

Fire resistance

The evaluation of metal anchors in concrete concerning resistance to fire is described in the Technical Report TR020 published in May 2004. The design of the anchorage under fire exposure has to be carried out as follows :

$$S_{d,fi} \leq R_{d,fi(t)}$$

$$S_{d,fi} = \gamma_{F,fi} \cdot S_{k,fi}$$

$$R_{d,fi(t)} = \frac{R_{k,fi(t)}}{\gamma_{M,fi}}$$

where :

- $S_{d,fi}$: Design value of action under fire exposure
- $S_{k,fi}$: Characteristic value of action under fire exposure
- $\gamma_{F,fi}$: Partial safety factor for action under fire exposure
- $R_{d,fi(t)}$: Design value of resistance under fire exposure
- $R_{k,fi(t)}$: Characteristic resistance under fire exposure
- $\gamma_{M,fi}$: Partial safety factor for resistance under fire exposure (usually = 1,0)

For mechanical anchors, 2 design concepts are possible in the technical report R020 to carry out the evaluation of the design resistance under fire exposure :

- The experimental determination of the duration of fire resistance of the anchor from the results of tests. The test report gives directly the $N_{Rk,s,fi(t)}$.
- The simplified design concept is used to determine the resistance of single anchors under fire exposure, the steel failure is often decisive. The design resistance may be obtained from the application of formulars for all directions and each failure mode.

The characteristic resistance of an anchorage in case of steel failure under fire exposure may be calculated from characteristic tension strength $\sigma_{Rk,s,fi(t)}$ given in the following tables :

$$N_{Rk,s,fi(t)} = A_s \cdot \sigma_{Rk,s,fi(t)} \text{ with } A_s : \text{min cross-section}$$

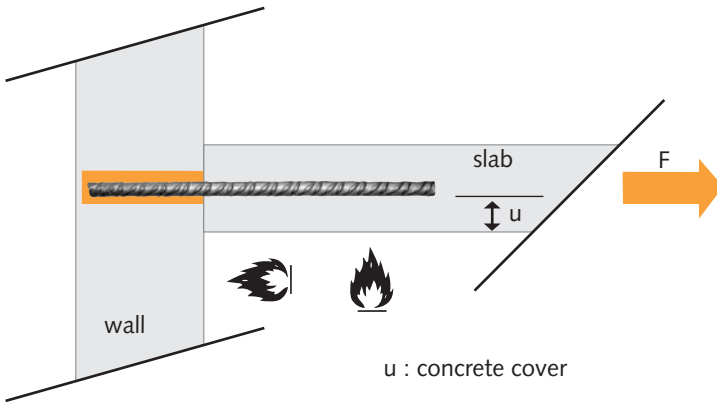
For anchor made of Carbon-steel in case of fire exposure

anchor bolt/thread diameter [mm]	anchorage depth h_{ef} [mm]	characteristic tension strength of an unprotected anchor made of Carbon-steel in case of fire exposure in the time up to: $\sigma_{Rk,s,fi}$ [N/mm ²]			
		30 min [R 15 to R30]	60 min [R45 and R60]	90 min [R90]	120 min [R120]
Ø 6 / M6	≥ 30	10	9	7	5
Ø 8 / M8	≥ 30	10	9	7	5
Ø 10 / M10	≥ 40	15	13	10	8
Ø 12 / M12 and greater	≥ 50	20	15	13	10

For anchor made of Stainless in case of fire exposure

anchor bolt/thread diameter [mm]	anchorage depth h_{ef} [mm]	characteristic tension strength of an unprotected anchor made of stainless in case of fire exposure in the time up to: $\sigma_{Rk,s,fi}$ [N/mm ²]			
		30 min [R 15 to R30]	60 min [R45 and R60]	90 min [R90]	120 min [R120]
Ø 6 / M6	≥ 30	10	9	7	5
Ø 8 / M8	≥ 30	20	16	12	10
Ø 10 / M10	≥ 40	25	20	16	14
Ø 12 / M12 and greater	≥ 50	30	25	20	16

RESISTANCE TO FIRE FOR STEEL REINFORCEMENT wall/slab



The present table is aimed at supplying data for the design of the injection anchoring system when exposed to fire. This study does not deal with the mechanical design at ambient temperature, neither does it deal with the simultaneous action of other factors, these shall be done in addition.

The table below gives performance subjected to fire exposure in wall to slab connection with concrete reinforcing bar, with SPIT EPOBAR resin, in concrete C20/25.

The values in white on orange background, indicate that the proof of resistance to fire is satisfied with $\eta_{fi} = 0,6$ in concrete class C20/25 (see method below).

Design method for resistance to fire according to Eurocode 2: Fire proof using design resistance: $R_{d,fi} \leq E_{d,fi}$

$R_{d,fi}$ Design resistance in case of fire.

$E_{d,fi}$ Design effect of actions in case of fire. This value can be derived from the calculation at ambient temperature:

$E_{d,fi} = \eta_{fi} \times F_{Rdu}$

F_{Rdu} Design ultimate limit load at ambient temperature for one rebar set at the l_s anchorage depth (mm)

η_{fi} Reduction factor for design load in case of fire.

η_{fi} is equal to 0,6 except for accumulated load of merchandises including access route where we must take η_{fi} equal to 0,7.

