



# The Passive Fire Protection Handbook I

STRUCTURAL STEEL  
CORRUGATED STEEL  
CONCRETE



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# 1. PROTECTION OF STRUCTURAL STEEL

## Fire protection increase of structural steel

Fire has become one of the greatest threats to buildings. It threatens and kills human beings, destroys properties and also leads to expensive production stoppages and high costs for consequential damage. The bearing capacity of a steel structure is substantially reduced if temperature rises due to fire. The temperature which the structure will reach in a fire will depend on the location, its size and a passive fire protection of structural steel members. Isover FireProtect® is a simple and reliable system that limits the temperature rise in the steel, therefore helps to save lives and protect property in the event of fire. Typical structures commonly designed using advantages of load-bearing capacities of steel are sports stadia, offices, industrial buildings, airport terminals, leisure centres, hospitals and shopping centres.

### Fire protection cladding Isover FireProtect®







The Isover FireProtect® system provides very efficient fire protection for structural steel. It is a quick, simple and secure system with easily worked materials and simple fixing equipment, which is assembled without complicated, expensive installation tools.

### Fire classification

Fire protection system Isover FireProtect® was officially tested in PAVUS, a.s., authorized body AO 216. Based on proven modern and innovative system design it is possible to protect both steel columns and beams up to fire resistance R 240 within design temperatures 350–750 °C, for section factor up to  $A_p/V = 716 \text{ m}^{-1}$ . Classification according to the latest standard EN 13501-2: 2023, testing based on EN 13381-4: 2013.



### Why use Isover FireProtect®?

Features	Benefits
 <ul style="list-style-type: none"> <li>Fulfills EN 13381-4:2013</li> <li>Euroclass A1 fire rating according to EN 13501-1</li> </ul>	<ul style="list-style-type: none"> <li>Superior fire resistance</li> <li>Totally non-combustible, top level reaction to fire performance</li> </ul>
 <ul style="list-style-type: none"> <li>Up to 5 times lighter than conventional solutions</li> </ul>	<ul style="list-style-type: none"> <li>Easy to handle</li> </ul>
 <ul style="list-style-type: none"> <li>Easy to cut and fit</li> </ul>	<ul style="list-style-type: none"> <li>Standard insulators knife can be used</li> </ul>
 <ul style="list-style-type: none"> <li>Fast installation</li> </ul>	<ul style="list-style-type: none"> <li>Dry way of assembly without need to use paint and glue</li> </ul>
 <ul style="list-style-type: none"> <li>Off-cuts can be used</li> <li>No need for pre-fabrication</li> </ul>	<ul style="list-style-type: none"> <li>Minimises wastes on site</li> <li>Cost savings</li> </ul>
 <ul style="list-style-type: none"> <li>High quality stone wool</li> </ul>	<ul style="list-style-type: none"> <li>Will not absorb moisture from the surrounding air and is chemically inert                             <ul style="list-style-type: none"> <li>- will not accelerate corrosion of steel</li> </ul> </li> <li>Performance will not deteriorate over time                             <ul style="list-style-type: none"> <li>- long product life, no ageing of product</li> </ul> </li> <li>Superior thermal insulation properties (low thermal conductivity)</li> </ul>



## 2. SYSTEM ISOVER FIREPROTECT®

### Fixing materials and tools:

- slabs Isover FireProtect® 150,
- Fire Screws,
- stud-welded pins or pins and washers as required,
- standard ladders knife,
- screwdriver (preferably battery-powered) or equipment with welding gun,
- rubber hammer.



Fig. 1 Tools to be used for mounting Isover FireProtect®

### Fire Screws

Fire Screw are available in different lengths. The screw must be at least twice as long as the insulation thickness.

Length (mm)	Pcs / Packing
40	1000
60	1000
80	1000
100	500
120	500



### Stud-welded pins or pins and washers

Pins have a diameter of 2.7 mm and the washer's diameter is 30 mm.



### Slabs Isover FireProtect® 150

The production of stone wool slabs is based on the defibering of molten raw materials consisting of minerals and different amounts of artificial resins as binders, mineral oils for dust suppression and hydrophobic means. Behaviour with stainless austenitic steels – AS quality for this application according to AGI Q 132, EN 13468 and ASTM C 795. Fibres are hydrophobic according to EN 1609.

#### Technical parameters:

**Designation code:** MW - EN 14303 - T5 - CS(10)20 - ST(+ )700 - WS1 - CL10

Thickness (mm)	Slabs are stored on a pallet		Packages on a pallet				
	Dimensions (mm)	m <sup>2</sup> / Pallet	Dimensions (mm)	m <sup>2</sup> / Pallet	m <sup>2</sup> / Package	Package / Pallet	Slabs / Package
20	1000 × 1200	72.00	600 × 1200	86.40	8.64	10	12
25	1000 × 1200	57.60	-	-	-	-	-
30	1000 × 1200	48.00	600 × 1200	60.48	5.04	12	7
40	1000 × 1200	36.00	600 × 1200	43.20	4.32	10	6
50	1000 × 1200	28.80	600 × 1200	34.56	2.88	12	4
60	1000 × 1200	24.00	600 × 1200	28.80	2.88	10	4

Other thicknesses and dimensions then stated can be produced at request when fulfilling minimum volume.  
Thickness tolerance: ±1 mm, width tolerance: ±5 mm, length tolerance: ±8 mm.

Parameter	Unit	Value										Standard			
<b>Thermal insulating properties</b>															
Declared value of the thermal conductivity coefficient $\lambda_D$ according to EN ISO 13787	°C	10	40	50	100	150	200	250	300	400	500	600	650	700	
	W·m <sup>-1</sup> ·K <sup>-1</sup>	0.036	0.039	0.041	0.047	0.053	0.060	0.068	0.077	0.098	0.123	0.154	0.172	0.192	
Measured value of the thermal conductivity coefficient according to EN 12667	W·m <sup>-1</sup> ·K <sup>-1</sup>	0.034	0.038	0.040	0.045	0.052	0.058	0.066	0.074	0.094	0.118	0.147	0.164	0.183	
Maximum service temperature	°C	700										EN 14706			
Specific heat capacity $c_d$	J·kg <sup>-1</sup> ·K <sup>-1</sup>	800										-			
<b>Physical properties</b>															
Density (thickness 20 and 25 mm)	kg·m <sup>-3</sup>	165										EN 1602, EN 13470			
Density (thickness ≥ 30 mm)	kg·m <sup>-3</sup>	150										EN 1602, EN 13470			
Short term water absorption $W_p$	kg·m <sup>-2</sup>	<< 1										EN 1609			
Diffusion resistance factor	-	1,0										EN 12086			
Flow resistance $\Xi$	kPa·s·m <sup>-2</sup>	> 90										EN 29053			
<b>Fire safety properties</b>															
Reaction to fire	-	A1										EN 13501-1			
Melting temperature $t_f$	°C	≥ 1000										DIN 4102 part 17			
<b>Additional properties</b>															
Acoustic absorption coefficient $\alpha$ for perpendicular impact of acoustic waves (-) according to EN ISO 354 and EN ISO 11654	Frequency	Hz	125	250	500	1000	2000	4000							
	Thickness	20 mm	0.05	0.20	0.55	0.85	0.95	1.00							
		40 mm	0.20	0.65	0.90	0.90	0.95	0.95							
		60 mm	0.25	0.65	0.80	0.85	0.90	0.95							
Definition of single number value according to EN ISO 11654	Single number value	-	$\alpha_w$			NRC		Absorption class							
	20 mm	mm	0.50 (M, H)			0.65		D							
	40 mm	mm	0.90			0.85		A							
	60 mm	mm	0.85			0.90		B							

# 3. MOUNTING AND FIXING

## Fixing

There are two possibilities how to fix slabs Isover FireProtect® 150 to the steel members:

- with Fire Screws in length corresponding to double the insulation thickness,
  - with stud-welded pins or pins and washers, where diameter of the pin is 2.7 mm and diameter of the washer is 30 mm.
- Both methods can be also combined.

## Use of Fire Screws

### Fixing of slabs to fitted pieces

Fixing of fire protective slabs Isover FireProtect® 150 is done with Fire Screws to fitted pieces from the same slab of width 100 mm and length corresponding to the distance between flanges plus 2-3 mm. However, a minimum slab thickness of 40 mm must be used for the fitted pieces. Maximum spacing is 600 mm.

Maximum distance between Fire Screws and from axis of connected slab is 200 mm. With steel section higher than 400 mm is a slab crosswise to the fitted piece necessary to support the joint. The web supports this crosswise mounted slab.

### Fixing of slabs at the corners

Adjacent slabs are at the corners connected by Fire Screws at distances 150 mm, first Fire Screw is positioned at least 25 mm from edge of the slab.

