MATERIALPRÜFANSTALT FÜR DAS BAUWESEN

INSTITUT FÜR BAUSTOFFE, MASSIVBAU UND BRANDSCHUTZ

iBMB MPA TU BRAUNSCHWEIG

MPA Braunschweig · Beethovenstr. 52 · D-38106 Braunschweig

HILTI Entwicklungsgesellschaft mbH
Herrn Manfred Hartmann
Hiltistr. 6

D 86916 Kaufering

Schreiben 9791/2006

Unser Zeichen:	(3838/7786)-CM
Kunden-Nr.:	6547
Sachbearbeiter:	Maertins
Abteilung:	BS
Tel. Durchwahl:	-8265
Ihre Zeichen:	Hr. Hartmann
Ihre Nachricht vom:	25.04.2006
Datum:	28.07.2006

Gültigkeit des Untersuchungsberichtes Nr. 3357/0550-5 -Nau- vom 30.07.2002

Sehr geehrter Herr Hartmann,

auf Grund Ihrer Anfrage teilen wir Ihnen mit, dass die in dem o.g. Untersuchungsbericht Nr. 3357/0550-5 -Nau- vom 30.07.2002 gemachten Aussagen zum Hochtemperaturverhalten hinsichtlich des Auszugs sowie zum brandschutztechnischen Bemessungskonzept für die Anwendung von Bewehrungsanschlüssen des auf zentrischen Zug belasteten Befestigungssystems mit der Bezeichnung

Hilti Injektionssystem HIT-RE 500

in Verbindung mit Betonstahlabschnitten der Stahlgüte BSt 500 S (Rebar) der Nenndurchmesser ∅ 8 mm bis ∅ 40 mm

in einem Untergrund aus **Normalbeton der Festigkeitsklasse von mindestens C20/25 und höchstens C50/60** bei einer Brandbeanspruchung nach der **Einheits-Temperaturzeitkurve (ETK) gemäß DIN 4102-2 : 1977-09** bis zum 30.07.2011 weiterhin Gültigkeit besitzen.

Der o.g. Untersuchungsbericht in Verbindung mit dieser Verlängerung ersetzt nicht den Nachweis nach dem deutschen bauaufsichtlichen Verfahren (abZ, abP, ETA). Insbesondere ist zu beachten, dass für das Hilti Injektionssystem HIT-RE 500 die Brandlastwerte in zukünftigen Nachweisdokumenten nach dem deutschen bauaufsichtlichen Verfahren bzw. in bestehenden allgemeinen bauaufsichtlichen Zulassungen geregelt sein können.

Dr.-Ing. Blume
stellv. Leiter der Prüfstelle

Materialprüfanstalt f. d. Bauwesen MPA BS 3.1 Braunschweig

i. A.
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Swift-Code: NOLADE 2H
USt.-ID-Nr. MPA-DE 183500654

MATERIALPRÜFANSTALT FÜR DAS BAUWESEN

INSTITUT FÜR BAUSTOFFE, MASSIVBAU UND BRANDSCHUTZ

iBMB MPA TU BRAUNSCHWEIG

Test Report

No. 3357/0550-5 -Nau- 1st issue
(July 30, 2002)

Applicant : Hilti Development Corporation
Hiltistrasse 6
D – 86 916 Kaufering

Order dated: February 13, 2001 Reference: Verbal Receipt: -

Order content :

Testing of

Hilti HIT-RE 500 injection systems in conjunction with reinforcing steel bars (rebar) of the BSt 500 S grade

set in small specimens (steel-encased concrete cylinders) of the grade ≥ C 20/25 which were subjected to pure tensile loading to ascertain their behaviour at high temperature in a fire according to DIN 4102-2 : 1977-09 respectively ISO 834 and to determine the pull-out behaviour as well as to develop a technical design concept for rebar connections suitable for fire protection

Receipt of test material :	07 CW 2000 to 06 CW 2001
Sampling :	The material testing laboratory has received no information about official sampling of the supplied material.
Marking :	None

This test report consists of 17 pages and 22 annexes.

The validity of this test report ceases on July 30, 2004.

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1 Reason and Order

With request dated February 13, 2001, the Hilti Corporation assigned the MPA Braunschweig with the task of developing a technical design concept for rebar connections suitable for fire protection using reinforcing steel bars of BSt 500 S grade, 8 to 40 mm in diameter, and Hilti HIT-RE 500 injection adhesive in reinforced-concrete slabs and wall sections exposed to fire on one side (see section 5).

To lay the foundations for the determination of the thermomechanical properties, high-temperature investigations were carried out using small specimens (steel-encased concrete cylinders) which were subjected to pure tensile loading to ascertain the pull-out behaviour when exposed to fire in accordance with DIN 4102-2 : 1977-09 respectively ISO 834.

2 Description of tested arrangements

The tested Hilti HIT-RE 500 injection system gives an anchor fastening that exerts no expansion forces when set in normal concrete with quarzitic aggregates and subjected primarily to a static (dead) load.

The Hilti HIT-RE 500 injection system is an anchoring system with a working principle based on utilisation of the bond between steel, two-component adhesive and concrete. This injection system consists of a two-component injection adhesive ready for use in a dual foil pack that is based on an organic binder. It is injected by a dispenser through an interchangeable static forced mixer into a drilled hole. The Hilti HIT-RE 500 injection adhesive is a binder system, comprising an epoxy resin mixture and a hardener based on amine. Steel bar material of the grade BSt 500 S with a diameter of 8 to 20 mm was used as the reinforcing steel. Technical data sheets from the applicant provide a ruling on setting and loading the fastenings made with Hilti HIT-RE 500.

Structural details concerning the range of applications and design possibilities with the Hilti HIT-RE 500 injection system are shown in annex 1 of this test report.

A total of 36 rebar sections with a nominal diameter of 8 to 20 mm of the BSt 500 S grade were set in steel-encased concrete cylinders using Hilti HIT-RE 500 injection adhesive. They were tested subjected to pure tensile loading for their high-temperature behaviour when exposed to fire according to DIN 4102-2: 1977-02 and ISO 834 in order to determine the thermo-mechanical properties as well as the pull-out behaviour and to develop a technical design concept for the use of rebar connections suitable for fire protection.

The rebars were set with the Hilti HIT-RE 500 injection system in accordance with the applicant's technical data sheets, while using the pertaining setting tools specified in them, i.e. rotary hammer, drill bit, dispenser and static forced mixer.

Further details regarding the installation of the rebars in the concrete cylinders can be seen in annex 2 of this test report.

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3 Test arrangement and realization

The tests were carried out in an electrically heated, servo-hydraulic, high-temperature test furnace. In the middle of a base surface of each concrete cylinder, a hole was drilled to a depth approximately 10 times the nominal rebar diameter and with a nominal diameter, d, of rebar diameter + 4 mm. After the holes had been cleaned, the rebars were set at an anchorage depth, l, of 10 times the rebar diameter using Hilti HIT-RE 500. Prior to setting each rebars, thermocouples were fastened to it in such a way that during the test the temperature in the injection adhesive at a depth about 10 mm below the concrete surface and on the lower end of the rebar at the bottom of the hole could be measured. The press cylinder of the test rig transferred the load centrally to the reinforcing bar.

Thermocouples fastened to the circumference of the concrete cylinders increased and measured the temperatures in the test rig. During the tests, the displacement of the rebars relative to the concrete surface was continuously plotted by a measuring device outside the rig.

Further design details of the test arrangement with the concrete cylinders in the test rig are given in annex 3 of this test report.

4 Test results

In the period from calendar week 07, 2000, to calendar week 06, 2001, 36 test specimens made with Hilti HIT-RE 500 injection system and rebar sections of steel grade BSt 500 S, 8 to 20 mm in nominal diameter, set in concrete cylinders of the grade ≥ C 20/25 were tested at high-temperature and subjected to pure tensile loading, to determine the pull-out behaviour as well as to develop a technical design concept suitable for fire protection according to DIN 4102-2: 1977-02 and ISO 834 for the use of rebar connections.

Based on the results when testing the high-temperature behaviour of the Hilti HIT-RE 500 injection mortar, the evaluation had to be expanded covering rebar connections with nominal diameters from 8 to 40 mm.

The results obtained when testing the Hilti HIT-RE 500 injection system, giving the failure temperatures, are compiled in following tables 1 and 2 (see pages 4 and 5).

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Table 1 : Summary of test results obtained with Hilti HIT-RE 500 injection system using rebar sections of the steel grade BSt 500 S with a nominal diameter of 12 mm

Date of Testing	Nominal diameter of rebar [mm]	Anchorage depth l [mm]	Actual load N_{actual} [kN]	Failure Temperature [°C]
May 02, 2000	12	120	10.0	146
May 04, 2000			4.0	287
May 08, 2000			6.0	278
May 10, 2000			20.0	83
May 11, 2000			30.0	83
May 15, 2000			8.0	292
October 12, 2000			2.4	331
October 13, 2000			13.2	157
October 16, 2000			8.0	273
October 17, 2000			50.0	67
October 18, 2000			50.0	65
October 19, 2000			24.8	70
November 10, 2000			9.2	287
November 13, 2000			10.0	148
November 14, 2000			9.6	157
November 15, 2000			15.2	89
November 22, 2000			12.0	145
November 23, 2000			55.2	61
November 24, 2000			40.0	59
November 27, 2000			60.0	57
November 13, 2000		60 [2)]	49.6 [1)]	20
November 13, 2000			52.4 [1)]	20
January 15, 2001			36.0	49
January 24, 2001			44.0	43
February 01, 2001			18.0	57

1) These tests were carried out by the Hilti Development Corporation at Kaufering, Germany. The values are the means of 5 results in each case.

2) During these tests, an anchorage depth of only l = 5 x diameter was used to ensure that a bond failure would be obtained each time.

Table 2 : Summary of test results obtained with Hilti HIT-RE 500 injection system using rebar sections of the steel grade BSt 500 S with a nominal diameter of 8, 10, 14, 16 and 20 mm

Date of Testing	Nominal diameter of rebar [mm]	Anchorage depth l [mm]	Actual load N_{actual} [kN]	Failure Temperature [°C]
May 24, 2000	**8**	80	3.2	281
May 25, 2000			9.2	72
May 29, 2000	**10**	100	15.2	71
June 05, 2000			5.2	291
November 16, 2000	**14**	140	20.0	108
January 16, 2001			44.0	106
January 18, 2001			12.0	148
November 17, 2000	**16**	160	20.0	124
December 07, 2000			80.0	57
January 02, 2001	**20**	200	25.2	134
February 02, 2001		100 [1)]	38.0	63

1) During this test, an anchorage depth of only l = 5 x diameter was used to ensure that a bond failure would be obtained.

...

5 Technical design concept suitable for fire protection for rebar connections using Hilti HIT-RE 500 injection system

5.1 General aspects

Based on the results when testing the high-temperature behaviour of Hilti HIT-RE 500 injection system, as given in section 4, a technical design concept for use of rebar connections, 8 to 40 mm in diameter, suitable for fire protection according to DIN 4102-2 : 1977-09 respectively ISO 834, made in reinforced-concrete slabs and wall sections when exposed to fire on one side, had to be developed for a fire resistance time of 30 to 240 minutes in accordance with the client's request.

This technical design concept should include both rebar connection versions, namely "OVERLAP JOINT" and "ANCHORING". These two connection variants are shown schematically in the following figures 1 and 2 (see page 7).

