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Engineering Judgment

120-year bonded anchor assessment
of
Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3
based on
EAD 330499-02-0601 Edition 12/2023

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1. General

This document provides characteristic bond strength values, ψ^0_{sus}-factors and displacements under tension load for the Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 bonded fastener for a working life of 120 years for temperature range I (24°C long-term/40°C short-term), temperature range II (50°C long-term/80°C short-term) and temperature range III (72°C long-term/120°C short-term). There is a valid European Technical Assessment ETA-19/0601 for the injection system Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 dated from 29th January 2024 based on the European Assessment Document EAD 330499-02-0601 Edition 12/2023 for a working life of 50 years and 100 years for static and quasi-static loading, fire exposure and seismic loading situations.

The bond strength values, ψ^0_{sus}-factors and displacements given in this document expand on European Technical Assessment ETA-19/0601 dated from 29th January 2024, which includes characteristic bond strength values, ψ^0_{sus}-factors and displacements up to a working life of 100 years in accordance with European Assessment Document EAD 330499-02-0601, Edition 12/2023. EAD 330499-02-0601, Annex C provides assessment criteria to extend the working life up to 100 years based on the maximum Working Life Category 5 in Eurocode EN 1990.

The 120-year characteristic bond strength values, ψ^0_{sus}-factors and displacements in this report follow the same rationale used for the extension for 100 years, including extension of sustained load tests at normal ambient and maximum long-term temperature (test series B14 and B15 according to EAD 330499-02-0601) to assess the long-term behaviour in uncracked concrete, as well as extrapolated crack cycling tests under sustained load (test series B13) to evaluate the long-term behaviour in cracked concrete.

The provided characteristic bond strength values, ψ^0_{sus}-factors and displacements under tension load are based on sustained load tests conducted for linearly scaled up requirements in terms of test duration and an evaluation of the measured displacements for an extended extrapolation period.

In order to assess the test results from a working life of **100 years to 120 years**, the displacements from sustained load tests are extrapolated up to 120 years for tests at normal ambient temperature and up to 24 years for sustained load tests at maximum long-term temperature.

The displacements of crack cycling tests are extrapolated from 2.000 measured cycles for 100 years up to 2.400 cycles for a working life of 120 years.

The assessed values are based on the present state of knowledge about the long-term degradation behaviour of the used bonding material. Therefore, the long-term behaviour

and robustness of the adhesive has to be guaranteed by the quality standards of the manufacturer!

Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 are assessed with three different types of steel elements (threaded rods, Hilti Tension Anchors and rebars) in various sizes. Consequently, the proposed characteristic bond strength values, ψ^0_{sus}-factors and displacements under tension load for a working life of 120 years are provided in separate tables for the different steel elements following the structure of ETA-19/0601.

2. Assessment of the long-term bond strength values, ψ^0_{sus}-factors and displacements under tension load of Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 for a working life of 120 years

2.1. Proposed values under static and quasi-static loading situations

2.1.1. Proposed characteristic bond strength values

The Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 bonded fastener is intended for use in uncracked and cracked concrete in combination with threaded rods in the sizes M8 to M30, with Hilti Tension Anchors HZA / HZA-R from sizes M12 to M27 and with rebars from sizes Ø8 to Ø32.

The 120-year characteristic bond strength values for uncracked and cracked concrete of strength class C20/25 for temperature range I (24°C long-term/40°C short-term), temperature range II (50°C long-term/80°C short-term) and temperature range III (72°C long-term/120°C short-term) are separated for the different steel element types in the following Tables 1 to 3.

Additional essential characteristics (e.g., partial factors, edge distances, spacings, etc.) remain the same as in ETA-19/0601 provided and can be found in the corresponding tables for each steel element.