## Placement of the Fire Screws

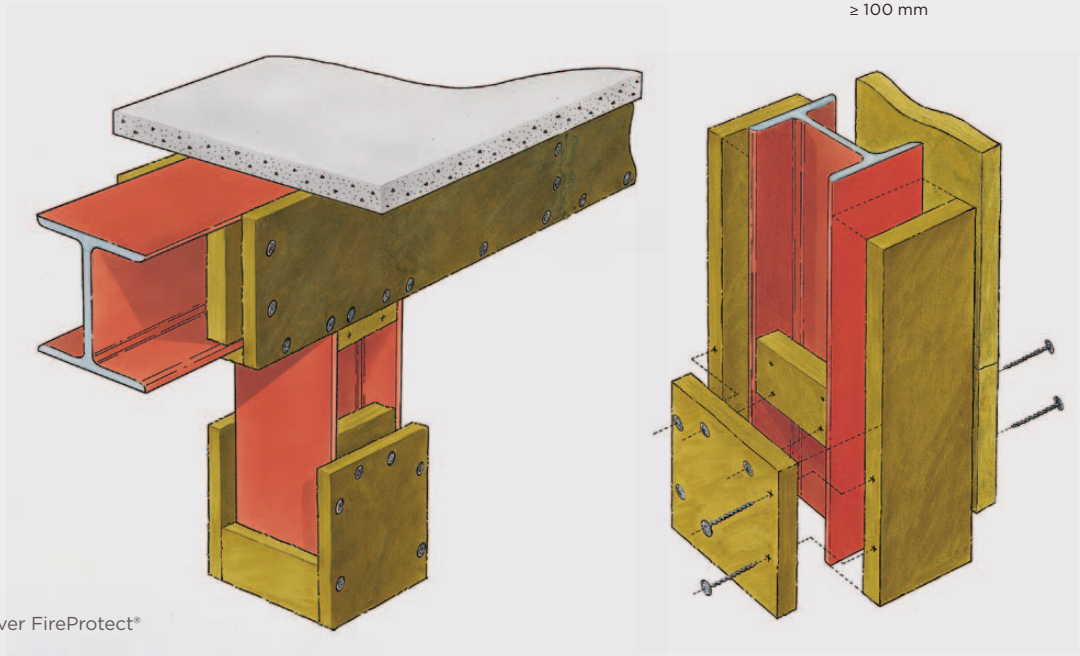
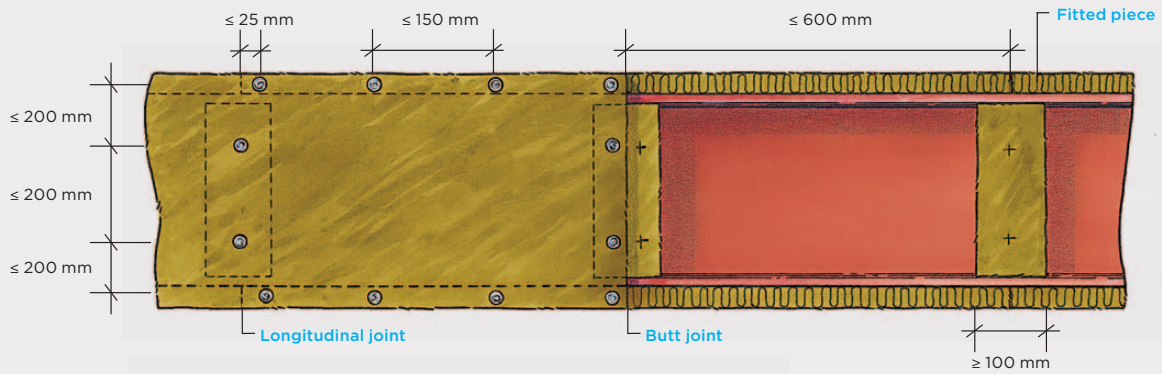
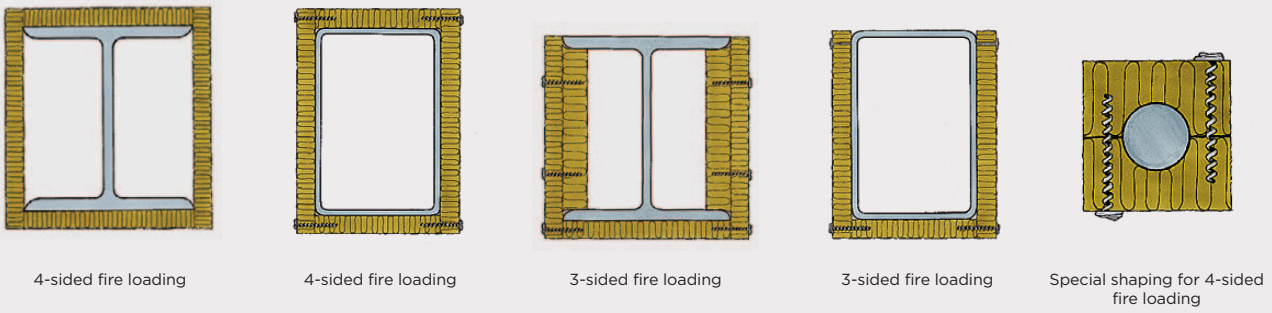
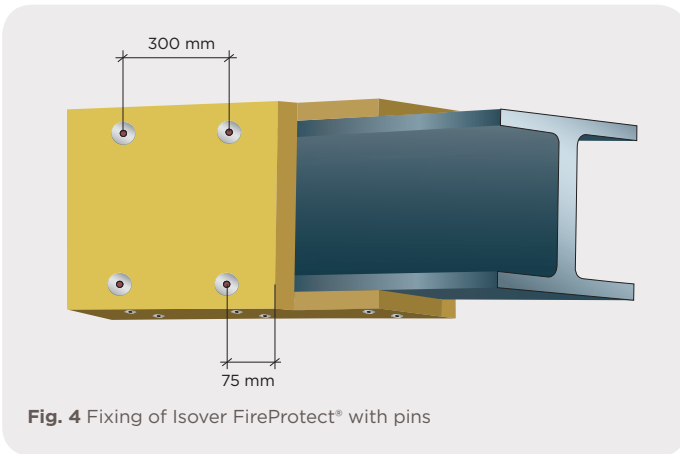


Fig. 2 Installation of Isover FireProtect® with Fire Screws



**Fig. 3** Position of the fixations

In the case of closed beams insulated with 3-sided cladding the upper row of Fire Screws is replaced with pins fixed to the top flange of the beam. For I-beam it is possible to use pins or Fire Screws.



**Fig. 4** Fixing of Isover FireProtect® with pins

### Use of pins

Slabs are fixed with welding pins in maximum distance of 300 mm. Maximum distance from the cladding's edges is 75 mm. When using welding pins there is no need to have fitted pieces between flanges as is required for the use of Fire Screws fixing method.





### Installation of bottom slabs on horizontal members

Horizontal loaded I-shaped steel members with insulation thickness  $\geq 50$  mm is also fixed to the lower flange with welding pins in maximum distance of 300 mm. Maximum distance from the cladding's edges is 75 mm.



Fig. 5 Bottom slab with insulation thickness  $\geq 50$  mm is fixed to the lower flange of the beam both with Fire Screws and welding pins.



Fig. 6 Both methods can be also combined – important is to keep the distances (between pins 300 mm and between Fire Screws 150 mm)

# 4. DESIGN

## What happens in a fire?

A fire is a blaze which is out of control. The design of steel structures must take account of the reduction in strength of the steel due to temperature loads in the event of fire.

### Fire

Fire is a combustion process that liberates heat and light. Combustible material, oxygen and heat must be present to feed the fire. If one of the three is absent, the fire goes out.



### Progress of a fire

The progress of a fire in a building is determined first and foremost by the quantity of combustible material. The oxygen supply is also highly significant. The progress of a normal fire can be described as shown in fig. 7.

The ignition phase is the most important phase from a safety point of view. It is during this phase that it is possible to make rescue efforts and extinguish the fire.

The temperature rises quickly, and combustible materials emit flammable gases and smoke. When the flammable gases reach their flashpoint, flashover can occur.

The flame phase starts when flashover occurs. People in the room at that time have little chance of leaving alive, and the rescue teams have little chance of extinguishing the fire. In the flame phase, the temperature reaches a maximum of around 1000 °C. Fire insulation of structural steelwork ensures that the building does not collapse.

In the cooling phase, or rather the glowing phase, the carbonised remnants and embers usually emit strong radiant heat. Even during this phase, the fire insulation protects the steel structures from harmful temperature rises.

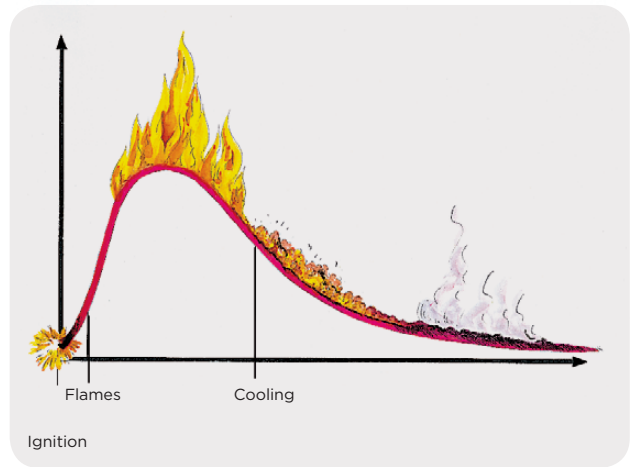


Fig. 7 Progression of a fire (in a building)

### Non-combustible materials

The combustibility of a material is determined in accordance with an international fire testing method (EN ISO 1182 and EN ISO 1716).

Slabs Isover FireProtect® 150 contains so little flammable binder that in practice it does not contribute to the fire. Therefore, the material is classified as non-combustible with reaction to fire A1 according to EN 13501-1.

### Steel strength

Steel strength is reduced at high temperatures. The critical temperature is the temperature at which yield stress occurs in the steel. The critical temperature of the steel therefore depends on the degree to which its strength is used structurally.