Fig. 1 : Schematic depiction of rebar connection version OVERLAPED JOINT

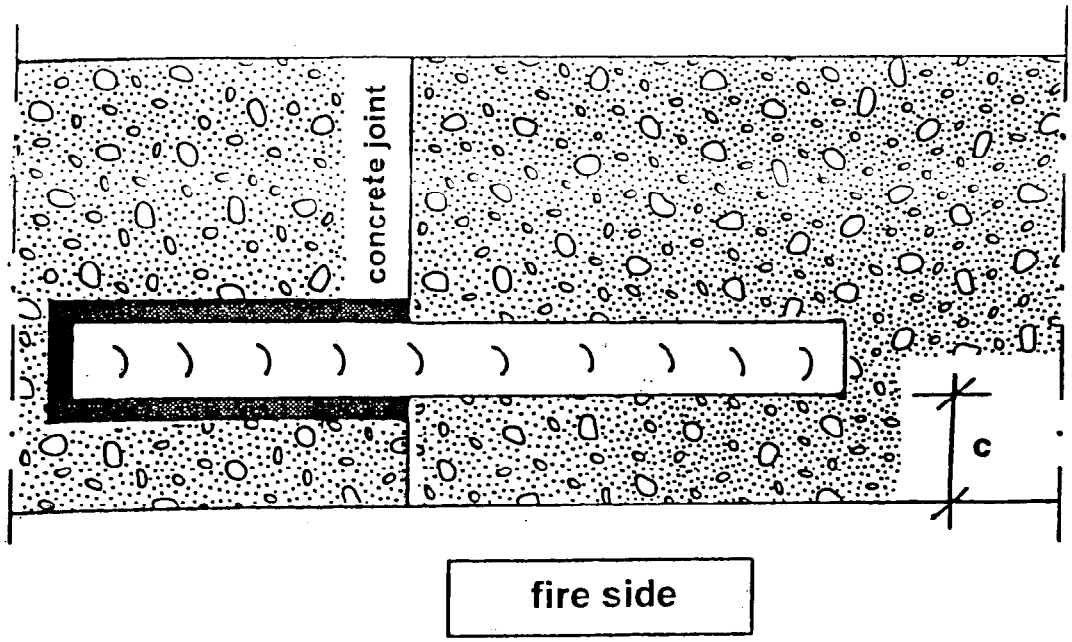
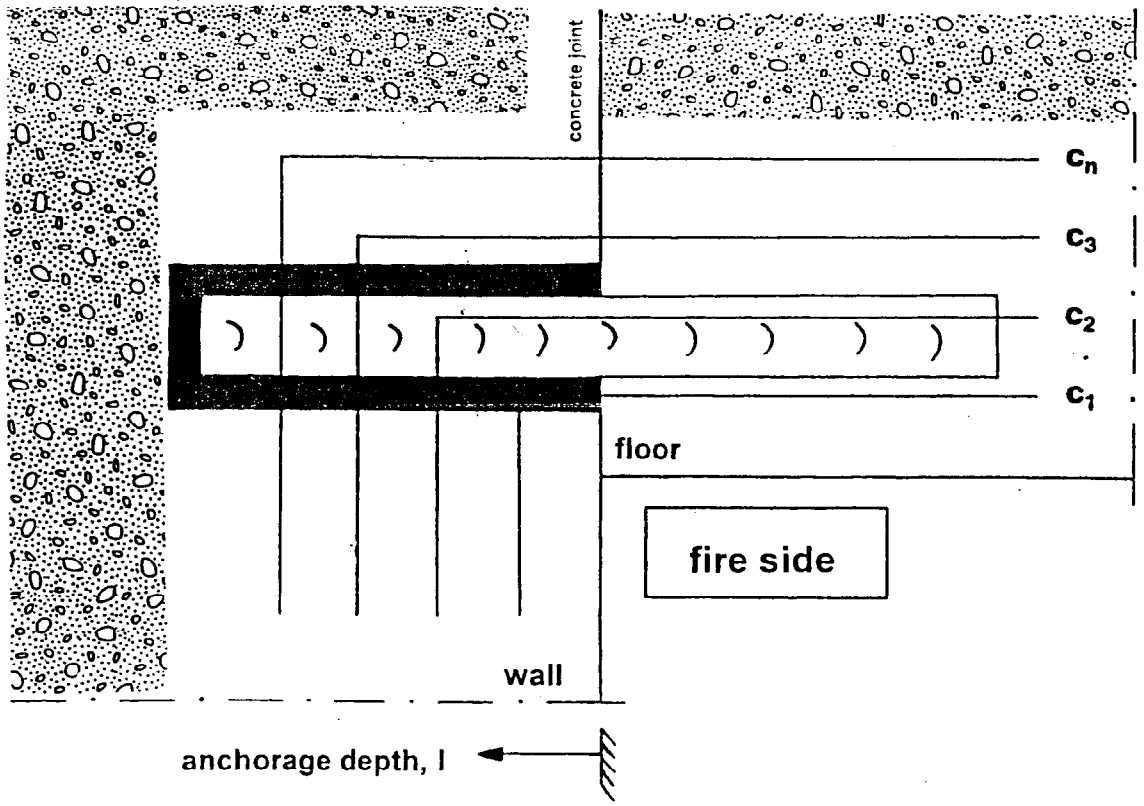


Fig. 2 : Schematic depiction of rebar connection version ANCHORING



5.2 Fundamentals and reference literature

Fundamentals for the technical design concept suitable for fire protection are as follows :

[1] DIN 1045, 1988-12, (Concrete and reinforced concrete, design and construction)

[2] DIN V ENV 1992 part 1-1 (issue 1992-06), Eurocode 2 (Planning of reinforced-concrete and prestressed-concrete structures; part 1 : Fundamentals and application regulations for building construction)

[3] DIN 1045 : 2001-07, (Structures of concrete, reinforced concrete and prestressed concrete)

[4] DIN 4102 - 2 : 1977-09 (ISO 834), (Behaviour in fire of building materials and components. Building components, terms, requirements and tests)

[5] (Concrete-fire protection manual). Prof. Dr.-Ing. Dr.-Ing. h.c. K. Kordina and Dr.-Ing. C. Meyer-Ottens, issue 1981

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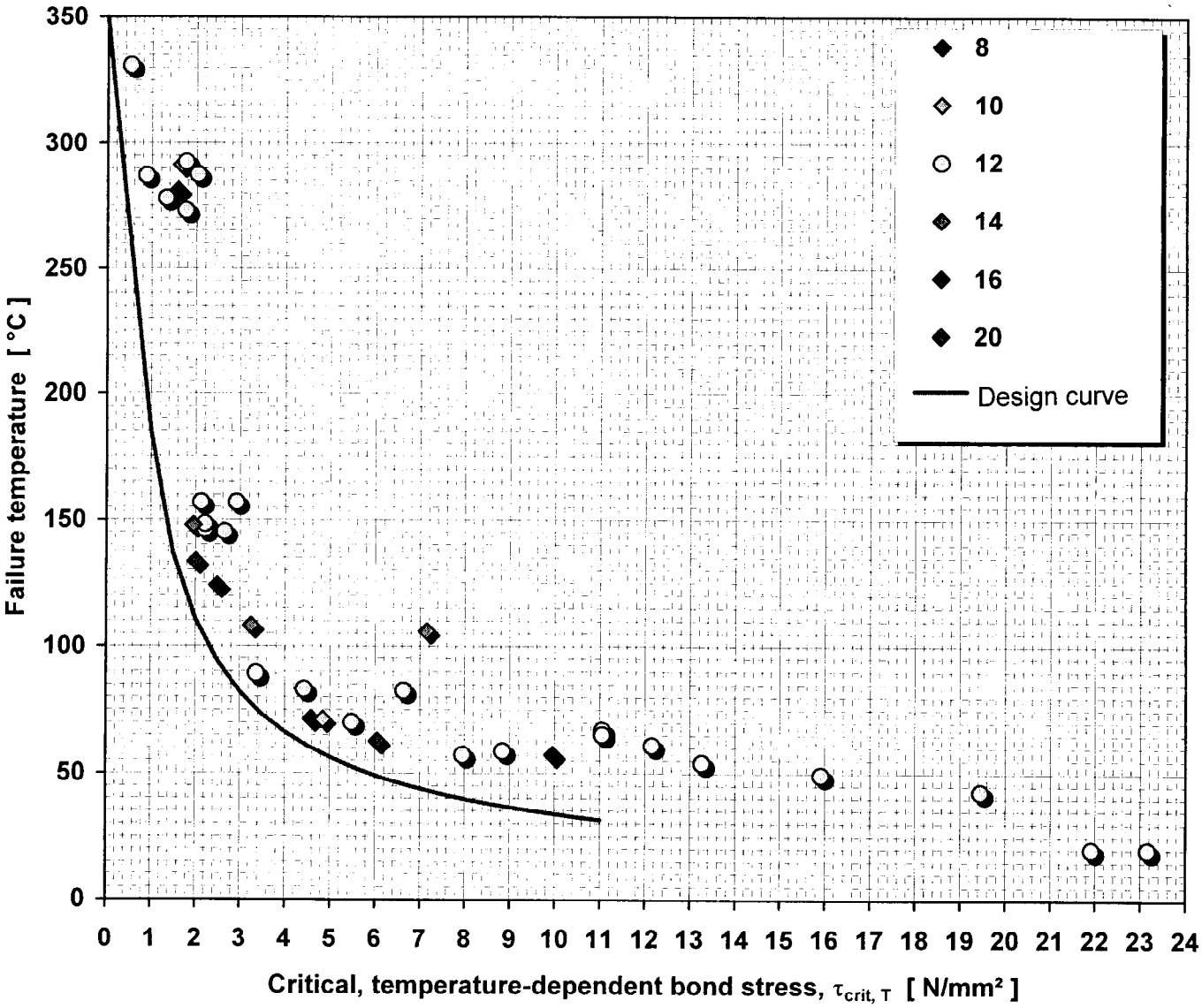
5.3 Evaluation of test results and design

As the design of rebar connections is generally based on the utilisation of bond stresses, the test results obtained with Hilti HIT-RE 500 injection adhesive, as given in tables 1 and 2 (see pages 4 and 5), have been depicted in the following fig. 3 as a function of the failure temperature and the pertaining critical bond stress, $\tau_{crit,T}$. In addition, a design curve, kept on the safe side and below the actual failure values, was configured in fig. 3, taking into account the test results and based on the experiences gained while testing.

Fig. 3 : Graphical presentation of test results obtained with Hilti HIT-RE 500 injection adhesive as well as the design curve as a function of failure temperature and critical, temperature-dependent bond stress, $\tau_{crit,T}$



Using the knowledge about the heat-up behaviour of concrete as per [5] (see fig. 4), the design curve from fig. 3 (see page 8) as well as further experiences from testing normal concrete with quarzitic aggregates, critical temperature-dependent bond stresses, $\tau_{crit,T}$, can be provided on the safe side in table 3 (see page 10) in relation to the respective concrete coverage, c, for a fire resistance time of 30 to 240 minutes.

Fig. 4 : Temperature distribution as per DIN 4102 - 2 : 1977-09 and ISO 834 in slabs and wall sections of normal concrete with quarzitic aggregates when exposed to fire on one side; from [5], page 141

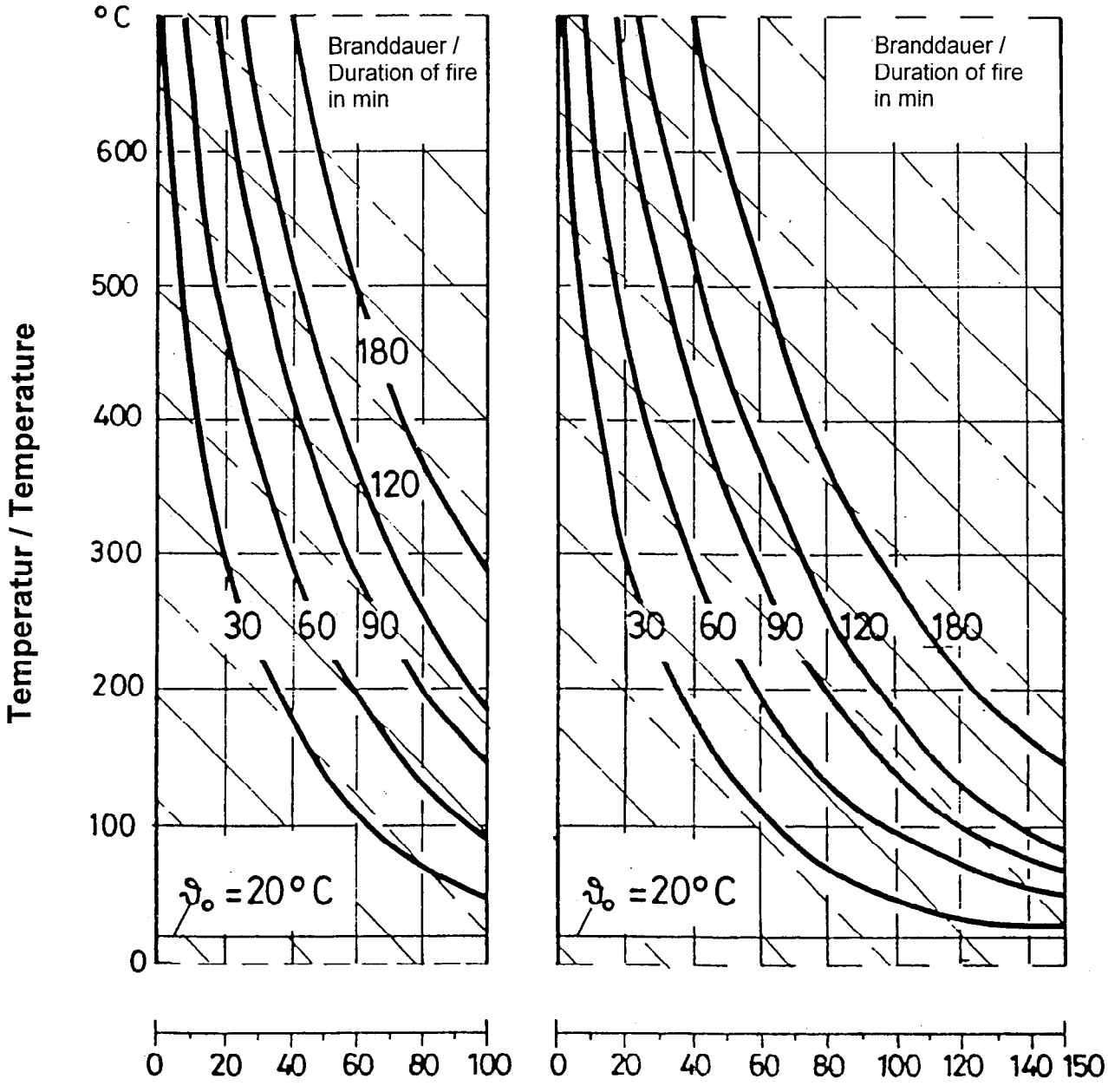


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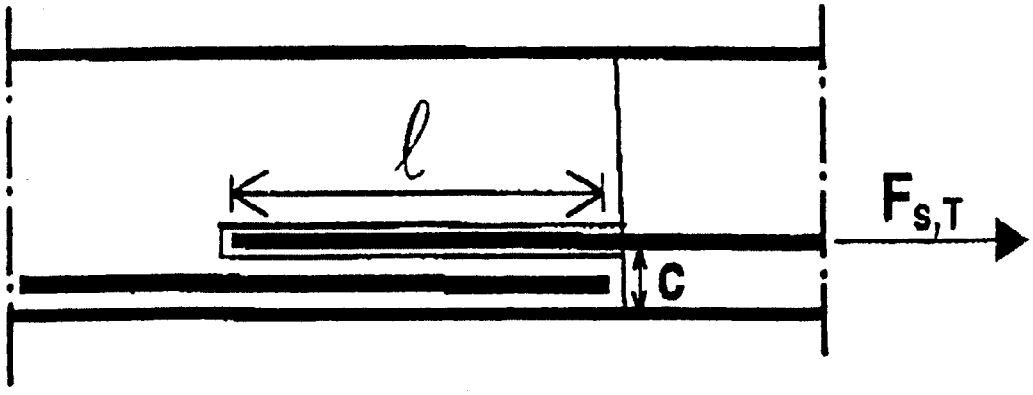
Table 3 : Critical, temperature-dependent bond stresses, $\tau_{crit,T}$, for Hilti HIT-RE 500 injection adhesive in relation to fire resistance times of 30 to 240 minutes and the required minimum concrete coverage, c