Table 1: Characteristic 120-year bond strength values for uncracked and cracked concrete for temperature ranges I, II and III for Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 with threaded rods

Threaded rods				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Combined pull-out and concrete cone failure for a working life of 120 years											
Characteristic bond resistance in uncracked concrete C20/25 for installation in dry or wet (water saturated) concrete, all drilling methods (HD, HDB, DD + RT)											
Temperature range I:	24°C/40°C	$\tau_{Rk,ucr}$	[N/mm²]	16,8							
Temperature range II:	50°C/80°C	$\tau_{Rk,ucr}$	[N/mm²]	13,8							
Temperature range III:	72°C/120°C	$\tau_{Rk,ucr}$	[N/mm²]	11,8							
Characteristic bond resistance in cracked concrete C20/25 for installation in dry or wet (water saturated) concrete, all drilling methods (HD, HDB, DD + RT)											
Temperature range I:	24°C/40°C	$\tau_{Rk,cr}$	[N/mm²]	6,3	6,4	7,8					
Temperature range II:	50°C/80°C	$\tau_{Rk,cr}$	[N/mm²]	5,3	5,5	6,7					
Temperature range III:	72°C/120°C	$\tau_{Rk,cr}$	[N/mm²]	4,8		5,8					
Characteristic bond resistance in uncracked concrete C20/25 for installation in water-filled drill holes (not sea water), HD and HDB											
Temperature range I:	24°C/40°C	$\tau_{Rk,ucr}$	[N/mm²]	13,8	13,6	13,3	12,8	12,3	11,7	11,2	10,7
Temperature range II:	50°C/80°C	$\tau_{Rk,ucr}$	[N/mm²]	11,7	11,5	11,3	10,9	10,4	9,9	9,6	9,2
Temperature range III:	72°C/120°C	$\tau_{Rk,ucr}$	[N/mm²]	10,0	9,9	9,8	9,4	9,0	8,6	8,2	7,9
Characteristic bond resistance in cracked concrete C20/25 for installation in water-filled drill holes (not sea water), HD and HDB											
Temperature range I:	24°C/40°C	$\tau_{Rk,cr}$	[N/mm²]	5,1	5,1	5,9	5,6	5,3	5,1	4,9	4,6
Temperature range II:	50°C/80°C	$\tau_{Rk,cr}$	[N/mm²]	4,3	4,3	5,0	4,7	4,5	4,3	4,1	3,9
Temperature range III:	72°C/120°C	$\tau_{Rk,cr}$	[N/mm²]	3,7	3,6	4,3	4,0	3,8	3,6	3,5	3,3

Table 2: Characteristic 120-year bond strength values for uncracked and cracked concrete for temperature ranges I, II and III for Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 with Hilti Tension Anchors HZA / HZA-R

Hilti Tension Anchor HZA, HZA-R				**M12**	**M16**	**M20**	**M24**	**M27**
Rebar diameter		Ø	[mm]	12	16	20	25	28
Effective anchorage depth	HZA	h_{ef}	[mm]	h_{nom} - 20				
	HZA-R	h_{ef}	[mm]	h_{nom} - 100				1)
Combined pull-out and concrete cone failure for a working life of 120 years								
Characteristic bond resistance in uncracked concrete C20/25 for installation in dry or wet (water saturated) concrete, all drilling methods (HD, HDB, DD + RT)								
Temperature range I:	24°C/40°C	$\tau_{Rk,ucr}$	[N/mm²]	11,8				
Temperature range II:	50°C/80°C	$\tau_{Rk,ucr}$	[N/mm²]	9,9				
Temperature range III:	72°C/120°C	$\tau_{Rk,ucr}$	[N/mm²]	8,4				
Characteristic bond resistance in cracked concrete C20/25 for installation in dry or wet (water saturated) concrete, all drilling methods (HD, HDB, DD + RT)								
Temperature range I:	24°C/40°C	$\tau_{Rk,cr}$	[N/mm²]	6,7				
Temperature range II:	50°C/80°C	$\tau_{Rk,cr}$	[N/mm²]	5,3				
Temperature range III:	72°C/120°C	$\tau_{Rk,cr}$	[N/mm²]	4,8				
Characteristic bond resistance in uncracked concrete C20/25 for installation in water-filled drill holes (not sea water), HD and HDB								
Temperature range I:	24°C/40°C	$\tau_{Rk,ucr}$	[N/mm²]	11,2				
Temperature range II:	50°C/80°C	$\tau_{Rk,ucr}$	[N/mm²]	9,2				
Temperature range III:	72°C/120°C	$\tau_{Rk,ucr}$	[N/mm²]	8,0				
Characteristic bond resistance in cracked concrete C20/25 for installation in water-filled drill holes (not sea water), HD and HDB								
Temperature range I:	24°C/40°C	$\tau_{Rk,cr}$	[N/mm²]	6,3				
Temperature range II:	50°C/80°C	$\tau_{Rk,cr}$	[N/mm²]	5,0				
Temperature range III:	72°C/120°C	$\tau_{Rk,cr}$	[N/mm²]	4,3				