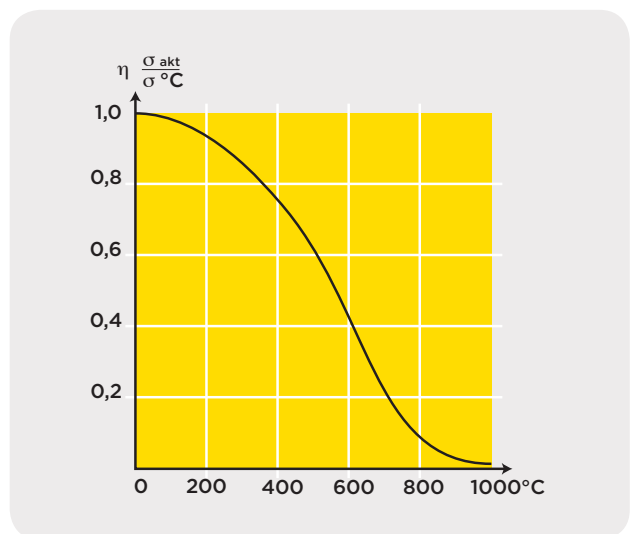


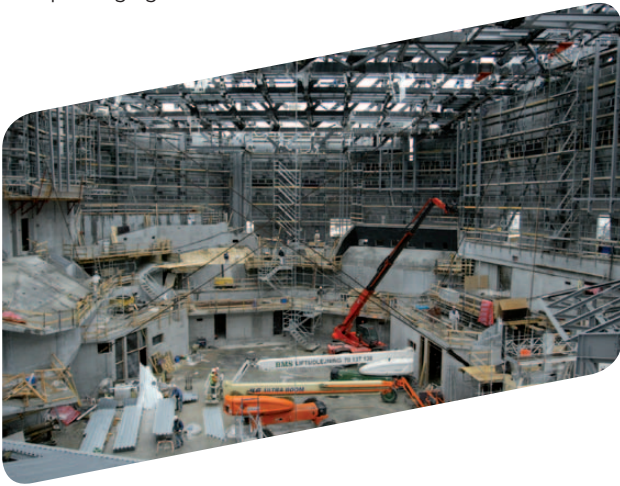
Fig. 8 The strength of the steel as a function of the temperature



# 4. DESIGN

## Steel structures

In the design of a steel structure, consideration must be given to how the steel would be affected under the influence of fire, causing the tension in the steel to decrease with increasing temperature. Isover FireProtect® is a very efficient system for limiting temperature rise of the supporting steel structure, thus prolonging its fire resistance.



### Fire resistance

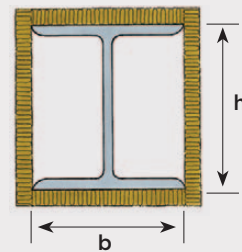
Coarse structures have the best fire resistance. How quickly a steel structure is heated in a given fire is measured by the ratio of profile steel fire exposed surfaces and profile heat capacity. This relationship is expressed through the so-called section factor,  $A_p/V$ .  $A_p$  is the internal perimeter of the insulation in meters,  $V$  is the steel cross-sectional area in  $m^2$ . Examples of profiles with a low section factor are HEB and HEM. High section factor means quick heating of the steel. This means that slender structural steel requires thicker fire insulation.



### Calculation

The fire resistance of a steel structure is calculated on the basis of the critical steel temperature. Calculation of the critical steel temperature is based on steel cross-section load ratio.

Normally, you can calculate the required insulation thickness at the critical steel temperature of 500 °C. You can check with the designer for that project on the critical steel temperature for the different structures and find out if it is higher compared to the amount of steel used in a normal situation. A higher critical steel temperature of the steel will require thinner insulation thickness. More information can be found in EN 1993-1-2: Eurocode 3: Design of steel structures - Part 1-2: General rules - Structural fire design.



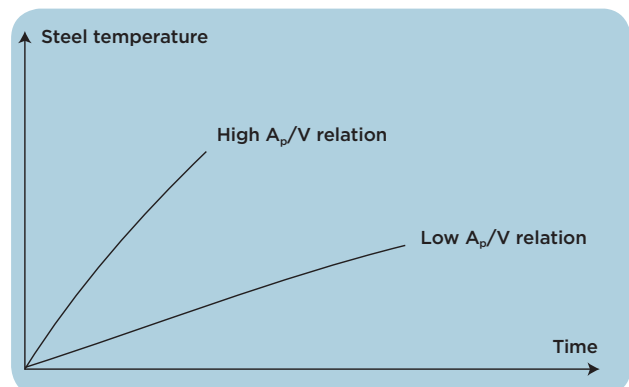
$$A_p = 2b + 2h$$

#### Section factor

$A_p$  = internal perimeter of the insulation (m)  
 $V$  = steel cross-sectional area ( $m^2$ )

**Fig. 9** Examples of profiles with a low section factor are HEB and HEM. High section factor means quick heating of the steel. This means that slender structural steel requires thicker fire insulation.

### Rising of steel temperature



## 4. DESIGN

### Design table of maximum section factors for all fire resistances

Fire resistance classification (min)	Protection thickness (mm)	Maximum section factor [ $m^{-1}$ ] to maintain steel temperature below design temperature											
		Critical steel temperature [ $^{\circ}C$ ]											
		350	400	450	500	525	550	560	600	620	650	700	750
R 15	20	716	716	716	716	716	716	716	716	716	716	716	716
	20	336	501	716	716	716	716	716	716	716	716	716	716
R 30	25	378	573	716	716	716	716	716	716	716	716	716	716
	20	152	198	261	354	390	460	494	674	716	716	716	716
R 45	25	185	239	314	393	457	536	573	716	716	716	716	716
	30	217	279	366	448	518	605	646	716	716	716	716	716
	40	278	356	423	546	627	716	716	716	716	716	716	716
	50	335	393	494	632	716	716	716	716	716	716	716	716
	60	371	446	557	708	716	716	716	716	716	716	716	716
	20	98	121	149	184	204	228	238	286	314	365	439	584
R 60	25	120	147	180	221	246	274	286	344	371	403	515	682
	30	142	173	210	258	287	320	335	371	404	462	588	716
	40	184	223	271	332	370	377	392	461	501	571	716	716
	50	224	271	330	371	407	447	465	544	591	672	716	716
	60	262	317	371	426	467	512	532	621	673	716	716	716
	20	57	68	80	94	101	109	112	126	134	146	169	196
R 90	25	71	83	97	113	121	130	134	151	159	174	202	235
	30	84	98	114	132	142	152	157	176	186	203	235	274
	40	109	127	147	169	182	196	202	226	239	262	305	358
	50	135	156	179	208	223	239	247	278	295	323	379	396
	60	159	184	212	245	264	284	293	331	352	371	402	461
	20		47	55	63	67	71	73	81	85	91	103	115
R 120	25	50	58	66	76	80	86	88	97	101	109	122	137
	30	59	68	78	88	94	99	102	112	118	126	141	158
	40	78	89	101	114	121	128	131	144	151	162	181	204
	50	96	109	124	139	148	157	161	176	185	198	223	251
	60	114	130	146	165	175	186	190	209	219	235	265	299
	20								47	49	52	58	63
R 180	25				46	48	51	52	56	58	62	68	74
	30			48	53	56	59	60	65	68	72	79	86
	40	49	56	62	69	72	76	77	83	87	92	100	109
	50	61	69	76	84	88	93	95	102	106	112	122	133
	60	73	81	90	99	105	109	112	120	125	132	144	158
	25											47	51
R 240	30								46	48	50	54	59
	40				49	52	54	55	59	61	64	69	75
	50	45	50	55	60	63	66	67	72	74	78	84	91
	60	54	59	65	71	74	78	79	85	87	92	99	107