concrete coverage	Critical, temperature-dependent bond stresses, $\tau_{crit,T}$, for Hilti HIT-RE 500 injection adhesive in relation to fire resistance class					
c	F30	F60	F90	F120	F180	F240
[mm]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]
10	0					
20	0.494	0				
30	0.665		0			
40	0.897	0.481		0		
50	1.209	0.623			0	
60	1.630	0.806	0.513			0
70	2.197	1.043	0.655	0.487		
80	2.962	1.351	0.835	0.614		
90	3.992	1.748	1.065	0.775	0.457	
100	5.382	2.263	1.358	0.977	0.553	
110	7.255	2.930	1.733	1.233	0.669	0.469
120	9.780	3.792	2.210	1.556	0.810	0.551
130		4.909	2.818	1.963	0.980	0.647
140		6.355	3.594	2.477	1.185	0.759
150		8.226	4.584	3.125	1.434	0.892
160		10.649	5.846	3.943	1.735	1.047
170			7.456	4.974	2.099	1.230
180			9.510	6.276	2.540	1.445
190				7.918	3.073	1.697
200				9.990	3.718	1.993
210					4.498	2.341
220	11.000				5.442	2.749
230					6.584	3.228
240		11.000			7.966	3.792
250			11.000		9.639	4.453
260				11.000		5.230
270						6.143
280					11.000	7.214
290						8.473
300						9.951
310						11.000

5.4 Application of design concept to rebar connection version OVERLAP JOINT

Verification of the suitability of overlap joints exposed to temperature must be calculated using the following formula. Fig. 5 below shows, schematically, the rebar connection version OVERLAP JOINT.

Fig. 5 : Schematic depiction of the connection version OVERLAP JOINT



$$F_{s,T} \leq l \cdot d_s \cdot \pi \cdot \tau_{crit,T}$$

Whereby :

$F_{s,T}$ Force in the reinforcing bar when subjected to fire exposure

l Length of overlap joint

d_s Nominal diameter of the reinforcing bar

$\tau_{crit,T}$ Critical, temperature-dependent bond stress as per table 3 based on consideration of the concrete coverage, c

Evaluations of the critical, temperature-dependent bond stress, $\tau_{crit,T}$, in relation to the concrete coverage, c, and the respective, stipulated fire resistance time of rebar connection version OVERLAP JOINT are shown in table 3 (see page 10). In this respect, the overlap joint length may not exceed 80 times the nominal rebar diameter, d_s, when the joint is exposed to fire.

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It can be seen from figs 1 (see page 6) and 5 (see page 11) that in the case of this rebar connection version the entire anchoring range of the reinforcement is parallel to the surface of the building component when exposed to fire and, thus, in principle, is within a single temperature zone which is decisive for the load bearing capacity. Consequently, increasing the anchorage depth respectively the overlap joint length for this version of a rebar connection is not meaningful.

As the concrete coverage, c, is the only protection against increase in temperatures, it would be possible to achieve full utilisation with respect to the maximum permissible force in the rebar by extending the concrete coverage.

An alternative to increasing the concrete coverage can be seen, to a certain extent, in a larger amount of joint reinforcement in the connection, depending on the degree of utilisation.

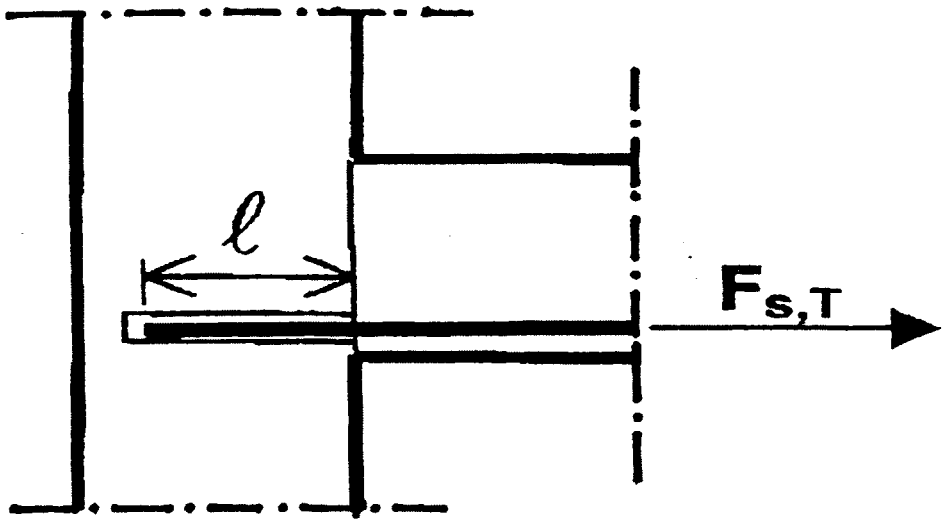
On the other hand, the passive fire protection requirements can also be met by plaster coatings or other claddings, if their suitability is verified, e.g. mineral fibre slabs of building material class A with a melting point ≥ 1000 °C and a bulk density ≥ 150 kg/m^3 as well as calcium silicate or vermiculite panels.

An equivalent thickness of concrete layer may be used for this kind of cladding (1 cm of cladding thickness = 2 cm of concrete coverage). The fastening of the cladding must also meet the passive fire protection requirements and be verified separately.

5.5 Application of design concept to rebar connection version ANCHORING

Verification of the suitability of anchored rebars exposed to temperature must be calculated using the following formula. Fig. 6 below shows, schematically, the rebar connection version ANCHORING.

Fig. 6 : Schematic depiction of the connection version ANCHORING



$$F_{s,T} \leq A_s \bullet \sigma_s$$

Whereby :

$F_{s,T}$ Force in the reinforcing bar when subjected to fire exposure

A_s Cross-sectional area of the reinforcing bar

σ_s Stress in steel transferable to the concrete joint through the injection adhesive in relation to the anchorage depth, l, of the reinforcing bar and the fire resistance time

Verification of the design of connection version ANCHORING is provided on basis of integration of the critical, temperature-dependent bond stress, $\tau_{crit,T}$, in relation to the rebar anchorage depth, l, and the fire resistance time.

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It can be seen in figs 2 (see page 7) and 6 (see page 13) that in case of this version of a rebar connection the anchoring range of the reinforcement is vertical to the surface of the building component when exposed to fire and thus comes within differing temperature zones. In view of this, full utilisation of the maximum permissible force in the rebar is possible for the connection version ANCHORING by increasing the anchorage depth, l. An alternative to this can be seen to be in a larger amount of connection reinforcement as a function of the fire resistance time. Furthermore, an equivalent thickness of concrete layer can be made in the form of cladding, as described in section 5.4.

This type of rebar connections should be evaluated for various countries, while taking into consideration the partial safety factors from the respective country-specific, reinforced-concrete construction standard (see annex 4) as a function of the force in the rebar and the rebar anchorage depth (see annexes 5 to 22).

6 Conclusions

In the period from calendar week 07, 2000, to calendar week 06, 2001, 36 test specimens made with Hilti HIT-RE 500 injection system and rebar sections of steel grade BSt 500 S, 8 to 20 mm in nominal diameter, set in concrete cylinders of the grade ≥ C 20/25 were tested on their high temperature behaviour in fire conditions according to DIN 4102-2: 1977-02 and ISO 834 and subjected to pure tensile loading to determine the pull-out behaviour.

By means of the test results obtained with Hilti HIT-RE 500 injection adhesive system, it is possible to calculate on the safe side critical, temperature-dependent bond stresses, $\tau_{crit,T}$, in relation to the respective concrete coverage, c, for a fire resistance time of 30 to 240 minutes. These, among other aspects, provided the basis for the requested technical design concept for the application of rebar connections suitable for fire protection.

Based on the temperature-dependent bond stress, $\tau_{crit,T}$, rulings have been provided in the technical design concept for the required concrete coverage, c, and rebar connection version OVERLAP JOINT, as per section 5.4, as well as for the required anchorage depth, l, and connection version ANCHORING, as per section 5.5, for Hilti HIT-RE 500 injection system using nominal diameters of rebars from 8 to 40 mm in relation to the respective fire resistance class.

Verification of the loading capacity of adhesive bonded overlap joints or anchored rebars exposed to fire according to DIN 4102-2 : 1977-09 respectively ISO 834 must be provided at the same time as verification of the serviceability state in accordance with the country-specific reinforced-concrete standards. Here, the larger calculated value concerning the overlap joint length or the rebar anchorage depth is decisive.

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7 Special notes

7.1 This evaluation applies only to rebar connections, 8 to 40 mm in nominal diameter, in conjunction with the Hilti HIT-RE 500 injection adhesive (current standard formulation), when taking into account the general conditions given in the client's technical data sheets for the rebar connection versions **OVERLAP JOINT** and **ANCHORING**.

7.2 The evaluation for rebar connections made with Hilti HIT-RE 500 injection adhesive applies only in conjunction with reinforced-concrete slabs or walls which are exposed to fire on one side and can be classified in at least a fire resistance class corresponding to the fire resistance time of the injection adhesive.

7.3 The validity of this test report ceases on July 30, 2004.

Director
on behalf

RD Dr.-Ing. Wesche

Test engineer

RR Dipl.-Ing. Nause

Braunschweig, July 30, 2002

See page 16 and 17 for a list of annexes

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Annex 1 : Fields of application and design possibilities of Hilti HIT-RE 500 injection system

Annex 2 : Test arrangement of rebars

Annex 3 : Testing equipment with built-in specimen

Annex 4 : Fundamentals for country-specific evaluations

Annexes 5 and 6 : Evaluation of the maximum forces in rebars for the connection version ANCHORING according to **German Standard DIN 1045 – 1988**, using reinforcing bars with a yielding point of $\mathbf{f_{yk}}$ **= 500 N/mm²**, as a function of the fire resistance time

Annexes 7 and 8 : Evaluation of the maximum forces in rebars for the connection version ANCHORING according to **German Standard DIN 1045 – 2001** respectively **Eurocode 2 - 1992**, using reinforcing bars with a yielding point of $\mathbf{f_{yk}}$ **= 500 N/mm²**, as a function of the fire resistance time (in German)

Annexes 9 and 10 : Evaluation of the maximum forces in rebars for the connection version ANCHORING according to **Eurocode 2 - 1992**, using reinforcing bars with a yielding point of $\mathbf{f_{yk}}$ **= 500 N/mm²**, as a function of the fire resistance time

Annexes 11 and 12 : Evaluation of the maximum forces in rebars for the connection version ANCHORING according to **French Standard NF-ENV 1991-2-2 : 1955-02 (Eurocode 2)**, using reinforcing bars with a yielding point of $\mathbf{f_{yk}}$ **= 500 N/mm²**, as a function of the fire resistance time (in French)

Annexes 13 and 14 : Evaluation of the maximum forces in rebars for the connection version ANCHORING according to **Austrian Standard B 4700 - 2000**, using reinforcing bars with a yielding point of $\mathbf{f_{yk}}$ **= 550 N/mm²**, as a function of the fire resistance time

Annexes 15 and 16 : Evaluation of the maximum forces in rebars for the connection version ANCHORING according to **British Standard BS 8110 : 1 - 1997**, using reinforcing bars with a yielding point of $\mathbf{f_{yk}}$ **= 460 N/mm²**, as a function of the fire resistance time

Annexes 17 and 18 : Evaluation of the maximum forces in rebars for the connection version ANCHORING according to **Singapore Standard CP – 65 : 1999**, using reinforcing bars with a yielding point of $\mathbf{f_{yk}}$ **= 460 Mpa**, as a function of the fire resistance time