1) No performance assessed.

Table 3: Characteristic 120-year bond strength values for uncracked and cracked concrete for temperature ranges I, II and III for Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 with rebars

Rebar				**Ø8**	**Ø10**	**Ø12**	**Ø14**	**Ø16**	**Ø20**	**Ø25**	**Ø26**	**Ø28**	**Ø30**	**Ø32**
Diameter of rebar		d	[mm]	8	10	12	14	16	20	25	26	28	30	32
Combined pull-out and concrete cone failure for a working life of 120 years														
Characteristic bond resistance in uncracked concrete C20/25 for installation in dry or wet (water saturated) concrete, all drilling methods (HD, HDB, DD + RT)														
Temperature range I:	24°C/40°C	$\tau_{Rk,ucr}$	[N/mm²]	11,8										
Temperature range II:	50°C/80°C	$\tau_{Rk,ucr}$	[N/mm²]	9,9										
Temperature range III:	72°C/120°C	$\tau_{Rk,ucr}$	[N/mm²]	8,4										
Characteristic bond resistance in cracked concrete C20/25 for installation in dry or wet (water saturated) concrete, all drilling methods (HD, HDB, DD + RT)														
Temperature range I:	24°C/40°C	$\tau_{Rk,cr}$	[N/mm²]	1)	4,8	6,7								
Temperature range II:	50°C/80°C	$\tau_{Rk,cr}$	[N/mm²]	1)	3,8	5,3								
Temperature range III:	72°C/120°C	$\tau_{Rk,cr}$	[N/mm²]	1)	3,3	4,8								
Characteristic bond resistance in uncracked concrete C20/25 for installation in water-filled drill holes (not sea water), HD and HDB														
Temperature range I:	24°C/40°C	$\tau_{Rk,ucr}$	[N/mm²]	1)	11,2									
Temperature range II:	50°C/80°C	$\tau_{Rk,ucr}$	[N/mm²]	1)	9,2									
Temperature range III:	72°C/120°C	$\tau_{Rk,ucr}$	[N/mm²]	1)	8,0									
Characteristic bond resistance in cracked concrete C20/25 for installation in water-filled drill holes (not sea water), HD and HDB														
Temperature range I:	24°C/40°C	$\tau_{Rk,cr}$	[N/mm²]	1)	4,4	6,3								
Temperature range II:	50°C/80°C	$\tau_{Rk,cr}$	[N/mm²]	1)	3,5	5,0								
Temperature range III:	72°C/120°C	$\tau_{Rk,cr}$	[N/mm²]	1)	3,1	4,3								

1) No performance assessed.

2.1.2. Proposed ψ^0_{sus}-factors for the influence of sustained tension loads

In the following Table 4 the proposed ψ^0_{sus}-factors for threaded rods for a working life of 120 years for the three temperature ranges are summarized. The same can be found in Table 5 for steel elements Hilti Tension Anchors and rebars. These ψ^0_{sus}-factors have to be applied for the various sizes of the different steel element types.