# 4. DESIGN

## Design table for fire resistance 15 min

	Design temperature (°C)											
	350	400	450	500	525	550	560	600	620	650	700	750
Section factor (m <sup>2</sup> )	Fire protection thickness (mm) to keep steel temperature under design temperature											
≤ 50	20	20	20	20	20	20	20	20	20	20	20	20
60	20	20	20	20	20	20	20	20	20	20	20	20
70	20	20	20	20	20	20	20	20	20	20	20	20
80	20	20	20	20	20	20	20	20	20	20	20	20
90	20	20	20	20	20	20	20	20	20	20	20	20
100	20	20	20	20	20	20	20	20	20	20	20	20
110	20	20	20	20	20	20	20	20	20	20	20	20
120	20	20	20	20	20	20	20	20	20	20	20	20
130	20	20	20	20	20	20	20	20	20	20	20	20
140	20	20	20	20	20	20	20	20	20	20	20	20
150	20	20	20	20	20	20	20	20	20	20	20	20
160	20	20	20	20	20	20	20	20	20	20	20	20
170	20	20	20	20	20	20	20	20	20	20	20	20
180	20	20	20	20	20	20	20	20	20	20	20	20
190	20	20	20	20	20	20	20	20	20	20	20	20
200	20	20	20	20	20	20	20	20	20	20	20	20
210	20	20	20	20	20	20	20	20	20	20	20	20
220	20	20	20	20	20	20	20	20	20	20	20	20
230	20	20	20	20	20	20	20	20	20	20	20	20
240	20	20	20	20	20	20	20	20	20	20	20	20
250	20	20	20	20	20	20	20	20	20	20	20	20
260	20	20	20	20	20	20	20	20	20	20	20	20
270	20	20	20	20	20	20	20	20	20	20	20	20
280	20	20	20	20	20	20	20	20	20	20	20	20
290	20	20	20	20	20	20	20	20	20	20	20	20
300	20	20	20	20	20	20	20	20	20	20	20	20
310	20	20	20	20	20	20	20	20	20	20	20	20
320	20	20	20	20	20	20	20	20	20	20	20	20
330	20	20	20	20	20	20	20	20	20	20	20	20
340	20	20	20	20	20	20	20	20	20	20	20	20
350	20	20	20	20	20	20	20	20	20	20	20	20
360	20	20	20	20	20	20	20	20	20	20	20	20
370	20	20	20	20	20	20	20	20	20	20	20	20
380	20	20	20	20	20	20	20	20	20	20	20	20
390	20	20	20	20	20	20	20	20	20	20	20	20
400	20	20	20	20	20	20	20	20	20	20	20	20
410	20	20	20	20	20	20	20	20	20	20	20	20
420	20	20	20	20	20	20	20	20	20	20	20	20
430	20	20	20	20	20	20	20	20	20	20	20	20
440	20	20	20	20	20	20	20	20	20	20	20	20
450	20	20	20	20	20	20	20	20	20	20	20	20
460	20	20	20	20	20	20	20	20	20	20	20	20
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480	20	20	20	20	20	20	20	20	20	20	20	20
490	20	20	20	20	20	20	20	20	20	20	20	20
500	20	20	20	20	20	20	20	20	20	20	20	20
510	20	20	20	20	20	20	20	20	20	20	20	20
520	20	20	20	20	20	20	20	20	20	20	20	20
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560	20	20	20	20	20	20	20	20	20	20	20	20
570	20	20	20	20	20	20	20	20	20	20	20	20
580	20	20	20	20	20	20	20	20	20	20	20	20
590	20	20	20	20	20	20	20	20	20	20	20	20
600	20	20	20	20	20	20	20	20	20	20	20	20
610	20	20	20	20	20	20	20	20	20	20	20	20
620	20	20	20	20	20	20	20	20	20	20	20	20
630	20	20	20	20	20	20	20	20	20	20	20	20
640	20	20	20	20	20	20	20	20	20	20	20	20
650	20	20	20	20	20	20	20	20	20	20	20	20
660	20	20	20	20	20	20	20	20	20	20	20	20
670	20	20	20	20	20	20	20	20	20	20	20	20
680	20	20	20	20	20	20	20	20	20	20	20	20
690	20	20	20	20	20	20	20	20	20	20	20	20
700	20	20	20	20	20	20	20	20	20	20	20	20
710	20	20	20	20	20	20	20	20	20	20	20	20
716	20	20	20	20	20	20	20	20	20	20	20	20



# 4. DESIGN

## Design table for fire resistance **30 min**

	Design temperature (°C)											
	350	400	450	500	525	550	560	600	620	650	700	750
Section factor (m <sup>2</sup> )	Fire protection thickness (mm) to keep steel temperature under design temperature											
≤ 50	20	20	20	20	20	20	20	20	20	20	20	20
60	20	20	20	20	20	20	20	20	20	20	20	20
70	20	20	20	20	20	20	20	20	20	20	20	20
80	20	20	20	20	20	20	20	20	20	20	20	20
90	20	20	20	20	20	20	20	20	20	20	20	20
100	20	20	20	20	20	20	20	20	20	20	20	20
110	20	20	20	20	20	20	20	20	20	20	20	20
120	20	20	20	20	20	20	20	20	20	20	20	20
130	20	20	20	20	20	20	20	20	20	20	20	20
140	20	20	20	20	20	20	20	20	20	20	20	20
150	20	20	20	20	20	20	20	20	20	20	20	20
160	20	20	20	20	20	20	20	20	20	20	20	20
170	20	20	20	20	20	20	20	20	20	20	20	20
180	20	20	20	20	20	20	20	20	20	20	20	20
190	20	20	20	20	20	20	20	20	20	20	20	20
200	20	20	20	20	20	20	20	20	20	20	20	20
210	20	20	20	20	20	20	20	20	20	20	20	20
220	20	20	20	20	20	20	20	20	20	20	20	20
230	20	20	20	20	20	20	20	20	20	20	20	20
240	20	20	20	20	20	20	20	20	20	20	20	20
250	20	20	20	20	20	20	20	20	20	20	20	20
260	20	20	20	20	20	20	20	20	20	20	20	20
270	20	20	20	20	20	20	20	20	20	20	20	20
280	20	20	20	20	20	20	20	20	20	20	20	20
290	20	20	20	20	20	20	20	20	20	20	20	20
300	20	20	20	20	20	20	20	20	20	20	20	20
310	20	20	20	20	20	20	20	20	20	20	20	20
320	20	20	20	20	20	20	20	20	20	20	20	20
330	20	20	20	20	20	20	20	20	20	20	20	20
340	25	20	20	20	20	20	20	20	20	20	20	20
350	25	20	20	20	20	20	20	20	20	20	20	20
360	25	20	20	20	20	20	20	20	20	20	20	20
370	25	20	20	20	20	20	20	20	20	20	20	20
380	30	20	20	20	20	20	20	20	20	20	20	20
390	30	20	20	20	20	20	20	20	20	20	20	20
400	30	20	20	20	20	20	20	20	20	20	20	20
410	30	20	20	20	20	20	20	20	20	20	20	20
420	30	20	20	20	20	20	20	20	20	20	20	20
430	40	20	20	20	20	20	20	20	20	20	20	20
440	40	20	20	20	20	20	20	20	20	20	20	20
450	40	20	20	20	20	20	20	20	20	20	20	20
460	40	20	20	20	20	20	20	20	20	20	20	20
470	40	20	20	20	20	20	20	20	20	20	20	20
480	40	20	20	20	20	20	20	20	20	20	20	20
490	40	20	20	20	20	20	20	20	20	20	20	20
500	40	20	20	20	20	20	20	20	20	20	20	20
510	40	25	20	20	20	20	20	20	20	20	20	20
520	50	25	20	20	20	20	20	20	20	20	20	20
530	50	25	20	20	20	20	20	20	20	20	20	20
540	50	25	20	20	20	20	20	20	20	20	20	20
550	50	25	20	20	20	20	20	20	20	20	20	20
560	50	25	20	20	20	20	20	20	20	20	20	20
570	50	25	20	20	20	20	20	20	20	20	20	20
580	60	30	20	20	20	20	20	20	20	20	20	20
590	60	30	20	20	20	20	20	20	20	20	20	20
600	60	30	20	20	20	20	20	20	20	20	20	20
610	60	30	20	20	20	20	20	20	20	20	20	20
620	60	30	20	20	20	20	20	20	20	20	20	20
630	60	30	20	20	20	20	20	20	20	20	20	20
640		40	20	20	20	20	20	20	20	20	20	20
650		40	20	20	20	20	20	20	20	20	20	20
660		40	20	20	20	20	20	20	20	20	20	20
670		40	20	20	20	20	20	20	20	20	20	20
680		40	20	20	20	20	20	20	20	20	20	20
690		40	20	20	20	20	20	20	20	20	20	20
700		40	20	20	20	20	20	20	20	20	20	20
710		40	20	20	20	20	20	20	20	20	20	20
716		40	20	20	20	20	20	20	20	20	20	20

# 4. DESIGN

## Design table for fire resistance 45 min

	Design temperature (°C)											
	350	400	450	500	525	550	560	600	620	650	700	750
Section factor (m <sup>2</sup> )	Fire protection thickness (mm) to keep steel temperature under design temperature											
≤ 50	20	20	20	20	20	20	20	20	20	20	20	20
60	20	20	20	20	20	20	20	20	20	20	20	20
70	20	20	20	20	20	20	20	20	20	20	20	20
80	20	20	20	20	20	20	20	20	20	20	20	20
90	20	20	20	20	20	20	20	20	20	20	20	20
100	20	20	20	20	20	20	20	20	20	20	20	20
110	20	20	20	20	20	20	20	20	20	20	20	20
120	20	20	20	20	20	20	20	20	20	20	20	20
130	20	20	20	20	20	20	20	20	20	20	20	20
140	20	20	20	20	20	20	20	20	20	20	20	20
150	20	20	20	20	20	20	20	20	20	20	20	20
160	25	20	20	20	20	20	20	20	20	20	20	20
170	25	20	20	20	20	20	20	20	20	20	20	20
180	25	20	20	20	20	20	20	20	20	20	20	20
190	30	20	20	20	20	20	20	20	20	20	20	20
200	30	25	20	20	20	20	20	20	20	20	20	20
210	30	25	20	20	20	20	20	20	20	20	20	20
220	40	25	20	20	20	20	20	20	20	20	20	20
230	40	30	20	20	20	20	20	20	20	20	20	20
240	40	30	20	20	20	20	20	20	20	20	20	20
250	40	30	20	20	20	20	20	20	20	20	20	20
260	40	30	20	20	20	20	20	20	20	20	20	20
270	40	30	25	20	20	20	20	20	20	20	20	20
280	50	40	25	20	20	20	20	20	20	20	20	20
290	50	40	25	20	20	20	20	20	20	20	20	20
300	50	40	25	20	20	20	20	20	20	20	20	20
310	50	40	25	20	20	20	20	20	20	20	20	20
320	50	40	30	20	20	20	20	20	20	20	20	20
330	50	40	30	20	20	20	20	20	20	20	20	20
340	60	40	30	20	20	20	20	20	20	20	20	20
350	60	40	30	20	20	20	20	20	20	20	20	20
360	60	50	30	25	20	20	20	20	20	20	20	20
370	60	50	40	25	20	20	20	20	20	20	20	20
380		50	40	25	20	20	20	20	20	20	20	20
390		50	40	25	20	20	20	20	20	20	20	20
400		60	40	30	25	20	20	20	20	20	20	20
410		60	40	30	25	20	20	20	20	20	20	20
420		60	40	30	25	20	20	20	20	20	20	20
430		60	50	30	25	20	20	20	20	20	20	20
440		60	50	30	25	20	20	20	20	20	20	20
450			50	40	25	20	20	20	20	20	20	20
460			50	40	30	20	20	20	20	20	20	20
470			50	40	30	25	20	20	20	20	20	20
480			50	40	30	25	20	20	20	20	20	20
490			50	40	30	25	20	20	20	20	20	20
500			60	40	30	25	25	20	20	20	20	20
510			60	40	30	25	25	20	20	20	20	20
520			60	40	40	25	25	20	20	20	20	20
530			60	40	40	25	25	20	20	20	20	20
540			60	40	40	30	25	20	20	20	20	20
550			60	50	40	30	25	20	20	20	20	20
560				50	40	30	25	20	20	20	20	20
570				50	40	30	25	20	20	20	20	20
580				50	40	30	30	20	20	20	20	20
590				50	40	30	30	20	20	20	20	20
600				50	40	30	30	20	20	20	20	20
610				50	40	40	30	20	20	20	20	20
620				50	40	40	30	20	20	20	20	20
630				50	50	40	30	20	20	20	20	20
640				60	50	40	30	20	20	20	20	20
650				60	50	40	40	20	20	20	20	20
660				60	50	40	40	20	20	20	20	20
670				60	50	40	40	20	20	20	20	20
680				60	50	40	40	25	20	20	20	20
690				60	50	40	40	25	20	20	20	20
700				60	50	40	40	25	20	20	20	20
710					50	40	40	25	20	20	20	20
716					50	40	40	25	20	20	20	20