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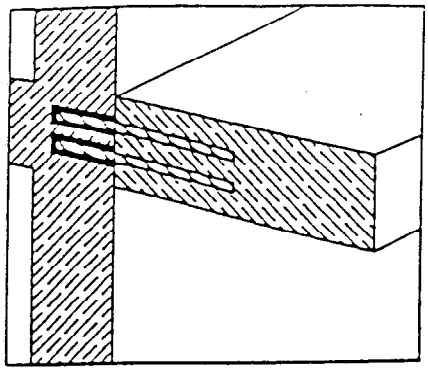
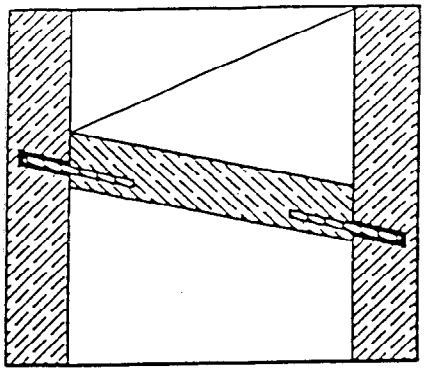
Annexes 19 and 20 : Evaluation of the maximum forces in rebars for the connection version ANCHORING according to **Australian Standard AS 3600 - 2001**, using reinforcing bars with a yielding point of $\mathbf{f_{yk}}$ **= 400 Mpa**, as a function of the fire resistance time

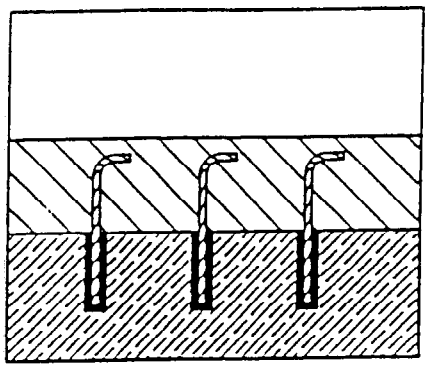
Annexes 21 and 22 : Evaluation of the maximum forces in rebars for the connection version ANCHORING according to **Australian Standard AS 3600 - 2001**, using reinforcing bars with a yielding point of $\mathbf{f_{yk}}$ **= 500 Mpa**, as a function of the fire resistance time



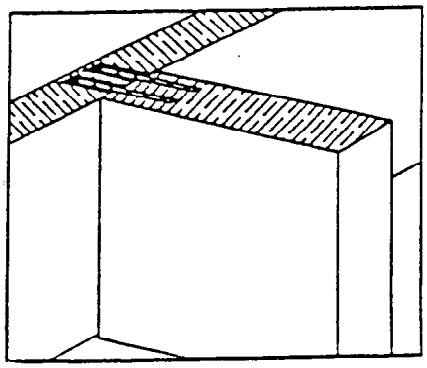
Balcony connection



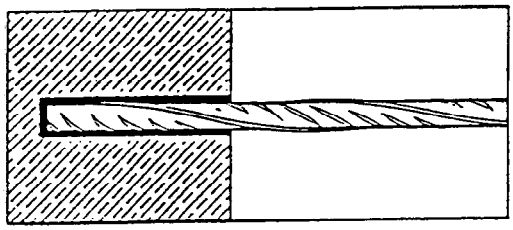
Floor connection



Concrete overlay connection



Wall connection

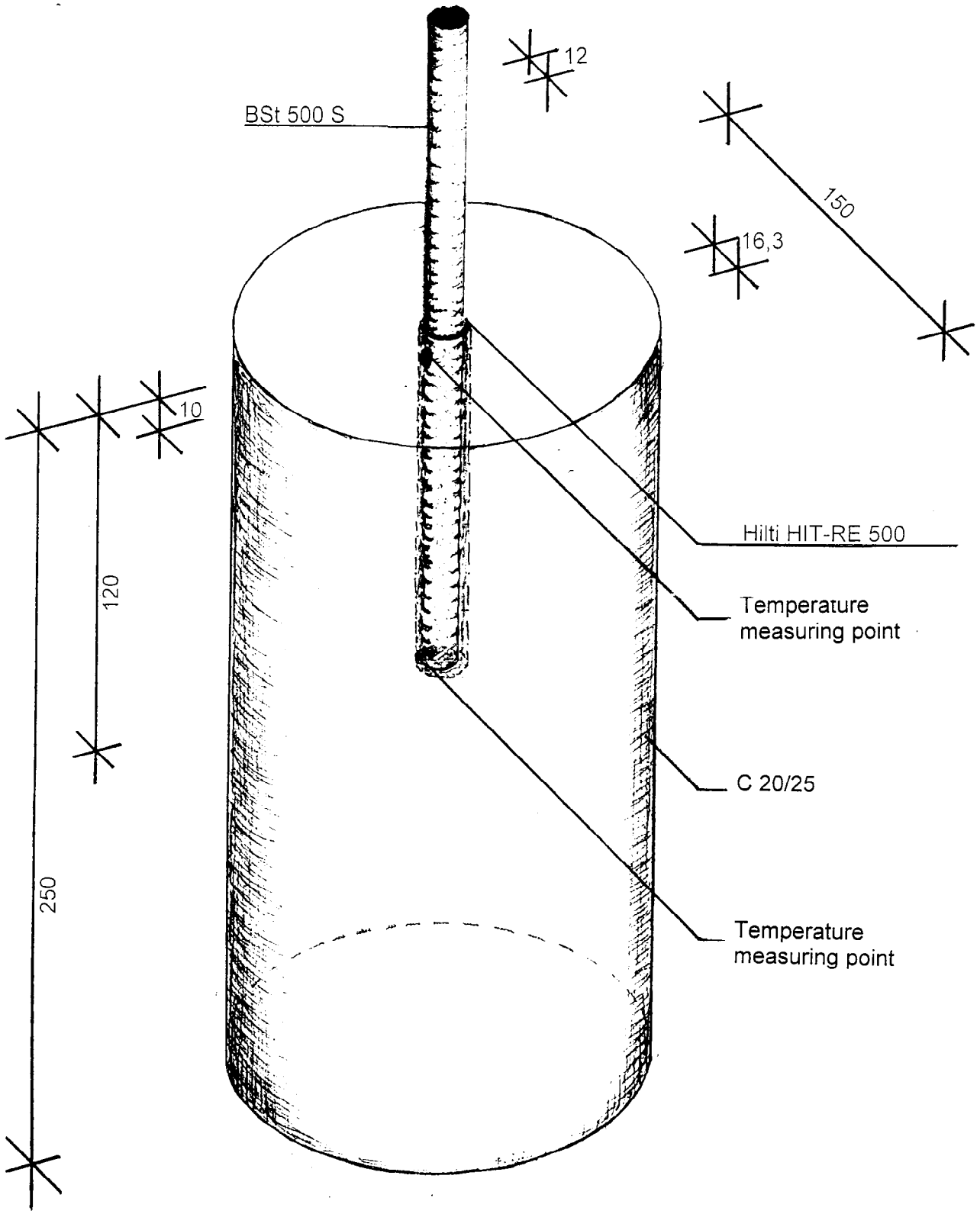


- Fastening of rebars
- As cast in
- High loads
- Design based on steel yield strength
- Design as per Eurocode 2
- Concrete and hard natural stone
- High level of safety / reliability
- Minimal displacement
- Small diameter of drilled hole
- Containing no styrene

- Automatic opening
- Reliable mixing
- Accurate dispensing
- Application friendly
- A coordinated complete system

Fields of application and design possibilities of Hilti HIT-RE 500 injection system	Annex 1 of Test Report No. 3357/0550-5 -Nau- dated July 30, 2002
Materialprüfanstalt für das Bauwesen Institut für Baustoffe, Massivbau und Brandschutz Technische Universität Braunschweig	

Test arrangement of rebars



Test arrangement of rebars

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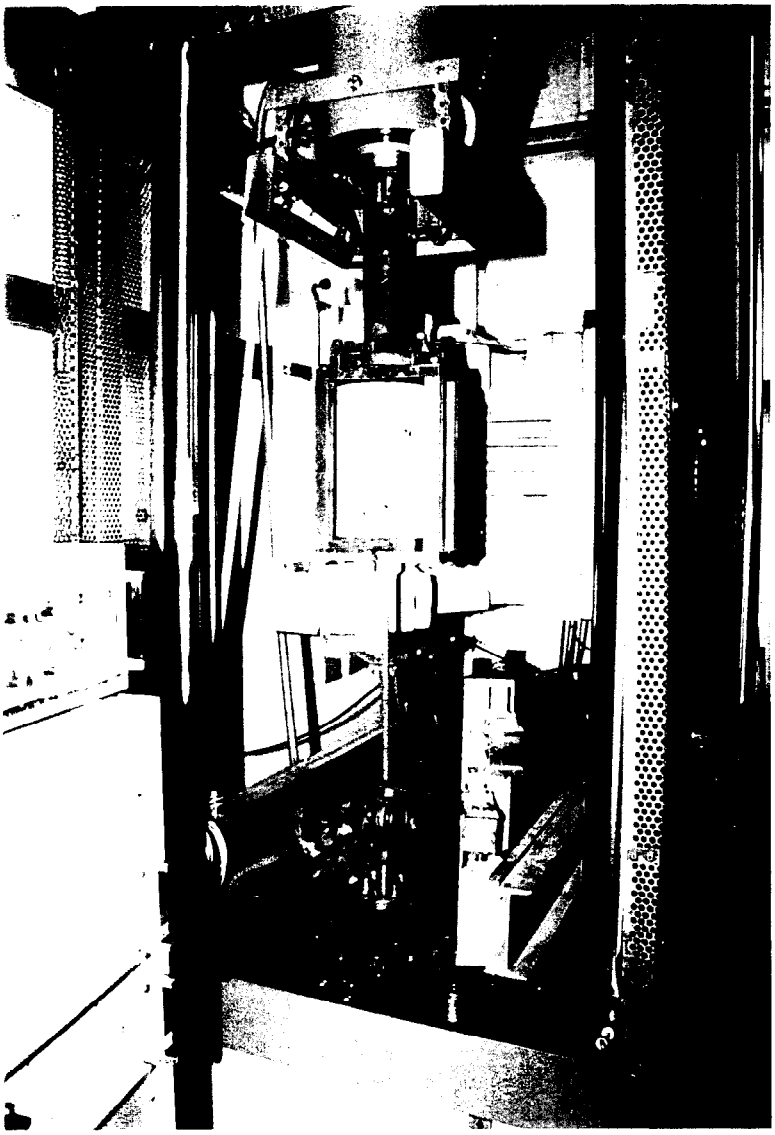

Testing equipment with built-in specimen

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Parameters specific to country for evaluating the maximum permissible force in a rebar as a function of the anchorage depth for the rebar connection version ANCHORING

Name of the Standard [---]	Country [---]	Partial safety factor for Permanent Load [---]	Partial safety factor for Steel [---]	Yielding point of the steel f_{yk} [N/mm²]	Rebar Diameter dia. [mm]
DIN 1045 - 1988	Germany	1.75		500	8, 10, 12, 14, 16, 20, 25, 32, 36 and 40
DIN 1045 - 2001		1.35	1.15	500	
EC 2 - 1992	Europe	1.35	1.15	500	
B 4700 - 2000	Austria	1.35	1.15	550	8, 10, 12, 14, 16, 20, 26, 30, 36 and 40
BS 8110 : 1 - 1997	Great Britain	1.40	1.05	460	8, 10, 12, 14, 16, 20, 25, 28, 32, 36 and 40
CP - 65 : 1999	Singapore	1.40	1.15	460	8, 10, 13, 16, 20, 22, 25, 28, 32 and 40
AS 3600 - 2001	Australia	1.25	0.80 *)	400 500	8, 10, 12, 16, 20, 22, 25, 28, 32 and 40

*) Reduction factor which must be added to the numerator.