Table 4: 120-year ψ^0_{sus}-factors for temperature ranges I, II and III for Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 for threaded rods

Influence of sustained tension load for a working life of 120 years for threaded rods				
Temperature range I:	24°C/40°C	ψ^0_{sus}	[-]	0,80
Temperature range II:	50°C/80°C	ψ^0_{sus}	[-]	0,89
Temperature range III:	72°C/120°C	ψ^0_{sus}	[-]	0,72

Table 5: 120-year ψ^0_{sus}-factors for temperature ranges I, II and III for Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 for Hilti Tension Anchor HZA / HZA-R and rebars

Influence of sustained tension load for a working life of 120 years for HZA / HZA-R and rebars				
Temperature range I:	24°C/40°C	ψ^0_{sus}	[-]	0,80
Temperature range II:	50°C/80°C	ψ^0_{sus}	[-]	0,89
Temperature range III:	72°C/120°C	ψ^0_{sus}	[-]	0,72

2.1.3. Proposed long-term displacements under tension load

Long-term displacements ($\delta_{N\infty}$) for the three different temperature ranges are provided in this section. These displacements represent unit displacements in mm/(N/mm^2) to be multiplied by the design bond stress of the adhesive. The short-term unit displacements (δ_{N0}), which are also given in the ETA are kept constant for a working life of 120 years, due to the fact that they are obtained from short-term pull-out tests at maximum service load and therefore not tied to time-dependent effects.

120-year long-term unit displacements ($\delta_{N\infty}$) are obtained from the additional sustained load tests for uncracked concrete and crack cycling tests for cracked concrete.

Short-term unit displacements (δ_{N0}) and long-term unit displacements ($\delta_{N\infty}$) for uncracked and cracked concrete of strength class C20/25 for temperature range I (24°C long-term/40°C short-term), temperature range II (50°C long-term/80°C short-term) and temperature range III (72°C long-term/120°C short-term) are given in separate tables for the different steel element types in the following Tables 6 to 8.

Table 6: Unit 120-year displacements for uncracked and cracked concrete for temperature ranges I, II and III for Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 with threaded rods

Threaded rods			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
For a working life of 120 years										
Uncracked concrete temperature range I: 24°C/40°C										
Displacement	δ_{N0}	[mm/(N/mm^2)]	0,02	0,03	0,03	0,04	0,06	0,07	0,07	0,08
	$\delta_{N\infty}$	[mm/(N/mm^2)]	0,04	0,05	0,06	0,08	0,10	0,14	0,15	0,17
Uncracked concrete temperature range II: 50°C/80°C										
Displacement	δ_{N0}	[mm/(N/mm^2)]	0,03	0,04	0,05	0,06	0,08	0,09	0,10	0,12
	$\delta_{N\infty}$	[mm/(N/mm^2)]	0,04	0,05	0,06	0,09	0,11	0,14	0,15	0,17
Uncracked concrete temperature range III: 72°C/120°C										
Displacement	δ_{N0}	[mm/(N/mm^2)]	0,04	0,05	0,06	0,08	0,10	0,12	0,13	0,16
	$\delta_{N\infty}$	[mm/(N/mm^2)]	0,04	0,05	0,07	0,09	0,11	0,14	0,15	0,17
Cracked concrete temperature range I: 24°C/40°C										
Displacement	δ_{N0}	[mm/(N/mm^2)]	0,07							
	$\delta_{N\infty}$	[mm/(N/mm^2)]	0,17							
Cracked concrete temperature range II: 50°C/80°C										
Displacement	δ_{N0}	[mm/(N/mm^2)]	0,10							
	$\delta_{N\infty}$	[mm/(N/mm^2)]	0,24							
Cracked concrete temperature range III: 72°C/120°C										
Displacement	δ_{N0}	[mm/(N/mm^2)]	0,13							
	$\delta_{N\infty}$	[mm/(N/mm^2)]	0,31							

Table 7: Unit 120-year displacements for uncracked and cracked concrete for temperature ranges I, II and III for Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 with Hilti Tension Anchors HZA / HZA-R