# 4. DESIGN

## Design table for fire resistance 60 min

	Design temperature (°C)											
	350	400	450	500	525	550	560	600	620	650	700	750
Section factor (m <sup>2</sup> )	Fire protection thickness (mm) to keep steel temperature under design temperature											
≤ 50	20	20	20	20	20	20	20	20	20	20	20	20
60	20	20	20	20	20	20	20	20	20	20	20	20
70	20	20	20	20	20	20	20	20	20	20	20	20
80	20	20	20	20	20	20	20	20	20	20	20	20
90	20	20	20	20	20	20	20	20	20	20	20	20
100	25	20	20	20	20	20	20	20	20	20	20	20
110	25	20	20	20	20	20	20	20	20	20	20	20
120	25	20	20	20	20	20	20	20	20	20	20	20
130	30	25	20	20	20	20	20	20	20	20	20	20
140	30	25	20	20	20	20	20	20	20	20	20	20
150	40	30	25	20	20	20	20	20	20	20	20	20
160	40	30	25	20	20	20	20	20	20	20	20	20
170	40	30	25	20	20	20	20	20	20	20	20	20
180	40	40	25	20	20	20	20	20	20	20	20	20
190	50	40	30	25	20	20	20	20	20	20	20	20
200	50	40	30	25	20	20	20	20	20	20	20	20
210	50	40	30	25	25	20	20	20	20	20	20	20
220	50	40	40	25	25	20	20	20	20	20	20	20
230	60	50	40	30	25	25	20	20	20	20	20	20
240	60	50	40	30	25	25	25	20	20	20	20	20
250	60	50	40	30	30	25	25	20	20	20	20	20
260	60	50	40	40	30	25	25	20	20	20	20	20
270		50	40	40	30	25	25	20	20	20	20	20
280		60	50	40	30	30	25	20	20	20	20	20
290		60	50	40	40	30	30	25	20	20	20	20
300		60	50	40	40	30	30	25	20	20	20	20
310		60	50	40	40	30	30	25	20	20	20	20
320			50	40	40	30	30	25	25	20	20	20
330			60	40	40	40	30	25	25	20	20	20
340			60	50	40	40	40	25	25	20	20	20
350			60	50	40	40	40	30	25	20	20	20
360			60	50	40	40	40	30	25	20	20	20
370			60	50	40	40	40	30	25	25	20	20
380				60	50	50	40	40	30	25	20	20
390				60	50	50	40	40	30	25	20	20
400				60	50	50	50	40	30	25	20	20
410				60	60	50	50	40	40	30	20	20
420				60	60	50	50	40	40	30	20	20
430					60	50	50	40	40	30	20	20
440					60	50	50	40	40	30	25	20
450					60	60	50	40	40	30	25	20
460					60	60	50	40	40	30	25	20
470						60	60	50	40	40	25	20
480						60	60	50	40	40	25	20
490						60	60	50	40	40	25	20
500						60	60	50	40	40	25	20
510						60	60	50	50	40	25	20
520							60	50	50	40	30	20
530							60	50	50	40	30	20
540								50	50	40	30	20
550								60	50	40	30	20
560								60	50	40	30	20
570								60	50	40	30	20
580								60	50	50	30	20
590								60	50	50	40	25
600								60	60	50	40	25
610								60	60	50	40	25
620								60	60	50	40	25
630									60	50	40	25
640									60	50	40	25
650									60	50	40	25
660									60	50	40	25
670									60	50	40	25
680										60	40	25
690										60	40	30
700										60	40	30
710										60	40	30
716										60	40	30



# 4. DESIGN

## Design table for fire resistance **90 min**

Section factor (m <sup>2</sup> )	Design temperature (°C)											
	350	400	450	500	525	550	560	600	620	650	700	750
	Fire protection thickness (mm) to keep steel temperature under design temperature											
≤ 50	20	20	20	20	20	20	20	20	20	20	20	20
60	25	20	20	20	20	20	20	20	20	20	20	20
70	25	25	20	20	20	20	20	20	20	20	20	20
80	30	25	20	20	20	20	20	20	20	20	20	20
90	40	30	25	20	20	20	20	20	20	20	20	20
100	40	40	30	25	20	20	20	20	20	20	20	20
110	50	40	30	30	25	25	20	20	20	20	20	20
120	50	40	40	30	25	25	25	20	20	20	20	20
130	50	50	40	30	30	25	25	25	20	20	20	20
140	60	50	40	40	30	30	30	25	25	20	20	20
150	60	50	50	40	40	30	30	25	25	25	20	20
160		60	50	40	40	40	40	30	25	25	20	20
170		60	50	50	40	40	40	30	30	25	25	20
180		60	50	50	40	40	40	40	30	30	25	20
190			60	50	50	40	40	40	40	30	25	20
200			60	50	50	50	40	40	40	30	25	25
210			60	60	50	50	50	40	40	40	30	25
220				60	50	50	50	40	40	40	30	25
230				60	60	50	50	50	40	40	30	25
240				60	60	50	50	50	40	40	40	30
250					60	60	60	50	50	40	40	30
260					60	60	60	50	50	40	40	30
270						60	60	50	50	50	40	30
280						60	60	60	50	50	40	40
290							60	60	50	50	40	40
300								60	60	50	40	40
310									60	60	50	40
320									60	60	50	40
330									60	60	60	50
340										60	60	50
350										60	60	50
360											60	50
370											60	50
380												60
390												60
400												60
410												60
420												60
430												60
440												60
450												60
460												60

## 4. DESIGN

### Design table for fire resistance **120 min**

Section factor (m <sup>2</sup> )	Design temperature (°C)											
	350	400	450	500	525	550	560	600	620	650	700	750
	Fire protection thickness (mm) to keep steel temperature under design temperature											
≤ 50	25	25	20	20	20	20	20	20	20	20	20	20
60	40	30	25	20	20	20	20	20	20	20	20	20
70	40	40	30	25	25	20	20	20	20	20	20	20
80	50	40	40	30	25	25	25	20	20	20	20	20
90	50	50	40	40	30	30	30	25	25	20	20	20
100	60	50	40	40	40	40	30	30	25	25	20	20
110	60	60	50	40	40	40	40	30	30	30	25	20
120	60	60	50	50	40	40	40	40	40	30	25	25
130			60	50	50	50	40	40	40	40	30	25
140			60	60	50	50	50	40	40	40	30	30
150				60	60	50	50	50	40	40	40	30
160				60	60	60	50	50	50	40	40	40
170					60	60	60	50	50	50	40	40
180						60	60	60	50	50	40	40
190							60	60	60	50	50	40
200								60	60	60	50	40
210									60	60	50	50
220										60	50	50
230										60	60	50
240											60	50
250											60	50
260											60	60
270												60
280												60
290												60

### Design table for fire resistance **150 min**

Section factor (m <sup>2</sup> )	Design temperature (°C)											
	350	400	450	500	525	550	560	600	620	650	700	750
	Fire protection thickness (mm) to keep steel temperature under design temperature											
≤ 50	40	30	25	25	20	20	20	20	20	20	20	20
60	40	40	40	30	25	25	25	25	20	20	20	20
70	50	50	40	40	30	30	30	25	25	25	20	20
80	60	50	50	40	40	40	40	30	30	30	25	20
90		60	50	50	40	40	40	40	40	30	30	25
100		60	60	50	50	50	50	40	40	40	30	30
110			60	60	50	50	50	50	40	40	40	30
120				60	60	60	60	50	50	50	40	40
130					60	60	60	60	50	50	50	40
140							60	60	60	50	50	40
150								60	60	60	50	50
160										60	60	50
170											60	50
180											60	60
190												60
200												60