Maximum connection force of rebar as per German Standard DIN 1045 – 1988 concerning ANCHORING during exposure to fire in relation to fire resistance times from 30 to 240 Minutes

Nominal rebar diameter	Drill hole diameter	Maximum force in rebar	Anchorage depth	Maximum force in rebar in conjunction with Hilti HIT-RE 500 (yielding point f_{yk} = 500 N/mm²) as a function of fire resistance class					
dia.	D	$F_{s,T}$	L	F30	F60	F90	F120	F180	F240
mm	mm	kN	mm	kN	kN	kN	kN	kN	kN
8	10	14.36	65	1.38	0.57	0.19	0.05	0	0
			80	2.35	1.02	0.47	0.26	0	0
			95	3.87	1.68	0.88	0.55	0.12	0
			115	7.30	3.07	1.71	1.14	0.44	0.18
			145	14.36	7.12	4.01	2.74	1.23	0.69
			175		14.36	8.80	5.96	2.62	1.52
			200			14.36	11.00	4.57	2.59
			215				14.36	6.27	3.48
			260					14.36	7.86
			300						14.36
10	12	22.44	80	2.94	1.27	0.59	0.33	0	0
			100	5.68	2.45	1.31	0.85	0.24	0
			120	10.66	4.44	2.48	1.68	0.68	0.31
			140	17.57	7.76	4.38	2.99	1.33	0.73
			155	22.44	11.66	6.55	4.47	2.01	1.15
			190		22.44	15.91	10.78	4.59	2.64
			210			22.44	17.21	7.06	3.95
			230				22.44	10.66	5.75
			270					22.44	11.68
			310						22.44
12	16	32.31	95	5.80	2.52	1.32	0.83	0.18	0
			120	12.79	5.33	2.97	2.01	0.82	0.37
			145	23.16	10.68	6.02	4.12	1.84	1.03
			170	32.31	20.15	11.61	7.88	3.49	2.03
			200		32.31	23.24	16.50	6.85	3.89
			225			32.31	26.87	11.55	6.29
			240				32.31	15.66	8.28
			285					32.31	18.10
			325						32.31
14	18	43.98	110	10.92	4.65	2.55	1.70	0.61	0.20
			140	24.60	10.87	6.13	4.19	1.86	1.03
			170	39.12	23.50	13.55	9.20	4.07	2.37
			185	43.98	30.76	19.85	13.36	5.75	3.32
			215		43.98	34.36	26.51	10.97	6.08
			235			43.98	36.18	16.52	8.82
			255				43.98	24.65	12.60
			295					43.98	25.00
			335						43.98
16	20	57.45	130	22.59	9.42	5.30	3.61	1.56	0.80
			160	39.17	21.33	11.95	8.15	3.65	2.11
			195	57.45	40.69	28.22	19.49	8.20	4.68
			230		57.45	47.57	38.59	17.06	9.20
			250			57.45	49.65	25.51	13.19
			265				57.45	33.70	17.14
			310					57.45	36.55
			350						57.45

Comments : Intermediate values may be obtained by linear interpolation. Extrapolating is not permitted.

Evaluation of the maximum forces in rebars according to DIN 1045 - 1988 for a nominal bar diameter from 8 to 16 mm

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Maximum connection force of rebar as per German Standard DIN 1045 – 1988 concerning ANCHORING during exposure to fire in relation to fire resistance times from 30 to 240 Minutes

Nominal rebar diameter	Drill hole diameter	Maximum force in rebar	Anchorage depth	Maximum force in rebar in conjunction with Hilti HIT-RE 500 (yielding point f_{yk} = 500 N/mm²) as a function of fire resistance class					
dia.	D	$F_{s,T}$	L	F30	F60	F90	F120	F180	F240
mm	mm	kN	mm	kN	kN	kN	kN	kN	kN
20	25	89.76	160	48.97	26.67	14.93	10.18	4.56	2.64
			200	76.61	54.31	38.73	27.50	11.42	6.48
			220	89.76	68.14	52.55	41.32	17.38	9.56
			255		89.76	76.74	65.51	35.22	18.00
			275			89.76	79.34	49.04	25.45
			295				89.76	62.86	35.72
			335					89.76	62.96
			375						89.76
25	30	140.25	200	95.77	67.89	48.41	34.37	14.27	8.10
			250	138.96	111.09	91.60	77.57	39.86	20.61
			255	140.25	115.41	95.92	81.89	44.02	22.50
			285		140.25	121.84	107.81	69.94	37.71
			310			140.25	129.41	91.54	57.11
			325				140.25	104.50	70.07
			370					140.25	108.94
			410						140.25
32	40	229.79	255	183.40	147.72	122.78	104.82	56.35	28.80
			275	205.52	169.84	144.90	126.94	78.46	40.71
			300	229.79	197.48	172.54	154.58	106.11	62.15
			330		229.79	205.72	187.76	139.28	95.21
			355			229.79	215.40	166.93	122.86
			370				229.79	183.52	139.45
			415					229.79	189.21
			455						229.79
36	44	290.82	290	249.87	209.73	181.67	161.46	106.93	59.10
			305	268.53	228.39	200.33	180.13	125.59	76.01
			325	290.82	253.27	225.21	205.01	150.47	100.89
			360		290.82	268.76	248.55	194.02	144.44
			380			290.82	273.43	218.90	169.32
			395				290.82	237.56	187.98
			440					290.82	243.96
			480						290.82
40	47	359.04	320	319.10	274.50	243.33	220.87	160.28	105.19
			335	339.84	295.24	264.06	241.61	181.02	125.93
			350	359.04	315.97	284.80	262.34	201.75	146.66
			385		359.04	333.18	310.72	250.13	195.04
			405			359.04	338.37	277.78	222.69
			420				359.04	298.51	243.42
			465					359.04	305.63
			505						359.04

Comments : Intermediate values may be obtained by linear interpolation. Extrapolating is not permitted.

Evaluation of the maximum forces in rebars according to DIN 1045 - 1988 for a nominal bar diameter from 20 to 40 mm

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Maximale Stabkräfte gemäß DIN 1045 – 2001 bzw. EC 2 - 1992 unter Brandbeanspruchung für die Bewehrungsanschlußvariante VERANKERUNG bezogen auf Feuerwiderstandsdauern von 30 bis 240 Minuten

Nenn-durch-messer	Bohrloch-durch-messer	Maximale Stab-kraft	Ver-ankerungs-tiefe	Maximale Stabkraft in Verbindung mit Hilti HIT-RE 500 (Streckgrenze f_{yk} = 500 N/mm²) in Abhängigkeit von der Feuerwiderstandsdauer					
Ø	D	$F_{s,T}$	L	F30	F60	F90	F120	F180	F240
mm	mm	kN	mm	kN	kN	kN	kN	kN	kN
8	10	16.19	65	1.38	0.57	0.19	0.05	0	0
			80	2.35	1.02	0.47	0.26	0	0
			95	3.87	1.68	0.88	0.55	0.12	0
			115	7.30	3.07	1.71	1.14	0.44	0.18
			150	16.19	8.15	4.59	3.14	1.41	0.80
			180		16.19	9.99	6.75	2.94	1.70
			205			16.19	12.38	5.08	2.86
			220				16.19	6.95	3.82
			265					16.19	8.57
			305						16.19
10	12	25.29	80	2.94	1.27	0.59	0.33	0	0
			100	5.68	2.45	1.31	0.85	0.24	0
			120	10.66	4.44	2.48	1.68	0.68	0.31
			140	17.57	7.76	4.38	2.99	1.33	0.73
			165	25.29	15.06	8.50	5.79	2.58	1.50
			195		25.29	17.63	12.18	5.12	2.93
			220			25.29	20.66	8.69	4.78
			235				25.29	11.80	6.30
			280					25.29	13.86
			320						25.29
12	16	36.42	95	5.80	2.52	1.32	0.83	0.18	0
			120	12.79	5.33	2.97	2.01	0.82	0.37
			145	23.16	10.68	6.02	4.12	1.84	1.03
			180	36.42	24.29	14.99	10.12	4.41	2.55
			210		36.42	27.38	20.65	8.47	4.74
			235			36.42	31.01	14.16	7.56
			250				36.42	19.13	9.89
			295					36.42	21.43
			335						36.42
14	18	49.58	110	10.92	4.65	2.55	1.70	0.61	0.20
			140	24.60	10.87	6.13	4.19	1.86	1.03
			170	39.12	23.50	13.55	9.20	4.07	2.37
			195	49.58	35.60	24.69	17.05	7.17	4.10
			225		49.58	39.20	31.34	13.48	7.34
			250			49.58	43.44	22.32	11.54
			265				49.58	29.49	15.00
			310					49.58	31.98
			350						49.58
16	20	64.75	130	22.59	9.42	5.30	3.61	1.56	0.80
			160	39.17	21.33	11.95	8.15	3.65	2.11
			190	55.76	37.92	25.45	17.25	7.35	4.22
			210	64.75	48.98	36.51	27.53	11.29	6.32
			240		64.75	53.10	44.12	20.88	11.04
			265			64.75	57.94	33.70	17.14
			280				64.75	42.00	22.17
			325					64.75	44.84
			365						64.75

Hinweis : Zwischenwerte dürfen linear interpoliert werden. Eine Extrapolation ist nicht erlaubt.

Evaluation of the maximum forces in rebars according to DIN 1045 - 2001 and Eurocode 2 – 1992 for a nominal bar diameter from 8 to 16 mm (in German)

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Maximale Stabkräfte gemäß DIN 1045 – 2001 bzw. EC 2 - 1992 unter Brandbeanspruchung für die Bewehrungsanschlußvariante VERANKERUNG bezogen auf Feuerwiderstandsdauern von 30 bis 240 Minuten

Nenn-durch-messer	Bohrloch-durch-messer	Maximale Stab-kraft	Ver-ankerungs-tiefe	Maximale Stabkraft in Verbindung mit Hilti HIT-RE 500 (Streckgrenze f_{yk} = 500 N/mm²) in Abhängigkeit von der Feuerwiderstandsdauer					
Ø	D	$F_{s,T}$	L	F30	F60	F90	F120	F180	F240
mm	mm	kN	mm	kN	kN	kN	kN	kN	kN
20	25	101.18	160	48.97	26.67	14.93	10.18	4.56	2.64
			200	76.61	54.31	38.73	27.50	11.42	6.48
			240	101.18	81.96	66.37	55.15	26.10	13.80
			270		101.18	87.11	75.88	45.58	23.36
			295			101.18	93.16	62.86	35.72
			310				101.18	73.23	45.69
			355					101.18	76.79
			395						101.18
25	30	158.09	200	95.77	67.89	48.41	34.37	14.27	8.10
			250	138.96	111.09	91.60	77.57	39.86	20.61
			275	158.09	132.69	113.20	99.17	61.30	31.81
			305		158.09	139.12	125.09	87.22	52.79
			330			158.09	146.69	108.82	74.39
			345				158.09	121.77	87.34
			390					158.09	126.22
			430						158.09
32	40	259.02	255	183.40	147.72	122.78	104.82	56.35	28.80
			275	205.52	169.84	144.90	126.94	78.46	40.71
			325	259.02	225.13	200.19	182.23	133.75	89.68
			360		259.02	238.89	220.93	172.46	128.39
			380			259.02	243.05	194.58	150.51
			395				259.02	211.16	167.09
			440					259.02	216.86
			480						259.02
36	44	327.82	290	249.87	209.73	181.67	161.46	106.93	59.10
			325	293.41	253.27	225.21	205.01	150.47	100.89
			355	327.82	290.59	262.54	242.33	187.80	138.22
			385		327.82	299.86	279.65	225.12	175.54
			410			327.82	310.75	256.22	206.64
			425				327.82	274.88	225.30
			470					327.82	281.28
			510						327.82
40	47	404.71	320	319.10	274.50	243.33	220.87	160.28	105.19
			355	367.48	322.88	291.71	269.25	208.66	153.57
			385	404.71	364.35	333.18	310.72	250.13	195.04
			415		404.71	374.64	352.19	291.60	236.51
			440			404.71	386.75	326.16	271.07
			455				404.71	346.89	291.80
			500					404.71	354.01
			540						404.71

Hinweis : Zwischenwerte dürfen linear interpoliert werden. Eine Extrapolation ist nicht erlaubt.

Evaluation of the maximum forces in rebars according to DIN 1045 - 2001 and Eurocode 2 – 1992 for a nominal bar diameter from 20 to 40 mm (in German)

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Maximum connection force of rebar as per Eurocode 2 - 1992 concerning ANCHORING during exposure to fire in relation to fire resistance times from 30 to 240 minutes

Nominal rebar diameter	Drill hole diameter	Maximum force in rebar	Anchorage depth	Maximum force in rebar in conjunction with Hilti HIT-RE 500 (yielding point f_{yk} = 500 N/mm²) as a function of fire resistance class					
dia.	D	$F_{s,T}$	L	F30	F60	F90	F120	F180	F240
mm	mm	kN	mm	kN	kN	kN	kN	kN	kN
8	10	16.19	65	1.38	0.57	0.19	0.05	0	0
			80	2.35	1.02	0.47	0.26	0	0
			95	3.87	1.68	0.88	0.55	0.12	0
			115	7.30	3.07	1.71	1.14	0.44	0.18
			150	16.19	8.15	4.59	3.14	1.41	0.80
			180		16.19	9.99	6.75	2.94	1.70
			205			16.19	12.38	5.08	2.86
			220				16.19	6.95	3.82
			265					16.19	8.57
			305						16.19
10	12	25.29	80	2.94	1.27	0.59	0.33	0	0
			100	5.68	2.45	1.31	0.85	0.24	0
			120	10.66	4.44	2.48	1.68	0.68	0.31
			140	17.57	7.76	4.38	2.99	1.33	0.73
			165	25.29	15.06	8.50	5.79	2.58	1.50
			195		25.29	17.63	12.18	5.12	2.93
			220			25.29	20.66	8.69	4.78
			235				25.29	11.80	6.30
			280					25.29	13.86
			320						25.29
12	16	36.42	95	5.80	2.52	1.32	0.83	0.18	0
			120	12.79	5.33	2.97	2.01	0.82	0.37
			145	23.16	10.68	6.02	4.12	1.84	1.03
			180	36.42	24.29	14.99	10.12	4.41	2.55
			210		36.42	27.38	20.65	8.47	4.74
			235			36.42	31.01	14.16	7.56
			250				36.42	19.13	9.89
			295					36.42	21.43
			335						36.42
14	18	49.58	110	10.92	4.65	2.55	1.70	0.61	0.20
			140	24.60	10.87	6.13	4.19	1.86	1.03
			170	39.12	23.50	13.55	9.20	4.07	2.37
			195	49.58	35.60	24.69	17.05	7.17	4.10
			225		49.58	39.20	31.34	13.48	7.34
			250			49.58	43.44	22.32	11.54
			265				49.58	29.49	15.00
			310					49.58	31.98
			350						49.58
16	20	64.75	130	22.59	9.42	5.30	3.61	1.56	0.80
			160	39.17	21.33	11.95	8.15	3.65	2.11
			190	55.76	37.92	25.45	17.25	7.35	4.22
			210	64.75	48.98	36.51	27.53	11.29	6.32
			240		64.75	53.10	44.12	20.88	11.04
			265			64.75	57.94	33.70	17.14
			280				64.75	42.00	22.17
			325					64.75	44.84
			365						64.75

Comments : Intermediate values may be obtained by linear interpolation. Extrapolating is not permitted.