Rebar Ø (mm)	Drill (mm)	Ls (mm)	F _{Rdu} (daN) Design resistance for Fe E500 rebar according to EC2 rules in concrete class C20/25 (ambient temperature)	Fe E500 Rebar maximum load (daN) in case of fire	Design resistance (daN) in case of fire according to Eurocode 2 for a fire duration of 30 to 240 min.					
					Fire duration (minutes)					
					R30	R60	R90	R120	R180	R240
Concrete cover (1) (mm)					10	20	25	35	50	70
8	10	120	848	1620	555	240	145	120	90	85
		190	1342		1620	990	630	500	330	260
		220	1554		1470	1020	790	550	420	
		240	1696		1620	1300	1030	730	550	
		270	1908		1620	1450	1050	780	550	
		325	2185		1620	1450	1050	780	550	
		355	2185		1620	1450	1050	780	550	
Concrete cover (1) (mm)					10	20	25	35	50	70
10	12	130	1102	2530	730	340	220	160	140	140
		180	1526		1740	960	680	470	320	280
		210	1780		2530	1520	1080	810	520	450
		250	2120		2340	1780	1360	930	790	
		290	2459		2530	2060	1480	1230	1050	
		350	2967		2530	2060	1480	1230	1050	
		375	3179		2530	2060	1480	1230	1050	
Concrete cover (1) (mm)					12	20	25	35	50	70
12	16	140	1583	3640	1054	514	336	266	212	200
		210	2374		2790	1650	1090	770	590	490
		240	2713		3640	2380	1740	1220	870	720
		285	3222		3640	2750	2030	1570	1260	
		320	3617		3640	2810	2290	1810	1570	
		360	3956		3640	2810	2290	1810	1570	
		405	4578		3640	2810	2290	1810	1570	
Concrete cover (1) (mm)					14	20	25	35	50	70
14	18	140	1780	4950	1110	500	340	290	230	220
		210	2671		3100	1900	1210	1000	650	520
		240	3052		4150	2620	1840	1450	1000	830
		265	3370		4950	3370	2630	2040	1400	1120
		320	4069		4950	4110	3580	2570	2040	1120
		350	4451		4950	4430	3320	2710	2040	1120
		405	5150		4950	4430	3320	2710	2040	1120
		430	5468		4950	4430	3320	2710	2040	1120

(1) : Minimum concrete cover according Eurocode 3 - partie 1.2

Fire resistance

RESISTANCE TO FIRE FOR STEEL REINFORCEMENT wall/slab (continued)

Rebar Ø (mm)	Drill (mm)	Ls (mm)	F _{Rdu} (daN) Design resistance for Fe E500 rebar according to EC2 rules in concrete class C20/25 (ambient temperature)	Fe E500 Rebar maximum load (daN) in case of fire	Design resistance (daN) in case of fire according to Eurocode 2 for a fire duration of 30 to 240 min.					
					Fire duration (minutes)					
					R30	R60	R90	R120	R180	R240
Concrete cover (1) (mm)					16	20	25	35	50	70
16	20	160	2261	6470	1790	790	530	440	350	320
		220	3109		3880	2150	1450	1140	820	700
		260	3674		5420	3460	2580	2100	1460	1150
		285	4027		6420	4320	3290	2780	1910	1520
		340	4804			6470	5300	4460	3320	2680
		360	5087				6070	5240	3960	3180
		400	5652					6470	5360	4400
	460	6500						6470		
Concrete cover (1) (mm)					20	20	25	35	50	70
20	25	200	3533	10110	3750	1160	1160	950	730	640
		240	4239		5410	3120	2260	1840	1320	990
		280	4946		7290	4610	3390	2770	2000	1620
		320	5652		9370	6410	5110	4360	3260	2460
		335	5917		10110	7080	5710	4900	3700	2850
		400	7065			10110	8780	7760	6140	4960
		500	8831						10110	9450
	515	9096					10110			
Concrete cover (1) (mm)					25	25	25	35	50	70
25	30	250	5299	15790	7880	3990	2560	2100	1570	1360
		280	5935		9710	5550	3800	3250	2310	1930
		340	7206		13400	8810	6510	5850	4120	3390
		385	8160		15790	11470	9000	8040	6230	5260
		440	9326			14900	12300	11000	8940	7550
		500	10598				15790	14600	12200	10600
		540	11445					15790	14680	12870
	590	12505					15790			
Concrete cover (1) (mm)					32	32	32	35	50	70
32	40	320	9043	25880	16300	9790	6400	4910	3770	3220
		370	10456		20270	13640	9810	7890	6250	5310
		420	11869		24270	17550	13400	11170	9050	7860
		500	14130		25880	23810	19330	16780	14110	12540
		585	16532				25880	23200	20230	18300
		635	17945						24210	22070
		685	19358							25880
Concrete cover (1) (mm)					40	40	40	40	50	70
40	50	400	13282	40430	29400	20200	15100	11400	8320	7270
		450	14942		34770	25480	19840	15710	12700	10660
		510	16935		40430	31470	25750	21540	17810	15470
		600	19923			40430	34500	29900	25100	22800
		660	21916				40430	36120	31220	28400
		760	25236						40430	37730
		790	26232							40430

(1) : Minimum concrete cover according to Eurocode 3 - part 1.2

Example:

Application:

- Design of works for Ø20 rebar in car park
- Requirement : fire duration 2 hours
- Ultimate load : 11180 daN

- Ambient temperature: Anchoring depth according to EC2 rules for ultimate load of 11180 daN in concrete class C30/37

$$L_s = \frac{F_{Rdu}}{4.71 \times f_{ctk5\%} \cdot d_0} = \frac{11180 N}{4.71 \times 2.0 \times 25}$$

$$L_s = 475 \text{ mm}$$

- Fire proof: fire duration 2 hours for anchoring depth equal to 475 mm

$$R_{d,fi(120 \text{ min})} = 7760 \text{ daN} > 6708 \text{ daN} [=0,6 \times 11180 \text{ daN}]$$



	
<p>European Technical Approval</p>	