## 4. DESIGN

### Design table for fire resistance **180 min**

	Design temperature (°C)											
	350	400	450	500	525	550	560	600	620	650	700	750
Section factor (m <sup>2</sup> )	Fire protection thickness (mm) to keep steel temperature under design temperature											
≤ 50	50	40	40	30	30	30	25	25	25	20	20	20
60	50	50	40	40	40	40	30	30	30	25	25	20
70	60	60	50	50	40	40	50	40	40	30	30	25
80		60	60	50	50	50	50	40	40	40	40	30
90			60	60	60	50	50	50	50	40	40	40
100					60	60	60	50	50	50	40	40
110							60	60	60	50	50	50
120								60	60	60	50	50
130										60	60	50
140											60	60
150												60

### Design table for fire resistance **240 min**

	Design temperature (°C)											
	350	400	450	500	525	550	560	600	620	650	700	750
Section factor (m <sup>2</sup> )	Fire protection thickness (mm) to keep steel temperature under design temperature											
≤ 50	60	60	50	50	40	40	40	40	40	30	30	25
60			60	50	50	50	50	50	40	40	40	40
70				60	60	60	60	50	50	50	50	40
80								60	60	60	50	50
90										60	60	50
100												60



# 4. DESIGN

## Design table for critical steel temperature **350 °C**

	Fire resistance classification								
	R 15	R 30	R 45	R 60	R 90	R 120	R 150	R 180	R 240
Section factor (m <sup>2</sup> )	Protection thickness (mm)								
≤ 50	20	20	20	20	20	25	40	50	60
60	20	20	20	20	25	40	40	50	
70	20	20	20	20	25	40	50	60	
80	20	20	20	20	30	50	60		
90	20	20	20	20	40	50			
100	20	20	20	25	40	60			
110	20	20	20	25	50	60			
120	20	20	20	25	50				
130	20	20	20	30	50				
140	20	20	20	30	60				
150	20	20	20	40	60				
160	20	20	25	40					
170	20	20	25	40					
180	20	20	25	40					
190	20	20	30	50					
200	20	20	30	50					
210	20	20	30	50					
220	20	20	40	50					
230	20	20	40	60					
240	20	20	40	60					
250	20	20	40	60					
260	20	20	40	60					
270	20	20	40						
280	20	20	50						
290	20	20	50						
300	20	20	50						
310	20	20	50						
320	20	20	50						
330	20	20	50						
340	20	25	60						
350	20	25	60						
360	20	25	60						
370	20	25	60						
380	20	30							
390	20	30							
400	20	30							
410	20	30							
420	20	30							
430	20	40							
440	20	40							
450	20	40							
460	20	40							
470	20	40							
480	20	40							
490	20	40							
500	20	40							
510	20	40							
520	20	50							
530	20	50							
540	20	50							
550	20	50							
560	20	50							
570	20	50							
580	20	60							
590	20	60							
600	20	60							
610	20	60							
620	20	60							
630	20	60							
640	20								
650	20								
660	20								
670	20								
680	20								
690	20								
700	20								
710	20								
716	20								

# 4. DESIGN

## Design table for critical steel temperature 400 °C

	Fire resistance classification								
	R 15	R 30	R 45	R 60	R 90	R 120	R 150	R 180	R 240
Section factor (m <sup>2</sup> )	Protection thickness (mm)								
≤ 50	20	20	20	20	20	25	30	40	60
60	20	20	20	20	20	30	40	50	
70	20	20	20	20	25	40	50	60	
80	20	20	20	20	25	40	50	60	
90	20	20	20	20	30	50	60		
100	20	20	20	20	40	50			
110	20	20	20	20	40	60			
120	20	20	20	20	40	60			
130	20	20	20	25	50				
140	20	20	20	25	50				
150	20	20	20	30	50				
160	20	20	20	30	60				
170	20	20	20	30	60				
180	20	20	20	40	60				
190	20	20	20	40					
200	20	20	25	40					
210	20	20	25	40					
220	20	20	25	40					
230	20	20	25	50					
240	20	20	30	50					
250	20	20	30	50					
260	20	20	30	50					
270	20	20	30	50					
280	20	20	40	60					
290	20	20	40	60					
300	20	20	40	60					
310	20	20	40	60					
320	20	20	40						
330	20	20	40						
340	20	20	40						
350	20	20	40						
360	20	20	50						
370	20	20	50						
380	20	20	50						
390	20	20	50						
400	20	20	60						
410	20	20	60						
420	20	20	60						
430	20	20	60						
440	20	20	60						
450	20	20							
460	20	20							
470	20	20							
480	20	20							
490	20	20							
500	20	20							
510	20	25							
520	20	25							
530	20	25							
540	20	25							
550	20	25							
560	20	25							
570	20	25							
580	20	30							
590	20	30							
600	20	30							
610	20	30							
620	20	30							
630	20	30							
640	20	40							
650	20	40							
660	20	40							
670	20	40							
680	20	40							
690	20	40							
700	20	40							
710	20	40							
716	20	40							

# 4. DESIGN

## Design table for critical steel temperature **450 °C**

Section factor (m <sup>2</sup> )	Fire resistance classification								
	R 15	R 30	R 45	R 60	R 90	R 120	R 150	R 180	R 240
	Protection thickness (mm)								
≤ 50	20	20	20	20	20	20	25	40	50
60	20	20	20	20	20	25	40	40	60
70	20	20	20	20	20	30	40	50	
80	20	20	20	20	20	40	50	60	
90	20	20	20	20	25	40	50	60	
100	20	20	20	20	30	40	60		
110	20	20	20	20	30	50	60		
120	20	20	20	20	40	50			
130	20	20	20	20	40	60			
140	20	20	20	20	40	60			
150	20	20	20	25	50				
160	20	20	20	25	50				
170	20	20	20	25	50				
180	20	20	20	30	60				
190	20	20	20	30	60				
200	20	20	20	30	60				
210	20	20	20	30	60				
220	20	20	20	40					
230	20	20	20	40					
240	20	20	20	40					
250	20	20	20	40					
260	20	20	20	40					
270	20	20	25	40					
280	20	20	25	50					
290	20	20	25	50					
300	20	20	25	50					
310	20	20	25	50					
320	20	20	30	50					
330	20	20	30	60					
340	20	20	30	60					
350	20	20	30	60					
360	20	20	30	60					
370	20	20	40	60					
380	20	20	40						
390	20	20	40						
400	20	20	40						
410	20	20	40						
420	20	20	40						
430	20	20	50						
440	20	20	50						
450	20	20	50						
460	20	20	50						
470	20	20	50						
480	20	20	50						
490	20	20	50						
500	20	20	60						
510	20	20	60						
520	20	20	60						
530	20	20	60						
540	20	20	60						
550	20	20	60						
560	20	20							
570	20	20							
580	20	20							
590	20	20							
600	20	20							
610	20	20							
620	20	20							
630	20	20							
640	20	20							
650	20	20							
660	20	20							
670	20	20							
680	20	20							
690	20	20							
700	20	20							
710	20	20							
716	20	20							

# 4. DESIGN

## Design table for critical steel temperature 500 °C

Section factor (m <sup>2</sup> )	Fire resistance classification								
	R 15	R 30	R 45	R 60	R 90	R 120	R 150	R 180	R 240
	Protection thickness (mm)								
≤ 50	20	20	20	20	20	20	25	30	50
60	20	20	20	20	20	20	30	40	50
70	20	20	20	20	20	25	40	50	60
80	20	20	20	20	20	30	40	50	
90	20	20	20	20	20	40	50	60	
100	20	20	20	20	25	40	50		
110	20	20	20	20	25	40	60		
120	20	20	20	20	30	50	60		
130	20	20	20	20	30	50			
140	20	20	20	20	40	60			
150	20	20	20	20	40	60			
160	20	20	20	20	40	60			
170	20	20	20	20	50				
180	20	20	20	20	50				
190	20	20	20	25	50				
200	20	20	20	25	50				
210	20	20	20	25	60				
220	20	20	20	25	60				
230	20	20	20	30	60				
240	20	20	20	30	60				
250	20	20	20	30					
260	20	20	20	40					
270	20	20	20	40					
280	20	20	20	40					
290	20	20	20	40					
300	20	20	20	40					
310	20	20	20	40					
320	20	20	20	40					
330	20	20	20	40					
340	20	20	20	50					
350	20	20	20	50					
360	20	20	25	50					
370	20	20	25	50					
380	20	20	25	60					
390	20	20	25	60					
400	20	20	30	60					
410	20	20	30	60					
420	20	20	30	60					
430	20	20	30						
440	20	20	30						
450	20	20	40						
460	20	20	40						
470	20	20	40						
480	20	20	40						
490	20	20	40						
500	20	20	40						
510	20	20	40						
520	20	20	40						
530	20	20	40						
540	20	20	40						
550	20	20	50						
560	20	20	50						
570	20	20	50						
580	20	20	50						
590	20	20	50						
600	20	20	50						
610	20	20	50						
620	20	20	50						
630	20	20	50						
640	20	20	60						
650	20	20	60						
660	20	20	60						
670	20	20	60						
680	20	20	60						
690	20	20	60						
700	20	20	60						
710	20	20							
716	20	20							