Evaluation of the maximum forces in rebars according to Eurocode 2 – 1992 for a nominal bar diameter from 8 to 16 mm

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Annex 9
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Maximum connection force of rebar as per Eurocode 2 - 1992 concerning ANCHORING during exposure to fire in relation to fire resistance times from 30 to 240 minutes

Nominal rebar diameter	Drill hole diameter	Maximum force in rebar	Anchorage depth	Maximum force in rebar in conjunction with Hilti HIT-RE 500 (yielding point f_{yk} = 500 N/mm²) as a function of fire resistance class					
dia.	D	$F_{s,T}$	L	F30	F60	F90	F120	F180	F240
mm	mm	kN	mm	kN	kN	kN	kN	kN	kN
20	25	101.18	160	48.97	26.67	14.93	10.18	4.56	2.64
			200	76.61	54.31	38.73	27.50	11.42	6.48
			240	101.18	81.96	66.37	55.15	26.10	13.80
			270		101.18	87.11	75.88	45.58	23.36
			295			101.18	93.16	62.86	35.72
			310				101.18	73.23	45.69
			355					101.18	76.79
			395						101.18
25	30	158.09	200	95.77	67.89	48.41	34.37	14.27	8.10
			250	138.96	111.09	91.60	77.57	39.86	20.61
			275	158.09	132.69	113.20	99.17	61.30	31.81
			305		158.09	139.12	125.09	87.22	52.79
			330			158.09	146.69	108.82	74.39
			345				158.09	121.77	87.34
			390					158.09	126.22
			430						158.09
32	40	259.02	255	183.40	147.72	122.78	104.82	56.35	28.80
			275	205.52	169.84	144.90	126.94	78.46	40.71
			325	259.02	225.13	200.19	182.23	133.75	89.68
			360		259.02	238.89	220.93	172.46	128.39
			380			259.02	243.05	194.58	150.51
			395				259.02	211.16	167.09
			440					259.02	216.86
			480						259.02
36	44	327.82	290	249.87	209.73	181.67	161.46	106.93	59.10
			325	293.41	253.27	225.21	205.01	150.47	100.89
			355	327.82	290.59	262.54	242.33	187.80	138.22
			385		327.82	299.86	279.65	225.12	175.54
			410			327.82	310.75	256.22	206.64
			425				327.82	274.88	225.30
			470					327.82	281.28
			510						327.82
40	47	404.71	320	319.10	274.50	243.33	220.87	160.28	105.19
			355	367.48	322.88	291.71	269.25	208.66	153.57
			385	404.71	364.35	333.18	310.72	250.13	195.04
			415		404.71	374.64	352.19	291.60	236.51
			440			404.71	386.75	326.16	271.07
			455				404.71	346.89	291.80
			500					404.71	354.01
			540						404.71

Comments : Intermediate values may be obtained by linear interpolation. Extrapolating is not permitted.

Evaluation of the maximum forces in rebars according to Eurocode 2 – 1992 for a nominal bar diameter from 20 to 40 mm

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Annex 10
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Force maximale de ou dans la barre selon NF-ENV 1991-2-2 : 1955-02 (Eurocode 2) sous tenue au feu pour l' ANCRAGE de barres d'armature en fonction des résistances au feu de 30 à 240 minutes

Diamètre nominal du fer HA	Diamètre de forage	Force maximale de barre	Longueur de scellement	Force maximale de barre pour Hilti HIT-RE 500 (limite d'étirage f_{yk} = 500 N/mm²) en fonction des classes de résistance au feu					
dia.	D	$F_{s,T}$	L	F30	F60	F90	F120	F180	F240
mm	mm	kN	mm	daN	daN	daN	daN	daN	daN
8	10	1619	65	138	57	19	5	0	0
			80	235	102	47	26	0	0
			95	387	168	88	55	12	0
			115	730	307	171	114	44	18
			150	1619	815	459	314	141	80
			180		1619	999	675	294	170
			205			1619	1238	508	286
			220				1619	695	382
			265					1619	857
			305						1619
10	12	2529	80	294	127	59	33	0	0
			100	568	245	131	85	24	0
			120	1066	444	248	168	68	31
			140	1757	776	438	299	133	73
			165	2529	1506	850	579	258	150
			195		2529	1763	1218	512	293
			220			2529	2066	869	478
			235				2529	1180	630
			280					2529	1386
			320						2529
12	16	3642	95	580	252	132	83	18	0
			120	1279	533	297	201	82	37
			145	2316	1068	602	412	184	103
			180	3642	2429	1499	1012	441	255
			210		3642	2738	2065	847	474
			235			3642	3101	1416	756
			250				3642	1913	989
			295					3642	2143
			335						3642
14	18	4958	110	1092	465	255	170	61	20
			140	2460	1087	613	419	186	103
			170	3912	2350	1355	920	407	237
			195	4958	3560	2469	1705	717	410
			225		4958	3920	3134	1348	734
			250			4958	4344	2232	1154
			265				4958	2949	1500
			310					4958	3198
			350						4958
16	20	6475	130	2259	942	530	361	156	80
			160	3917	2133	1195	815	365	211
			190	5576	3792	2545	1725	735	422
			210	6475	4898	3651	2753	1129	632
			240		6475	5310	4412	2088	1104
			265			6475	5794	3370	1714
			280				6475	4200	2217
			325					6475	4484
			365						6475

Remarque : Les Valeurs intermédiaires peuvent être obtenues par interpolation linéaire. Extrapolation n'est pas permis.

Evaluation of the maximum forces in rebars according to NF-ENV 1991-2-2 : 1955-02 (Eurocode 2) for a nominal bar diameter from 8 to 16 mm (in French)

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Force maximale de ou dans la barre selon NF-ENV 1991-2-2 : 1955-02 (Eurocode 2) sous tenue au feu pour l' ANCRAGE de barres d'armature en fonction des résistances au feu de 30 à 240 minutes

Diamètre nominal du fer HA	Diamètre de forage	Force maximale de barre	Longueur de scellement	Force maximale de barre pour Hilti HIT-RE 500 (limite d'étirage f_{yk} = 500 N/mm²) en fonction des classes de résistance au feu					
dia.	D	$F_{s,T}$	L	F30	F60	F90	F120	F180	F240
mm	mm	kN	mm	daN	daN	daN	daN	daN	daN
20	25	10118	160	4897	2667	1493	1018	456	264
			200	7661	5431	3873	2750	1142	648
			240	10118	8196	6637	5515	2610	1380
			270		10118	8711	7588	4558	2336
			295			10118	9316	6286	3572
			310				10118	7323	4569
			355					10118	7679
			395						10118
25	30	15809	200	9577	6789	4841	3437	1427	810
			250	13896	11109	9160	7757	3986	2061
			275	15809	13269	11320	9917	6130	3181
			305		15809	13912	12509	8722	5279
			330			15809	14669	10882	7439
			345				15809	12177	8734
			390					15809	12622
			430						15809
32	40	25902	255	18340	14772	12278	10482	5635	2880
			275	20552	16984	14490	12694	7846	4071
			325	25902	22513	20019	18223	13375	8968
			360		25902	23889	22093	17246	12839
			380			25902	24305	19458	15051
			395				25902	21116	16709
			440					25902	21686
			480						25902
36	44	32782	290	24987	20973	18167	16146	10693	5910
			325	29341	25327	22521	20501	15047	10089
			355	32782	29059	26254	24233	18780	13822
			385		32782	29986	27965	22512	17554
			410			32782	31075	25622	20664
			425				32782	27488	22530
			470					32782	28128
			510						32782
40	47	40471	320	31910	27450	24333	22087	16028	10519
			355	36748	32288	29171	26925	20866	15357
			385	40471	36435	33318	31072	25013	19504
			415		40471	37464	35219	29160	23651
			440			40471	38675	32616	27107
			455				40471	34689	29180
			500					40471	35401
			540						40471

Remarque : Les Valeurs intermédiaires peuvent être obtenues par interpolation linéaire. Extrapolation n'est pas permis.

Evaluation of the maximum forces in rebars according to NF-ENV 1991-2-2 : 1955-02 (Eurocode 2) for a nominal bar diameter from 20 to 40 mm (in French)

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Maximum connection force of rebar as per Austrian Standard B 4700 – 2000 concerning ANCHORING during exposure to fire in relation to fire resistance times from 30 to 240 Minutes

Nominal rebar diameter	Drill hole diameter	Maximum force in rebar	Anchorage depth	Maximum force in rebar in conjunction with Hilti HIT-RE 500 (yielding point f_{yk} = 550 N/mm²) as a function of fire resistance class					
dia.	D	$F_{s,T}$	L	F30	F60	F90	F120	F180	F240
mm	mm	kN	mm	kN	kN	kN	kN	kN	kN
8	10	17.81	65	1.38	0.57	0.19	0.05	0	0
			80	2.35	1.02	0.47	0.26	0	0
			95	3.87	1.68	0.88	0.55	0.12	0
			115	7.30	3.07	1.71	1.14	0.44	0.18
			155	17.81	9.33	5.24	3.58	1.61	0.92
			190		17.81	12.73	8.63	3.67	2.11
			210			17.81	13.76	5.65	3.16
			225				17.81	7.70	4.20
			270					17.81	9.34
			310						17.81
10	12	27.82	80	2.94	1.27	0.59	0.33	0	0
			100	5.68	2.45	1.31	0.85	0.24	0
			120	10.66	4.44	2.48	1.68	0.68	0.31
			140	17.57	7.76	4.38	2.99	1.33	0.73
			170	27.82	16.79	9.68	6.57	2.91	1.69
			205		27.82	21.09	15.48	6.35	3.58
			225			27.82	22.39	9.63	5.25
			245				27.82	14.43	7.54
			285					27.82	15.08
			325						27.82
12	16	40.07	95	5.80	2.52	1.32	0.83	0.18	0
			120	12.79	5.33	2.97	2.01	0.82	0.37
			145	23.16	10.68	6.02	4.12	1.84	1.03
			190	40.07	28.44	19.09	12.94	5.51	3.17
			220		40.07	31.53	24.79	10.43	5.73
			245			40.07	35.16	17.31	9.05
			260				40.07	23.20	11.79
			305					40.07	25.34
			345						40.07
14	18	54.54	110	10.92	4.65	2.55	1.70	0.61	0.20
			140	24.60	10.87	6.13	4.19	1.86	1.03
			170	39.12	23.50	13.55	9.20	4.07	2.37
			205	54.54	40.44	29.53	21.67	8.89	5.01
			235		54.54	44.04	36.18	16.52	8.82
			260			54.54	48.28	27.07	13.75
			275				54.54	34.33	17.81
			320					54.54	36.82
			360						54.54
16	20	71.23	130	22.59	9.42	5.30	3.61	1.56	0.80
			160	39.17	21.33	11.95	8.15	3.65	2.11
			190	55.76	37.92	25.45	17.25	7.35	4.22
			220	71.23	54.51	42.04	33.06	13.90	7.64
			255		71.23	61.39	52.41	28.17	14.40
			275			71.23	63.47	39.23	20.36
			290				71.23	47.52	26.26
			335					71.23	50.37
			375						71.23

Comments : Intermediate values may be obtained by linear interpolation. Extrapolating is not permitted.