Hilti Tension Anchor HZA, HZA-R			**M12**	**M16**	**M20**	**M24**	**M27**
Rebar diameter		Ø [mm]	12	16	20	25	28
For a working life of 120 years							
Uncracked concrete temperature range I: 24°C/40°C							
Displacement	δ_{N0}	[mm/(N/mm²)]	0,03	0,04	0,06	0,07	0,08
	$\delta_{N\infty}$	[mm/(N/mm²)]	0,06	0,08	0,14	0,14	0,16
Uncracked concrete temperature range II: 50°C/80°C							
Displacement	δ_{N0}	[mm/(N/mm²)]	0,05	0,06	0,08	0,10	0,11
	$\delta_{N\infty}$	[mm/(N/mm²)]	0,06	0,09	0,14	0,14	0,16
Uncracked concrete temperature range III: 72°C/120°C							
Displacement	δ_{N0}	[mm/(N/mm²)]	0,06	0,08	0,10	0,12	0,14
	$\delta_{N\infty}$	[mm/(N/mm²)]	0,07	0,09	0,14	0,14	0,16
Cracked concrete temperature range I: 24°C/40°C							
Displacement	δ_{N0}	[mm/(N/mm²)]	0,11				
	$\delta_{N\infty}$	[mm/(N/mm²)]	0,17				
Cracked concrete temperature range II: 50°C/80°C							
Displacement	δ_{N0}	[mm/(N/mm²)]	0,15				
	$\delta_{N\infty}$	[mm/(N/mm²)]	0,24				
Cracked concrete temperature range III: 72°C/120°C							
Displacement	δ_{N0}	[mm/(N/mm²)]	0,20				
	$\delta_{N\infty}$	[mm/(N/mm²)]	0,31				

Table 8: Unit 120-year displacements for uncracked and cracked concrete for temperature ranges I, II and III for Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 with rebars

Rebars			**Ø8**	**Ø10**	**Ø12**	**Ø14**	**Ø16**	**Ø20**	**Ø25**	**Ø26**	**Ø28**	**Ø30**	**Ø32**
For a working life of 120 years													
Uncracked concrete temperature range I: 24°C/40°C													
Displacement	δ_{N0}	[mm/(N/mm²)]	0,02	0,03	0,03	0,04	0,04	0,06	0,07	0,08	0,08	0,09	0,09
	$\delta_{N\infty}$	[mm/(N/mm²)]	0,04	0,05	0,06	0,07	0,08	0,10	0,14	0,15	0,16	0,17	0,18
Uncracked concrete temperature range II: 50°C/80°C													
Displacement	δ_{N0}	[mm/(N/mm²)]	0,03	0,04	0,05	0,05	0,06	0,08	0,10	0,11	0,11	0,12	0,12
	$\delta_{N\infty}$	[mm/(N/mm²)]	0,04	0,05	0,06	0,07	0,09	0,11	0,14	0,15	0,16	0,17	0,18
Uncracked concrete temperature range III: 72°C/120°C													
Displacement	δ_{N0}	[mm/(N/mm²)]	0,04	0,05	0,06	0,07	0,08	0,10	0,12	0,13	0,14	0,15	0,16
	$\delta_{N\infty}$	[mm/(N/mm²)]	0,04	0,05	0,07	0,08	0,09	0,11	0,14	0,15	0,16	0,17	0,18
Cracked concrete temperature range I: 24°C/40°C													
Displacement	δ_{N0}	[mm/(N/mm²)]	0,11										
	$\delta_{N\infty}$	[mm/(N/mm²)]	0,17										
Cracked concrete temperature range II: 50°C/80°C													
Displacement	δ_{N0}	[mm/(N/mm²)]	0,15										
	$\delta_{N\infty}$	[mm/(N/mm²)]	0,24										
Cracked concrete temperature range III: 72°C/120°C													
Displacement	δ_{N0}	[mm/(N/mm²)]	0,20										
	$\delta_{N\infty}$	[mm/(N/mm²)]	0,31										

2.2. Proposed values under seismic loading

2.2.1. Seismic performance category C1

The Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 bonded fastener is intended for use in seismic loading situations in combination with threaded rods in the sizes M10 to M30, with Hilti Tension Anchors HZA / HZA-R from sizes M12 to M27 and with rebars from sizes Ø10 to Ø32 for seismic performance category C1.

The 120-year characteristic bond resistances for cracked concrete for seismic performance category C1 for temperature range I (24°C long-term/40°C short-term), temperature range II (50°C long-term/80°C short-term) and temperature range III (72°C long-term/120°C short-term) are separated for the different steel element types in the following Tables 9 to 11. Additional specifications concerning seismic loading remain the same as in ETA-19/0601.