# 4. DESIGN

## Design table for critical steel temperature 525 °C

Section factor (m <sup>2</sup> )	Fire resistance classification								
	R 15	R 30	R 45	R 60	R 90	R 120	R 150	R 180	R 240
	Protection thickness (mm)								
≤ 50	20	20	20	20	20	20	20	30	40
60	20	20	20	20	20	20	25	40	50
70	20	20	20	20	20	25	30	40	60
80	20	20	20	20	20	25	40	50	
90	20	20	20	20	20	30	40	60	
100	20	20	20	20	20	40	50	60	
110	20	20	20	20	25	40	50		
120	20	20	20	20	25	40	60		
130	20	20	20	20	30	50	60		
140	20	20	20	20	30	50			
150	20	20	20	20	40	60			
160	20	20	20	20	40	60			
170	20	20	20	20	40	60			
180	20	20	20	20	40				
190	20	20	20	20	50				
200	20	20	20	20	50				
210	20	20	20	25	50				
220	20	20	20	25	50				
230	20	20	20	25	60				
240	20	20	20	25	60				
250	20	20	20	30	60				
260	20	20	20	30	60				
270	20	20	20	30					
280	20	20	20	30					
290	20	20	20	40					
300	20	20	20	40					
310	20	20	20	40					
320	20	20	20	40					
330	20	20	20	40					
340	20	20	20	40					
350	20	20	20	40					
360	20	20	20	40					
370	20	20	20	40					
380	20	20	20	50					
390	20	20	20	50					
400	20	20	25	50					
410	20	20	25	60					
420	20	20	25	60					
430	20	20	25	60					
440	20	20	25	60					
450	20	20	25	60					
460	20	20	30	60					
470	20	20	30						
480	20	20	30						
490	20	20	30						
500	20	20	30						
510	20	20	30						
520	20	20	40						
530	20	20	40						
540	20	20	40						
550	20	20	40						
560	20	20	40						
570	20	20	40						
580	20	20	40						
590	20	20	40						
600	20	20	40						
610	20	20	40						
620	20	20	40						
630	20	20	50						
640	20	20	50						
650	20	20	50						
660	20	20	50						
670	20	20	50						
680	20	20	50						
690	20	20	50						
700	20	20	50						
710	20	20	50						
716	20	20	50						



# 4. DESIGN

## Design table for critical steel temperature **550 °C**

	Fire resistance classification								
	R 15	R 30	R 45	R 60	R 90	R 120	R 150	R 180	R 240
Section factor (m <sup>2</sup> )	Protection thickness (mm)								
≤ 50	20	20	20	20	20	20	20	25	40
60	20	20	20	20	20	20	25	40	50
70	20	20	20	20	20	20	30	40	60
80	20	20	20	20	20	25	40	50	
90	20	20	20	20	20	30	40	50	
100	20	20	20	20	20	40	50	60	
110	20	20	20	20	25	40	50		
120	20	20	20	20	25	40	60		
130	20	20	20	20	25	50	60		
140	20	20	20	20	30	50			
150	20	20	20	20	30	50			
160	20	20	20	20	40	60			
170	20	20	20	20	40	60			
180	20	20	20	20	40	60			
190	20	20	20	20	40				
200	20	20	20	20	50				
210	20	20	20	20	50				
220	20	20	20	20	50				
230	20	20	20	25	50				
240	20	20	20	25	60				
250	20	20	20	25	60				
260	20	20	20	25	60				
270	20	20	20	25	60				
280	20	20	20	30	60				
290	20	20	20	30					
300	20	20	20	30					
310	20	20	20	30					
320	20	20	20	40					
330	20	20	20	40					
340	20	20	20	40					
350	20	20	20	40					
360	20	20	20	40					
370	20	20	20	40					
380	20	20	20	50					
390	20	20	20	50					
400	20	20	20	50					
410	20	20	20	50					
420	20	20	20	50					
430	20	20	20	50					
440	20	20	20	50					
450	20	20	20	60					
460	20	20	20	60					
470	20	20	25	60					
480	20	20	25	60					
490	20	20	25	60					
500	20	20	25	60					
510	20	20	25	60					
520	20	20	25						
530	20	20	25						
540	20	20	30						
550	20	20	30						
560	20	20	30						
570	20	20	30						
580	20	20	30						
590	20	20	30						
600	20	20	30						
610	20	20	40						
620	20	20	40						
630	20	20	40						
640	20	20	40						
650	20	20	40						
660	20	20	40						
670	20	20	40						
680	20	20	40						
690	20	20	40						
700	20	20	40						
710	20	20	40						
716	20	20	40						

# 4. DESIGN

## Design table for critical steel temperature **560 °C**

Section factor (m <sup>2</sup> )	Fire resistance classification								
	R 15	R 30	R 45	R 60	R 90	R 120	R 150	R 180	R 240
	Protection thickness (mm)								
≤ 50	20	20	20	20	20	20	20	25	40
60	20	20	20	20	20	20	25	30	50
70	20	20	20	20	20	20	30	40	60
80	20	20	20	20	20	25	40	50	
90	20	20	20	20	20	30	40	50	
100	20	20	20	20	20	30	50	60	
110	20	20	20	20	20	40	50	60	
120	20	20	20	20	25	40	60		
130	20	20	20	20	25	40	60		
140	20	20	20	20	30	50	60		
150	20	20	20	20	30	50			
160	20	20	20	20	40	50			
170	20	20	20	20	40	60			
180	20	20	20	20	40	60			
190	20	20	20	20	40	60			
200	20	20	20	20	40				
210	20	20	20	20	50				
220	20	20	20	20	50				
230	20	20	20	20	50				
240	20	20	20	25	50				
250	20	20	20	25	60				
260	20	20	20	25	60				
270	20	20	20	25	60				
280	20	20	20	25	60				
290	20	20	20	30	60				
300	20	20	20	30					
310	20	20	20	30					
320	20	20	20	30					
330	20	20	20	30					
340	20	20	20	40					
350	20	20	20	40					
360	20	20	20	40					
370	20	20	20	40					
380	20	20	20	40					
390	20	20	20	40					
400	20	20	20	50					
410	20	20	20	50					
420	20	20	20	50					
430	20	20	20	50					
440	20	20	20	50					
450	20	20	20	50					
460	20	20	20	50					
470	20	20	20	60					
480	20	20	20	60					
490	20	20	20	60					
500	20	20	25	60					
510	20	20	25	60					
520	20	20	25	60					
530	20	20	25	60					
540	20	20	25						
550	20	20	25						
560	20	20	25						
570	20	20	25						
580	20	20	30						
590	20	20	30						
600	20	20	30						
610	20	20	30						
620	20	20	30						
630	20	20	30						
640	20	20	30						
650	20	20	40						
660	20	20	40						
670	20	20	40						
680	20	20	40						
690	20	20	40						
700	20	20	40						
710	20	20	40						
716	20	20	40						

# 4. DESIGN

## Design table for critical steel temperature 600 °C

	Fire resistance classification								
	R 15	R 30	R 45	R 60	R 90	R 120	R 150	R 180	R 240
Section factor (m <sup>2</sup> )	Protection thickness (mm)								
≤ 50	20	20	20	20	20	20	20	25	40
60	20	20	20	20	20	20	25	30	50
70	20	20	20	20	20	20	25	40	50
80	20	20	20	20	20	20	30	40	60
90	20	20	20	20	20	25	40	50	
100	20	20	20	20	20	30	40	50	
110	20	20	20	20	20	30	50	60	
120	20	20	20	20	20	40	50	60	
130	20	20	20	20	25	40	60		
140	20	20	20	20	25	40	60		
150	20	20	20	20	25	50	60		
160	20	20	20	20	30	50			
170	20	20	20	20	30	50			
180	20	20	20	20	40	60			
190	20	20	20	20	40	60			
200	20	20	20	20	40	60			
210	20	20	20	20	40				
220	20	20	20	20	40				
230	20	20	20	20	50				
240	20	20	20	20	50				
250	20	20	20	20	50				
260	20	20	20	20	50				
270	20	20	20	20	50				
280	20	20	20	20	60				
290	20	20	20	25	60				
300	20	20	20	25	60				
310	20	20	20	25	60				
320	20	20	20	25	60				
330	20	20	20	25	60				
340	20	20	20	25					
350	20	20	20	30					
360	20	20	20	30					
370	20	20	20	30					
380	20	20	20	40					
390	20	20	20	40					
400	20	20	20	40					
410	20	20	20	40					
420	20	20	20	40					
430	20	20	20	40					
440	20	20	20	40					
450	20	20	20	40					
460	20	20	20	40					
470	20	20	20	50					
480	20	20	20	50					
490	20	20	20	50					
500	20	20	20	50					
510	20	20	20	50					
520	20	20	20	50					
530	20	20	20	50					
540	20	20	20	50					
550	20	20	20	60					
560	20	20	20	60					
570	20	20	20	60					
580	20	20	20	60					
590	20	20	20	60					
600	20	20	20	60					
610	20	20	20	60					
620	20	20	20	60					
630	20	20	20						
640	20	20	20						
650	20	20	20						
660	20	20	20						
670	20	20	20						
680	20	20	25						
690	20	20	25						
700	20	20	25						
710	20	20	25						
716	20	20	25						