Evaluation of the maximum forces in rebars according to Austrian Standard B 4700 - 2000 for a nominal bar diameter from 8 to 16 mm

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Maximum connection force of rebar as per Austrian Standard B 4700 – 2000 concerning ANCHORING during exposure to fire in relation to fire resistance times from 30 to 240 Minutes

Nominal rebar diameter	Drill hole diameter	Maximum force in rebar	Anchorage depth	Maximum force in rebar in conjunction with Hilti HIT-RE 500 (yielding point f_{yk} = 550 N/mm²) as a function of fire resistance class					
dia.	D	$F_{s,T}$	L	F30	F60	F90	F120	F180	F240
mm	mm	kN	mm	kN	kN	kN	kN	kN	kN
20	25	111.30	160	48.97	26.67	14.93	10.18	4.56	2.64
			200	76.61	54.31	38.73	27.50	11.42	6.48
			240	104.26	81.96	66.37	55.15	26.10	13.80
			255	111.30	92.33	76.74	65.51	35.22	18.00
			285		111.30	97.47	86.25	55.95	30.17
			305			111.30	100.07	69.77	42.23
			325				111.30	83.60	56.05
			370					111.30	87.15
			405						111.30
26	34	188.09	210	108.58	79.59	59.33	44.73	18.35	10.26
			260	153.51	124.52	104.25	89.66	50.27	25.54
			300	188.09	160.46	140.19	125.60	86.21	50.49
			335		188.09	171.64	157.05	117.66	81.85
			355			188.09	175.02	135.63	99.82
			370				188.09	149.11	113.30
			415					188.09	153.73
			455						188.09
30	38	250.42	240	156.39	122.94	99.56	82.72	39.16	20.69
			300	218.59	185.14	161.76	144.92	99.48	58.26
			335	250.42	221.43	198.05	181.21	135.76	94.45
			365		250.42	229.15	212.31	166.86	125.55
			390			250.42	238.23	192.78	151.47
			405				250.42	208.33	167.02
			450					250.42	213.67
			490						250.42
36	44	360.60	290	249.87	209.73	181.67	161.46	106.93	59.10
			360	336.96	296.81	268.76	248.55	194.02	144.44
			380	360.60	321.70	293.64	273.43	218.90	169.32
			415		360.60	337.18	316.97	262.44	212.86
			435			360.60	341.86	287.32	237.74
			455				360.60	312.20	262.62
			495					360.60	312.39
			535						360.60
40	47	445.19	320	319.10	274.50	243.33	220.87	160.28	105.19
			400	429.69	385.09	353.91	331.46	270.87	215.78
			415	445.19	405.82	374.64	352.19	291.60	236.51
			445		445.19	416.11	393.66	333.07	277.98
			470			445.19	428.22	367.63	312.54
			485				445.19	388.36	333.27
			530					445.19	395.48
			570						445.19

Comments : Intermediate values may be obtained by linear interpolation. Extrapolating is not permitted.

Evaluation of the maximum forces in rebars according to Austrian Standard B 4700 - 2000 for a nominal bar diameter from 20 to 40 mm

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Maximum connection force of rebar as per British Standard BS 8110 : 1 – 1997 concerning ANCHORING during exposure to fire in relation to fire resistance times from 30 to 240 Minutes

Nominal rebar diameter	Drill hole diameter	Maximum force in rebar	Anchorage depth	Maximum force in rebar in conjunction with Hilti HIT-RE 500 (yielding point f_{yk} = 460 N/mm²) as a function of fire resistance class					
dia.	D	$F_{s,T}$	L	F30	F60	F90	F120	F180	F240
mm	mm	kN	mm	kN	kN	kN	kN	kN	kN
8	10	15.73	65	1.38	0.57	0.19	0.05	0	0
			80	2.35	1.02	0.47	0.26	0	0
			95	3.87	1.68	0.88	0.55	0.12	0
			115	7.30	3.07	1.71	1.14	0.44	0.18
			150	15.73	8.15	4.59	3.14	1.41	0.80
			180		15.73	9.99	6.75	2.94	1.70
			205			15.73	12.38	5.08	2.86
			220				15.73	6.95	3.82
			265					15.73	8.57
			305						15.73
10	12	24.58	80	2.94	1.27	0.59	0.33	0	0
			100	5.68	2.45	1.31	0.85	0.24	0
			120	10.66	4.44	2.48	1.68	0.68	0.31
			140	17.57	7.76	4.38	2.99	1.33	0.73
			165	24.58	15.06	8.50	5.79	2.58	1.50
			195		24.58	17.63	12.18	5.12	2.93
			220			24.58	20.66	8.69	4.78
			235				24.58	11.80	6.30
			280					24.58	13.86
			320						24.58
12	16	35.39	95	5.80	2.52	1.32	0.83	0.18	0
			120	12.79	5.33	2.97	2.01	0.82	0.37
			145	23.16	10.68	6.02	4.12	1.84	1.03
			175	35.39	22.22	13.20	8.94	3.93	2.28
			210		35.39	27.38	20.65	8.47	4.74
			230			35.39	28.94	12.80	6.90
			250				35.39	19.13	9.89
			290					35.39	19.70
			330						35.39
14	18	48.17	110	10.92	4.65	2.55	1.70	0.61	0.20
			140	24.60	10.87	6.13	4.19	1.86	1.03
			170	39.12	23.50	13.55	9.20	4.07	2.37
			190	48.17	33.18	22.27	15.10	6.43	3.69
			225		48.17	39.20	31.34	13.48	7.34
			245			48.17	41.02	20.20	10.56
			260				48.17	27.07	13.75
			305					48.17	29.56
			345						48.17
16	20	62.92	130	22.59	9.42	5.30	3.61	1.56	0.80
			160	39.17	21.33	11.95	8.15	3.65	2.11
			190	55.76	37.92	25.45	17.25	7.35	4.22
			205	62.92	46.21	33.74	24.76	10.16	5.73
			240		62.92	53.10	44.12	20.88	11.04
			260			62.92	55.17	30.94	15.72
			275				62.92	39.23	20.36
			320					62.92	42.08
			360						62.92

Comments : Intermediate values may be obtained by linear interpolation. Extrapolating is not permitted.

Evaluation of the maximum forces in rebars according to British Standard BS 8110 : 1 - 1997 for a nominal bar diameter from 8 to 16 mm

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Maximum connection force of rebar as per British Standard BS 8110 : 1 – 1997 concerning ANCHORING during exposure to fire in relation to fire resistance times from 30 to 240 Minutes

Nominal rebar diameter	Drill hole diameter	Maximum force in rebar	Anchorage depth	Maximum force in rebar in conjunction with Hilti HIT-RE 500 (yielding point f_{yk} = 460 N/mm²) as a function of fire resistance class					
dia.	D	$F_{s,T}$	L	F30	F60	F90	F120	F180	F240
mm	mm	kN	mm	kN	kN	kN	kN	kN	kN
20	25	98.31	160	48.97	26.67	14.93	10.18	4.56	2.64
			200	76.61	54.31	38.73	27.50	11.42	6.48
			235	98.31	78.50	62.92	51.69	23.60	12.60
			265		98.31	83.65	72.42	42.13	21.43
			290			98.31	89.70	59.41	32.83
			305				98.31	69.77	42.23
			350					98.31	73.33
			390						98.31
25	30	153.61	200	95.77	67.89	48.41	34.37	14.27	8.10
			250	138.96	111.09	91.60	77.57	39.86	20.61
			270	153.61	128.37	108.88	94.85	56.98	29.19
			300		153.61	134.80	120.77	82.90	48.55
			325			153.61	142.37	104.50	70.07
			340				153.61	117.45	83.02
			385					153.61	121.90
			425						153.61
28	35	192.68	225	131.45	100.23	78.41	62.69	26.96	14.69
			250	155.64	124.42	102.60	86.88	44.64	23.08
			290	192.68	163.12	141.30	125.58	83.17	45.96
			325		192.68	175.17	159.45	117.04	78.47
			345			192.68	178.80	136.39	97.83
			360				192.68	150.90	112.34
			405					192.68	155.88
			445						192.68
32	40	251.67	255	183.40	147.72	122.78	104.82	56.35	28.80
			280	211.05	175.37	150.43	132.47	83.99	44.34
			320	251.67	219.60	194.66	176.70	128.23	84.15
			350		251.67	227.84	209.87	161.40	117.33
			375			251.67	237.52	189.05	144.98
			390				251.67	205.63	161.56
			435					251.67	211.33
			475						251.67
36	44	318.52	290	249.87	209.73	181.67	161.46	106.93	59.10
			320	287.19	247.05	218.99	198.79	144.25	94.67
			350	318.52	284.37	256.32	236.11	181.58	132.00
			380		318.52	293.64	273.43	218.90	169.32
			400			318.52	298.31	243.78	194.20
			420				318.52	268.66	219.08
			465					318.52	275.06
			500						318.52
40	47	393.23	320	319.10	274.50	243.33	220.87	160.28	105.19
			350	360.57	315.97	284.80	262.34	201.75	146.66
			375	393.23	350.53	319.35	296.90	236.31	181.22
			410		393.23	367.73	345.28	284.69	229.60
			430			393.23	372.93	312.33	257.25
			445				393.23	333.07	277.98
			490					393.23	340.18
			530						393.23

Comments : Intermediate values may be obtained by linear interpolation. Extrapolating is not permitted.

Evaluation of the maximum forces in rebars according to British Standard BS 8110 : 1 - 1997 for a nominal bar diameter from 20 to 40 mm

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Maximum connection force of rebar as per Singapore Standard CP - 65 : 1999 concerning ANCHORING during exposure to fire in relation to fire resistance times from 30 to 240 Minutes

Nominal rebar diameter	Drill hole diameter	Maximum force in rebar	Anchorage depth	Maximum force in rebar in conjunction with Hilti HIT-RE 500 (yielding point f_{yk} = 460 Mpa) as a function of fire resistance class					
dia.	D	$F_{s,T}$	L	F30	F60	F90	F120	F180	F240
mm	mm	kN	mm	kN	kN	kN	kN	kN	kN
8	10	14.36	65	1.38	0.57	0.19	0.05	0	0
			80	2.35	1.02	0.47	0.26	0	0
			95	3.87	1.68	0.88	0.55	0.12	0
			115	7.30	3.07	1.71	1.14	0.44	0.18
			145	14.36	7.12	4.01	2.74	1.23	0.69
			175		14.36	8.80	5.96	2.62	1.52
			200			14.36	11.00	4.57	2.59
			215				14.36	6.27	3.48
			260					14.36	7.86
			300						14.36
10	12	22.44	80	2.94	1.27	0.59	0.33	0	0
			100	5.68	2.45	1.31	0.85	0.24	0
			120	10.66	4.44	2.48	1.68	0.68	0.31
			140	17.57	7.76	4.38	2.99	1.33	0.73
			155	22.44	11.66	6.55	4.47	2.01	1.15
			190		22.44	15.91	10.78	4.59	2.64
			210			22.44	17.21	7.06	3.95
			230				22.44	10.66	5.75
			270					22.44	11.68
			310						22.44
13	18	37.92	105	8.66	3.72	2.02	1.33	0.43	0.09
			130	18.35	7.65	4.31	2.94	1.27	0.65
			155	29.58	15.16	8.51	5.81	2.61	1.50
			175	37.92	24.07	14.30	9.68	4.25	2.47
			210		37.92	29.66	22.37	9.17	5.13
			230			37.92	31.35	13.86	7.48
			245				37.92	18.76	9.81
			290					37.92	21.34
			330						37.92
16	20	57.45	130	22.59	9.42	5.30	3.61	1.56	0.80
			160	39.17	21.33	11.95	8.15	3.65	2.11
			195	57.45	40.69	28.22	19.49	8.20	4.68
			230		57.45	47.57	38.59	17.06	9.20
			250			57.45	49.65	25.51	13.19
			265				57.45	33.70	17.14
			310					57.45	36.55
			350						57.45
20	25	89.76	160	48.97	26.67	14.93	10.18	4.56	2.64
			200	76.61	54.31	38.73	27.50	11.42	6.48
			220	89.76	68.14	52.55	41.32	17.38	9.56
			255		89.76	76.74	65.51	35.22	18.00
			275			89.76	79.34	49.04	25.45
			295				89.76	62.86	35.72
			335					89.76	62.96
			375						89.76

Comments : Intermediate values may be obtained by linear interpolation. Extrapolating is not permitted.

Evaluation of the maximum forces in rebars according to Singapore Standard CP - 65 : 1999 for a nominal bar diameter from 8 to 20 mm

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Maximum connection force of rebar as per Singapore Standard CP - 65 : 1999 concerning ANCHORING during exposure to fire in relation to fire resistance times from 30 to 240 Minutes

Nominal rebar diameter	Drill hole diameter	Maximum force in rebar	Anchorage depth	Maximum force in rebar in conjunction with Hilti HIT-RE 500 (yielding point f_{yk} = 460 Mpa) as a function of fire resistance class					
dia.	D	$F_{s,T}$	L	F30	F60	F90	F120	F180	F240
mm	mm	kN	mm	kN	kN	kN	kN	kN	kN
22	28	108.61	175	65.27	40.74	24.20	16.38	7.20	4.18
			220	99.48	74.95	57.80	45.45	19.11	10.51
			235	108.61	86.35	69.21	56.86	25.96	13.86
			265		108.61	92.01	79.67	46.34	23.57
			290			108.61	98.67	65.35	36.11
			305				108.61	76.75	46.45
			350					108.61	80.66
			390						108.61
25	30	140.25	200	95.77	67.89	48.41	34.37	14.27	8.10
			250	138.96	111.09	91.60	77.57	39.86	20.61
			255	140.25	115.41	95.92	81.89	44.02	22.50
			285		140.25	121.84	107.81	69.94	37.71
			310			140.25	129.41	91.54	57.11
			325				140.25	104.50	70.07
			370					140.25	108.94
			410						140.25
28	35	175.93	225	131.45	100.23	78.41	62.69	26.96	14.69
			250	155.64	124.42	102.60	86.88	44.64	23.08
			275	175.93	148.61	126.79	111.07	68.65	35.62
			305		175.93	155.81	140.10	97.68	59.12
			330			175.93	164.29	121.87	83.31
			345				175.93	136.39	97.83
			390					175.93	141.37
			430						175.93
32	40	229.79	255	183.40	147.72	122.78	104.82	56.35	28.80
			280	211.05	175.37	150.43	132.47	83.99	44.34
			300	229.79	197.48	172.54	154.58	106.11	62.15
			330		229.79	205.72	187.76	139.28	95.21
			355			229.79	215.40	166.93	122.86
			370				229.79	183.52	139.45
			415					229.79	189.21
			455						229.79
40	47	359.04	320	319.10	274.50	243.33	220.87	160.28	105.19
			335	339.84	295.24	264.06	241.61	181.02	125.93
			350	359.04	315.97	284.80	262.34	201.75	146.66
			385		359.04	333.18	310.72	250.13	195.04
			405			359.04	338.37	277.78	222.69
			420				359.04	298.51	243.42
			465					359.04	305.63
			505						359.04

Comments : Intermediate values may be obtained by linear interpolation. Extrapolating is not permitted.