Table 9: Characteristic 120-year bond resistances for seismic performance category C1 for temperature ranges TI, TII and TIII for Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 with threaded rods

Threaded rods				**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Combined pull-out and concrete cone failure for a working life of 120 years										
Characteristic bond resistance in cracked concrete C20/25 for installation in dry or wet (water saturated) concrete, all drilling methods (HD, HDB, DD + RT)										
Temperature range I:	24°C/40°C	$\tau_{Rk,120,C1}$	[N/mm²]	4,3	6,1					
Temperature range II:	50°C/80°C	$\tau_{Rk,120,C1}$	[N/mm²]	3,5	5,0					
Temperature range III:	72°C/120°C	$\tau_{Rk,120,C1}$	[N/mm²]	3,0	4,2					

Table 10: Characteristic 120-year bond resistances for seismic performance category C1 for temperature ranges TI, TII and TIII for Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 with Hilti Tension Anchor HZA / HZA-R

Hilti Tension Anchor HZA, HZA-R				**M12**	**M16**	**M20**	**M24**	**M27**
Rebar diameter		d	[mm]	12	16	20	25	28
Combined pull-out and concrete cone failure for a working life of 120 years								
Characteristic bond resistance in cracked concrete C20/25 for installation in dry or wet (water saturated) concrete, all drilling methods (HD, HDB, DD + RT)								
Temperature range I:	24°C/40°C	$\tau_{Rk,120,C1}$	[N/mm²]	5,9				
Temperature range II:	50°C/80°C	$\tau_{Rk,120,C1}$	[N/mm²]	4,6				
Temperature range III:	72°C/120°C	$\tau_{Rk,120,C1}$	[N/mm²]	4,2				

Table 11: Characteristic 120-year bond resistances for seismic performance category C1 for temperature ranges TI, TII and TIII for Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 with rebars

Rebar				**Ø10**	**Ø12**	**Ø14**	**Ø16**	**Ø20**	**Ø25**	**Ø26**	**Ø28**	**Ø30**	**Ø32**
Diameter of rebar		d	[mm]	10	12	14	16	20	25	26	28	30	32
Combined pull-out and concrete cone failure for a working life of 120 years													
Characteristic bond resistance in cracked concrete C20/25 for installation in dry or wet (water saturated) concrete, all drilling methods (HD, HDB, DD + RT)													
Temperature range I:	24°C/40°C	$\tau_{Rk,120,C1}$	[N/mm²]	4,2	5,9								
Temperature range II:	50°C/80°C	$\tau_{Rk,120,C1}$	[N/mm²]	3,3	4,6								
Temperature range III:	72°C/120°C	$\tau_{Rk,120,C1}$	[N/mm²]	2,9	4,2								

2.2.2. Seismic performance category C2

The Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 bonded fastener is intended for use in seismic loading situations in combination with threaded rods in the sizes M12 to M24 for seismic performance category C2. The 120-year characteristic bond resistances for cracked concrete for seismic performance category C2 for temperature range I (24°C long-term/40°C short-term), temperature range II (50°C long-term/80°C short-term) and temperature range III (72°C long-term/120°C short-term) are given in the following Table 12. Additional specifications concerning seismic loading remain the same as in ETA-19/0601.

Table 12: Characteristic 120-year bond resistances for seismic performance category C2 for temperature ranges TI, TII and TIII for Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 with threaded rods

Threaded rods				**M12**	**M16**	**M20**	**M24**
Combined pull-out and concrete cone failure for a working life of 120 years							
Characteristic bond resistance in cracked concrete C20/25 for installation in dry or wet (water saturated) concrete, all drilling methods (HD, HDB, DD + RT)							
Temperature range I:	24°C/40°C	$\tau_{Rk,120,C2}$	[N/mm²]	2,6	4,4	4,4	3,3
Temperature range II:	50°C/80°C	$\tau_{Rk,120,C2}$	[N/mm²]	2,2	3,7	3,7	2,8
Temperature range III:	72°C/120°C	$\tau_{Rk,120,C2}$	[N/mm²]	1,9	3,2	3,2	2,4

2.3. Proposed values under fire exposure

The Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 bonded fastener is intended for use under fire exposure in concrete strength classes C20/25 to C50/60 in combination with threaded rods in the sizes M8 to M30 and with rebars from sizes Ø8 to Ø32 for all permitted drilling methods.

