5 · h_{ef})
Minimum concrete thickness below borehole bottom [2]	$h_b \geq$	[mm]	21	27	32	34	36
Width across flats	SW	[mm]	13	17	19	24	30
Installation torque	T_{inst}	[Nm]	20	40	60	120	180

[1] For the design of bigger clearance holes in the fixture see EN 1992-4:2018.
[2] Under consideration of minimum concrete thickness below borehole bottom: $h_{min} \geq h_1 + h_b$

Figure 2: Hilti expansion anchors HST4-R: Installation parameters, from [P1]

In the course of installation of the expansion anchors, the manufacturer's instructions have to be obeyed.
The Hilti expansion anchors HST4 and HST4-R are manufactured using the materials (see also Figure 3)

- HST4: galvanized steel,
- HST4-R: stainless steel A4.

Each type is available in sizes M8, M10, M12, M16 and M20 and different length.

Table A2: Materials, Hilti HST4-R

Designation	Material
HST4-R **Corrosion resistance class III according EN 1993-1-4:2006+A1:2015**	
Expansion sleeve	Stainless steel A4 according to EN 10088-1:2014
Bolt	Stainless steel A4 according to EN 10088-1:2014 Rupture elongation (l_0 = 5d) > 8 %
Washer	Stainless steel A4 according to according to EN 10088-1:2014
Hexagon nut Dome nut	Stainless steel A4 according to EN 10088-1:2014
Filling set **Corrosion resistance class III according EN 1993-1-4:2006+A1:2015**	
Sealing washer	Stainless steel A4 according to EN 10088-1:2014
Spherical washer	Stainless steel A4 according to EN 10088-1:2014
Mortar	
Injection mortar	Injection mortar Hilti HIT-HY...

Figure 3: Hilti expansion anchors HST4 and HST4-R: Utilized materials, from [P1]

The advisory opinion at hand covers expansion anchors HST4-R M8 to M20 with hexagon nut without additional filling set.

3 References

3.1 Utilized guidelines, rules and standards

The analyses are based on the following guidelines, rules and standards:

[N1] Zusätzliche Technische Vertragsbedingungen und Richtlinien für Ingenieurbauten, ZTV-ING: Teil 5, Tunnelbau – Bundesanstalt für Straßenwesen, Stand: 2018/01

[N2] DIN EN 206:2021-06: Concrete - Specification, performance, production and conformity; German version EN 206:2013+A2:2021

[N3] EAD 330232-01-0601: Mechanical fasteners for use in concrete; 12/2019

[N4] DIN EN 1992-4:2019-04: Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete; German version EN 1992-4:2018

[N5] DIN EN 1992-1-2:2010-12: Eurocode 2: Design of concrete structures - Part 1-2: General rules - Structural fire design; German version EN 1992-1-2:2004 + AC:2008

3.2 Reference documents

The analyses are based on the following additional documents:

3.2.1 ETAs and verifications of applicability

[P1] ETA-21/0878: Hilti HST4-R, Torque-controlled expansion anchor, made of stainless steel, for use in concrete: sizes M8, M10, M12, M16 and M20 – Centre Scientifique et Technique du Bâtiment, 25.10.2023

3.2.2 Assessment and test reports

[G1] Gutachterliche Stellungnahme Nr. GS 6.1/22-065-2-r1: Bewertung des Tragverhaltens von Hilti HST4-R Spreizankern unter zentrischem Zug und einseitiger Brandbeanspruchung gemäß der ZTV-ING-Kurve – MFPA Leipzig GmbH; 30.11.2023

4 Assessment of the performance

4.1 Design concept

The products described above fall within the scope of EAD 330232-01-0601 [N3]. In [N3], Chapters 2.2.18, 2.2.19 and 2.2.20 the experimental determination of the fire resistance for

- tensile loading and steel failure,
- tensile loading and pull-out failure and
- shear loading and steel failure

is described. In addition, DIN EN 1992-4 [N4] is a technical standard that allows hot design of mechanical anchors in concrete structures using simplified calculation methods.
The verification methods described in [N3, N4] are designed for fire exposure using the standard temperature-time curve. From an expert's point of view, however, the same qualitative failure mechanisms are to be expected for a fire exposure with the ZTV-ING curve.
According to the client's request, tests basing on [N3], Chapter 2.2.18 were carried out to determine the fire resistance to steel failure $N_{Rk,s,fi}$ under tensile loading.

4.2 Load bearing capacity in case of fire

The characteristic load bearing capacity $N_{Rk,s,fi}$ for steel failure under fire loading by the ZTV-ING curve as well as the minimum embedment depth h_{ef} are shown in Table 1.

anchor	h_{ef} $[mm]$	$N_{Rk,s,fi}$ $[kN]$
HST4-R M8	≥ 40	0.60
HST4-R M10	≥ 40	1.05
HST4-R M12	≥ 50 ≥ 70	1.75 2.75
HST4-R M16	≥ 65 ≥ 85	3.80 4.50
HST4-R M20	≥ 117	4.50

Table 1: Hilti expansion anchors HST4-R: Characteristic load bearing capacity $N_{Rk,s,fi}$ $[kN]$ for steel failure and fire loading according to the ZTV-ING curve

5 Special notes

The advisory opinion at hand is valid for Hilti expansion anchors HST4-R with hexagon nut and without additional filling set which are installed according to the manufacturer's instructions. The mechanical loading must not exceed the load bearing capacity in ambient climate.

The load bearing capacities specified in the framework of the document at hand are determined for one-sided fire loading according to the ZTV-ING curve. According to [N4], Annex D.1(5) the values may also be used for multilateral fire loading when the edge distance of the fastener is $c \geq 300mm$ and $c \geq 2 \cdot h_{ef}$.

The load bearing capacities for steel failure specified in the framework of the document at hand are determined for centrical tensile loading in the anchor's longitudinal direction. Following [N3], on the safe side, a transfer is possible to steel failure under tensile loads perpendicular and oblique to the anchor axis. Failure modes affecting the substrate in centrical as well as transverse and oblique tension, such as pull-out failure, concrete cone failure and concrete edge failure, shall be verified separately (cf. [N4]).

The assessment at hand is valid for constructions of reinforced or unreinforced normal concrete of the strength class $\geq$ C20/25 and $\leq$ C50/60 according to [N2], which exhibit at least the same fire resistance class as the utilized anchors. The design of the concrete construction has to be carried out according to [N5].

The load bearing capacities specified in the framework of the document at hand are determined assuming that no explosive concrete spalling occurs and are only valid under this condition. Evidence on the prevention of explosive concrete spalling is given in [N5], Chapter 4.5.

6 Signatures

This document does not replace a certificate of constancy of performance or suitability according to national and European building codes.

Leipzig, 30.11.2023

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