Evaluation of the maximum forces in rebars according to Singapore Standard CP - 65 : 1999 for a nominal bar diameter from 22 to 40 mm

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Maximum connection force of rebar as per Australian Standard AS 3600 - 2001 concerning ANCHORING during exposure to fire in relation to fire resistance times from 30 to 240 Minutes (yielding point f_{yk} = 400 Mpa)

Nominal rebar diameter	Drill hole diameter	Maximum force in rebar	Anchorage depth	Maximum force in rebar in conjunction with Hilti HIT-RE 500 (yielding point f_{yk} = 400 Mpa) as a function of fire resistance class					
dia.	D	$F_{s,T}$	L	F30	F60	F90	F120	F180	F240
mm	mm	kN	mm	kN	kN	kN	kN	kN	kN
8	10	12.87	65	1.38	0.57	0.19	0.05	0	0
			80	2.35	1.02	0.47	0.26	0	0
			95	3.87	1.68	0.88	0.55	0.12	0
			115	7.30	3.07	1.71	1.14	0.44	0.18
			140	12.87	6.21	3.50	2.39	1.06	0.59
			170		12.87	7.74	5.26	2.33	1.35
			195			12.87	9.74	4.10	2.34
			210				12.87	5.65	3.16
			255					12.87	7.20
			290						12.87
10	12	20.11	80	2.94	1.27	0.59	0.33	0	0
			100	5.68	2.45	1.31	0.85	0.24	0
			120	10.66	4.44	2.48	1.68	0.68	0.31
			140	17.57	7.76	4.38	2.99	1.33	0.73
			150	20.11	10.19	5.74	3.92	1.76	1.00
			180		20.11	12.49	8.43	3.67	2.13
			205			20.11	15.48	6.35	3.58
			220				20.11	8.69	4.78
			265					20.11	10.71
			305						20.11
12	16	28.95	95	5.80	2.52	1.32	0.83	0.18	0
			120	12.79	5.33	2.97	2.01	0.82	0.37
			145	23.16	10.68	6.02	4.12	1.84	1.03
			160	28.95	16.00	8.96	6.11	2.74	1.58
			195		28.95	21.16	14.62	6.15	3.51
			215			28.95	22.72	9.40	5.21
			235				28.95	14.16	7.56
			275					28.95	15.27
			315						28.95
16	20	51.47	130	22.59	9.42	5.30	3.61	1.56	0.80
			160	39.17	21.33	11.95	8.15	3.65	2.11
			185	51.47	35.16	22.69	15.26	6.58	3.80
			215		51.47	39.27	30.29	12.53	6.95
			240			51.47	44.12	20.88	11.04
			255				51.47	28.17	14.40
			300					51.47	31.07
			340						51.47
20	25	80.42	160	48.97	26.67	14.93	10.18	4.56	2.64
			200	76.61	54.31	38.73	27.50	11.42	6.48
			210	80.42	61.22	45.64	34.41	14.11	7.89
			240		80.42	66.37	55.15	26.10	13.80
			265			80.42	72.42	42.13	21.43
			280				80.42	52.49	27.71
			325					80.42	56.05
			365						80.42

Comments : Intermediate values may be obtained by linear interpolation. Extrapolating is not permitted.

Evaluation of the maximum forces in rebars according to Australian Standard AS 3600 - 2001 for a nominal bar diameter from 8 to 20 mm (f_{yk} = 400 Mpa)

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Maximum connection force of rebar as per Australian Standard AS 3600 - 2001 concerning ANCHORING during exposure to fire in relation to fire resistance times from 30 to 240 Minutes (yielding point f_{yk} = 400 Mpa)

Nominal rebar diameter	Drill hole diameter	Maximum force in rebar	Anchorage depth	Maximum force in rebar in conjunction with Hilti HIT-RE 500 (yielding point f_{yk} = 400 Mpa) as a function of fire resistance class					
dia.	D	$F_{s,T}$	L	F30	F60	F90	F120	F180	F240
mm	mm	kN	mm	kN	kN	kN	kN	kN	kN
22	28	97.31	175	65.27	40.74	24.20	16.38	7.20	4.18
			200	84.27	59.74	42.60	30.25	12.56	7.13
			220	97.31	74.95	57.80	45.45	19.11	10.51
			250		97.31	80.61	68.26	35.07	18.13
			275			97.31	87.27	53.94	27.99
			290				97.31	65.35	36.11
			335					97.31	69.26
			375						97.31
25	30	125.66	200	95.77	67.89	48.41	34.37	14.27	8.10
			220	113.05	85.17	65.69	51.65	21.72	11.94
			235	125.66	98.13	78.64	64.61	29.50	15.76
			270		125.66	108.88	94.85	56.98	29.19
			290			125.66	112.13	74.26	41.04
			310				125.66	91.54	57.11
			350					125.66	91.66
			390						125.66
28	35	157.63	225	131.45	100.23	78.41	62.69	26.96	14.69
			240	145.96	114.74	92.92	77.20	36.55	19.31
			255	157.63	129.26	107.43	91.72	49.30	25.20
			285		157.63	136.46	120.75	78.33	42.24
			310			157.63	144.94	102.52	63.96
			325				157.63	117.04	78.47
			370					157.63	122.02
			410						157.63
32	40	205.89	255	183.40	147.72	122.78	104.82	56.35	28.80
			265	194.46	158.78	133.84	115.88	67.40	34.28
			280	205.89	175.37	150.43	132.47	83.99	44.34
			310		205.89	183.60	165.64	117.17	73.10
			335			205.89	193.29	144.81	100.74
			350				205.89	161.40	117.33
			395					205.89	167.09
			435						205.89
40	47	321.70	320	319.10	274.50	243.33	220.87	160.28	105.19
			325	321.70	281.41	250.24	227.79	167.19	112.11
			355		321.70	291.71	269.25	208.66	153.57
			380			321.70	303.81	243.22	188.13
			395				321.70	263.95	208.87
			440					321.70	271.07
			480						321.70

Comments : Intermediate values may be obtained by linear interpolation. Extrapolating is not permitted.

Evaluation of the maximum forces in rebars according to Australian Standard AS 3600 - 2001 for a nominal bar diameter from 22 to 40 mm (f_{yk} = 400 Mpa)

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Maximum connection force of rebar as per Australian Standard AS 3600 - 2001 concerning ANCHORING during exposure to fire in relation to fire resistance times from 30 to 240 Minutes (yielding point f_{yk} = 500 Mpa)

Nominal rebar diameter	Drill hole diameter	Maximum force in rebar	Anchorage depth	Maximum force in rebar in conjunction with Hilti HIT-RE 500 (yielding point f_{yk} = 500 Mpa) as a function of fire resistance class					
dia.	D	$F_{s,T}$	L	F30	F60	F90	F120	F180	F240
mm	mm	kN	mm	kN	kN	kN	kN	kN	kN
8	10	16.08	65	1.38	0.57	0.19	0.05	0	0
			80	2.35	1.02	0.47	0.26	0	0
			95	3.87	1.68	0.88	0.55	0.12	0
			115	7.30	3.07	1.71	1.14	0.44	0.18
			150	16.08	8.15	4.59	3.14	1.41	0.80
			180		16.08	9.99	6.75	2.94	1.70
			205			16.08	12.38	5.08	2.86
			220				16.08	6.95	3.82
			265					16.08	8.57
			305						16.08
10	12	25.13	80	2.94	1.27	0.59	0.33	0	0
			100	5.68	2.45	1.31	0.85	0.24	0
			120	10.66	4.44	2.48	1.68	0.68	0.31
			140	17.57	7.76	4.38	2.99	1.33	0.73
			165	25.13	15.06	8.50	5.79	2.58	1.50
			195		25.13	17.63	12.18	5.12	2.93
			220			25.13	20.66	8.69	4.78
			235				25.13	11.80	6.30
			295					25.13	17.86
			320						25.13
12	16	36.19	95	5.80	2.52	1.32	0.83	0.18	0
			120	12.79	5.33	2.97	2.01	0.82	0.37
			145	23.16	10.68	6.02	4.12	1.84	1.03
			180	36.19	24.29	14.99	10.12	4.41	2.55
			210		36.19	27.38	20.65	8.47	4.74
			235			36.19	31.01	14.16	7.56
			250				36.19	19.13	9.89
			295					36.19	21.43
			335						36.19
16	20	64.34	130	22.59	9.42	5.30	3.61	1.56	0.80
			160	39.17	21.33	11.95	8.15	3.65	2.11
			190	55.76	37.92	25.45	17.25	7.35	4.22
			210	64.34	48.98	36.51	27.53	11.29	6.32
			240		64.34	53.10	44.12	20.88	11.04
			265			64.34	57.94	33.70	17.14
			280				64.34	42.00	22.17
			325					64.34	44.84
			365						64.34
20	25	100.53	160	48.97	26.67	14.93	10.18	4.56	2.64
			200	76.61	54.31	38.73	27.50	11.42	6.48
			235	100.53	78.50	62.92	51.69	23.60	12.60
			270		100.53	87.11	75.88	45.58	23.36
			290			100.53	89.70	59.41	32.83
			310				100.53	73.23	45.69
			350					100.53	73.33
			390						100.53

Comments : Intermediate values may be obtained by linear interpolation. Extrapolating is not permitted.

Evaluation of the maximum forces in rebars according to Australian Standard AS 3600 - 2001 for a nominal bar diameter from 8 to 20 mm (f_{yk} = 500 Mpa)

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Maximum connection force of rebar as per Australian Standard AS 3600 - 2001 concerning ANCHORING during exposure to fire in relation to fire resistance times from 30 to 240 Minutes (yielding point f_{yk} = 500 Mpa)

Nominal rebar diameter	Drill hole diameter	Maximum force in rebar	Anchorage depth	Maximum force in rebar in conjunction with Hilti HIT-RE 500 (yielding point f_{yk} = 500 Mpa) as a function of fire resistance class					
dia.	D	$F_{s,T}$	L	F30	F60	F90	F120	F180	F240
mm	mm	kN	mm	kN	kN	kN	kN	kN	kN
22	28	121.64	175	65.27	40.74	24.20	16.38	7.20	4.18
			220	99.48	74.95	57.80	45.45	19.11	10.51
			250	121.64	97.76	80.61	68.26	35.07	18.13
			285		121.64	107.22	94.87	61.55	33.19
			305			121.64	110.08	76.75	46.45
			325				121.64	91.96	61.66
			365					121.64	92.07
			405						121.64
25	30	157.08	200	95.77	67.89	48.41	34.37	14.27	8.10
			250	138.96	111.09	91.60	77.57	39.86	20.61
			275	157.08	132.69	113.20	99.17	61.30	31.81
			305		157.08	139.12	125.09	87.22	52.79
			330			157.08	146.69	108.82	74.39
			345				157.08	121.77	87.34
			390					157.08	126.22
			430						157.08
28	35	197.04	225	131.45	100.23	78.41	62.69	26.96	14.69
			250	155.64	124.42	102.60	86.88	44.64	23.08
			295	197.04	167.96	146.14	130.42	88.01	50.00
			330		197.04	180.00	164.29	121.87	83.31
			350			197.04	183.64	141.23	102.66
			365				197.04	155.74	117.18
			410					197.04	160.72
			450						197.04
32	40	257.36	255	183.40	147.72	122.78	104.82	56.35	28.80
			280	211.05	175.37	150.43	132.47	83.99	44.34
			325	257.36	225.13	200.19	182.23	133.75	89.68
			355		257.36	233.37	215.40	166.93	122.86
			380			257.36	243.05	194.58	150.51
			395				257.36	211.16	167.09
			440					257.36	216.86
			480						257.36
40	47	402.12	320	319.10	274.50	243.33	220.87	160.28	105.19
			350	360.57	315.97	284.80	262.34	201.75	146.66
			385	402.12	364.35	333.18	310.72	250.13	195.04
			415		402.12	374.64	352.19	291.60	236.51
			435			402.12	379.84	319.25	264.16
			455				402.12	346.89	291.80
			495					402.12	347.10
			535						402.12

Comments : Intermediate values may be obtained by linear interpolation. Extrapolating is not permitted.

Evaluation of the maximum forces in rebars according to Australian Standard AS 3600 - 2001 for a nominal bar diameter from 22 to 40 mm (f_{yk} = 500 Mpa)

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Annex 22
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