The 120-year characteristic bond resistance under fire $\tau_{Rk,fi,120}(\theta)$ is obtained by multiplying the 120-year characteristic bond resistance for cracked concrete of strength class C20/25 $\tau_{Rk,cr,120,C20/25}$ by the reduction factor for bond resistance under fire conditions $k_{fi,p}(\theta)$. Depending on the type of steel element used, the characteristic bond resistance for cracked concrete $\tau_{Rk,cr,120,C20/25}$ has to be taken from Table 1 for threaded rods and Table 3 for rebars. In these two tables the characteristic bond resistance for cracked concrete $\tau_{Rk,cr,120,C20/25}$ is denominated with $\tau_{Rk,cr}$.

The exact calculation of the 120-year characteristic bond resistances under fire $\tau_{Rk,fi,120}(\theta)$ based on the reduction factor for bond resistance under fire conditions $k_{fi,p}(\theta)$ for threaded rods and rebars for concrete strength classes C20/25 to C50/60 with all permitted drilling methods is given below.

Additional specifications concerning fire exposure remain the same as in ETA-19/0601.

$$\tau_{Rk,fi,120}(\theta) = k_{fi,p}(\theta) \cdot \tau_{Rk,cr,120,C20/25}$$

Equation 1: Calculation of the 120-year characteristic bond resistances under fire $\tau_{Rk,fi,120}(\theta)$ for concrete strength classes C20/25 to C50/60

Description of the symbols:

$\tau_{Rk,fi,120}(\theta)$	characteristic bond resistance for cracked concrete under fire exposure for a given temperature for a working life of 120 years
$k_{fi,p}(\theta)$	reduction factor for bond resistance under fire conditions depending on the used steel element (threaded rod or rebar)
$\tau_{Rk,cr,120,C20/25}$	characteristic bond resistance for cracked concrete C20/25 for a working life of 120 years, taken as value $\tau_{Rk,cr}$ from Table 1 for threaded rods and Table 3 for rebars

The temperature reduction factor for threaded rods is calculated as follows.

$$with: \quad \theta \leq 392°C: \qquad k_{fi,P}(\theta) = 1{,}01 \cdot e^{(-0{,}013 \cdot \theta)} \leq 1{,}0$$
$$and: \quad \theta > \theta_{max}: \qquad k_{fi,p}(\theta) = 0 \qquad (\theta_{max} = 392°C)$$

Equation 2: Calculation of the temperature reduction factor for threaded rods

The temperature reduction factor for rebars is calculated as follows.

$$with: \quad \theta \leq 271°C: \qquad k_{fi,P}(\theta) = 1{,}244 \cdot e^{(-0{,}014 \cdot \theta)} \leq 1{,}0$$
$$and: \quad \theta > \theta_{max}: \qquad k_{fi,p}(\theta) = 0 \qquad (\theta_{max} = 271°C)$$

Equation 3: Calculation of the temperature reduction factor for rebars

The present assessment takes into account sustained load tests with a test duration of 22,5 months (temperature range I) and 7,5 months (temperature ranges II and III), which fulfill the linearly scaled up requirements for a working life of 120 years. No additional tests have been performed in case of crack cycling under load tests.

The assessed values are based on the present state of knowledge about the long-term degradation behaviour of the used bonding material. Therefore, the long-term behaviour and robustness of the adhesive has to be guaranteed by the quality standards of the manufacturer!

The assessed values within this document are based on an extended assessment of the test results, which are the basis for the 100-year values to a working life of 120 years, specific to the bonded fastener Hilti HIT-HY 200-A V3 and HIT-HY 200-R V3 respectively and therefore, only valid for these systems with the specified sizes and steel elements.

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