# 4. DESIGN

## Design table for critical steel temperature **620 °C**

Section factor (m <sup>2</sup> )	Fire resistance classification								
	R 15	R 30	R 45	R 60	R 90	R 120	R 150	R 180	R 240
	Protection thickness (mm)								
≤ 50	20	20	20	20	20	20	20	25	40
60	20	20	20	20	20	20	20	30	40
70	20	20	20	20	20	20	25	40	50
80	20	20	20	20	20	20	30	40	60
90	20	20	20	20	20	25	40	50	
100	20	20	20	20	20	25	40	50	
110	20	20	20	20	20	30	40	60	
120	20	20	20	20	20	40	50	60	
130	20	20	20	20	20	40	50		
140	20	20	20	20	25	40	60		
150	20	20	20	20	25	40	60		
160	20	20	20	20	30	50			
170	20	20	20	20	30	50			
180	20	20	20	20	30	50			
190	20	20	20	20	40	60			
200	20	20	20	20	40	60			
210	20	20	20	20	40	60			
220	20	20	20	20	40				
230	20	20	20	20	40				
240	20	20	20	20	50				
250	20	20	20	20	50				
260	20	20	20	20	50				
270	20	20	20	20	50				
280	20	20	20	20	50				
290	20	20	20	20	50				
300	20	20	20	20	60				
310	20	20	20	20	60				
320	20	20	20	25	60				
330	20	20	20	25	60				
340	20	20	20	25	60				
350	20	20	20	25	60				
360	20	20	20	25					
370	20	20	20	25					
380	20	20	20	30					
390	20	20	20	30					
400	20	20	20	30					
410	20	20	20	40					
420	20	20	20	40					
430	20	20	20	40					
440	20	20	20	40					
450	20	20	20	40					
460	20	20	20	40					
470	20	20	20	40					
480	20	20	20	40					
490	20	20	20	40					
500	20	20	20	40					
510	20	20	20	50					
520	20	20	20	50					
530	20	20	20	50					
540	20	20	20	50					
550	20	20	20	50					
560	20	20	20	50					
570	20	20	20	50					
580	20	20	20	50					
590	20	20	20	50					
600	20	20	20	60					
610	20	20	20	60					
620	20	20	20	60					
630	20	20	20	60					
640	20	20	20	60					
650	20	20	20	60					
660	20	20	20	60					
670	20	20	20	60					
680	20	20	20						
690	20	20	20						
700	20	20	20						
710	20	20	20						
716	20	20	20						

# 4. DESIGN

## Design table for critical steel temperature **650 °C**

	Fire resistance classification								
	R 15	R 30	R 45	R 60	R 90	R 120	R 150	R 180	R 240
Section factor (m <sup>2</sup> )	Protection thickness (mm)								
≤ 50	20	20	20	20	20	20	20	20	30
60	20	20	20	20	20	20	20	25	40
70	20	20	20	20	20	20	25	30	50
80	20	20	20	20	20	20	30	40	60
90	20	20	20	20	20	20	30	40	60
100	20	20	20	20	20	25	40	50	
110	20	20	20	20	20	30	40	50	
120	20	20	20	20	20	30	50	60	
130	20	20	20	20	20	40	50	60	
140	20	20	20	20	20	40	50		
150	20	20	20	20	25	40	60		
160	20	20	20	20	25	40	60		
170	20	20	20	20	25	50			
180	20	20	20	20	30	50			
190	20	20	20	20	30	50			
200	20	20	20	20	30	60			
210	20	20	20	20	40	60			
220	20	20	20	20	40	60			
230	20	20	20	20	40	60			
240	20	20	20	20	40				
250	20	20	20	20	40				
260	20	20	20	20	40				
270	20	20	20	20	50				
280	20	20	20	20	50				
290	20	20	20	20	50				
300	20	20	20	20	50				
310	20	20	20	20	50				
320	20	20	20	20	50				
330	20	20	20	20	60				
340	20	20	20	20	60				
350	20	20	20	20	60				
360	20	20	20	20	60				
370	20	20	20	25	60				
380	20	20	20	25					
390	20	20	20	25					
400	20	20	20	25					
410	20	20	20	30					
420	20	20	20	30					
430	20	20	20	30					
440	20	20	20	30					
450	20	20	20	30					
460	20	20	20	30					
470	20	20	20	40					
480	20	20	20	40					
490	20	20	20	40					
500	20	20	20	40					
510	20	20	20	40					
520	20	20	20	40					
530	20	20	20	40					
540	20	20	20	40					
550	20	20	20	40					
560	20	20	20	40					
570	20	20	20	40					
580	20	20	20	50					
590	20	20	20	50					
600	20	20	20	50					
610	20	20	20	50					
620	20	20	20	50					
630	20	20	20	50					
640	20	20	20	50					
650	20	20	20	50					
660	20	20	20	50					
670	20	20	20	50					
680	20	20	20	60					
690	20	20	20	60					
700	20	20	20	60					
710	20	20	20	60					
716	20	20	20	60					



# 4. DESIGN

## Design table for critical steel temperature **700 °C**

	Fire resistance classification								
	R 15	R 30	R 45	R 60	R 90	R 120	R 150	R 180	R 240
Section factor (m <sup>2</sup> )	Protection thickness (mm)								
≤ 50	20	20	20	20	20	20	20	20	30
60	20	20	20	20	20	20	20	25	40
70	20	20	20	20	20	20	20	30	50
80	20	20	20	20	20	20	25	40	50
90	20	20	20	20	20	20	30	40	60
100	20	20	20	20	20	20	30	40	
110	20	20	20	20	20	25	40	50	
120	20	20	20	20	20	25	40	50	
130	20	20	20	20	20	30	50	60	
140	20	20	20	20	20	30	50	60	
150	20	20	20	20	20	40	50		
160	20	20	20	20	20	40	60		
170	20	20	20	20	25	40	60		
180	20	20	20	20	25	40	60		
190	20	20	20	20	25	50			
200	20	20	20	20	25	50			
210	20	20	20	20	30	50			
220	20	20	20	20	30	50			
230	20	20	20	20	30	60			
240	20	20	20	20	40	60			
250	20	20	20	20	40	60			
260	20	20	20	20	40	60			
270	20	20	20	20	40				
280	20	20	20	20	40				
290	20	20	20	20	40				
300	20	20	20	20	40				
310	20	20	20	20	50				
320	20	20	20	20	50				
330	20	20	20	20	50				
340	20	20	20	20	50				
350	20	20	20	20	50				
360	20	20	20	20	50				
370	20	20	20	20	50				
380	20	20	20	20	60				
390	20	20	20	20	60				
400	20	20	20	20	60				
410	20	20	20	20					
420	20	20	20	20					
430	20	20	20	20					
440	20	20	20	25					
450	20	20	20	25					
460	20	20	20	25					
470	20	20	20	25					
480	20	20	20	25					
490	20	20	20	25					
500	20	20	20	25					
510	20	20	20	25					
520	20	20	20	30					
530	20	20	20	30					
540	20	20	20	30					
550	20	20	20	30					
560	20	20	20	30					
570	20	20	20	30					
580	20	20	20	30					
590	20	20	20	40					
600	20	20	20	40					
610	20	20	20	40					
620	20	20	20	40					
630	20	20	20	40					
640	20	20	20	40					
650	20	20	20	40					
660	20	20	20	40					
670	20	20	20	40					
680	20	20	20	40					
690	20	20	20	40					
700	20	20	20	40					
710	20	20	20	40					
716	20	20	20	40					

# 4. DESIGN

## Design table for critical steel temperature 750 °C

	Fire resistance classification								
	R 15	R 30	R 45	R 60	R 90	R 120	R 150	R 180	R 240
Section factor (m <sup>2</sup> )	Protection thickness (mm)								
≤ 50	20	20	20	20	20	20	20	20	25
60	20	20	20	20	20	20	20	20	40
70	20	20	20	20	20	20	20	25	40
80	20	20	20	20	20	20	20	30	50
90	20	20	20	20	20	20	25	40	50
100	20	20	20	20	20	20	30	40	60
110	20	20	20	20	20	20	30	50	
120	20	20	20	20	20	25	40	50	
130	20	20	20	20	20	25	40	50	
140	20	20	20	20	20	30	40	60	
150	20	20	20	20	20	30	50	60	
160	20	20	20	20	20	40	50		
170	20	20	20	20	20	40	50		
180	20	20	20	20	20	40	60		
190	20	20	20	20	20	40	60		
200	20	20	20	20	25	40	60		
210	20	20	20	20	25	50			
220	20	20	20	20	25	50			
230	20	20	20	20	25	50			
240	20	20	20	20	30	50			
250	20	20	20	20	30	50			
260	20	20	20	20	30	60			
270	20	20	20	20	30	60			
280	20	20	20	20	40	60			
290	20	20	20	20	40	60			
300	20	20	20	20	40				
310	20	20	20	20	40				
320	20	20	20	20	40				
330	20	20	20	20	40				
340	20	20	20	20	40				
350	20	20	20	20	40				
360	20	20	20	20	50				
370	20	20	20	20	50				
380	20	20	20	20	50				
390	20	20	20	20	50				
400	20	20	20	20	60				
410	20	20	20	20	60				
420	20	20	20	20	60				
430	20	20	20	20	60				
440	20	20	20	20	60				
450	20	20	20	20	60				
460	20	20	20	20	60				
470	20	20	20	20					
480	20	20	20	20					
490	20	20	20	20					
500	20	20	20	20					
510	20	20	20	20					
520	20	20	20	20					
530	20	20	20	20					
540	20	20	20	20					
550	20	20	20	20					
560	20	20	20	20					
570	20	20	20	20					
580	20	20	20	20					
590	20	20	20	25					
600	20	20	20	25					
610	20	20	20	25					
620	20	20	20	25					
630	20	20	20	25					
640	20	20	20	25					
650	20	20	20	25					
660	20	20	20	25					
670	20	20	20	25					
680	20	20	20	25					
690	20	20	20	30					
700	20	20	20	30					
710	20	20	20	30					
716	20	20	20	30					

# 5. FIRE PROTECTION OF TRAPEZOIDAL ROOF

## Fire protection of trapezoidal roofs with fire resistance REI 60 and REI 90 according to EN 13501-2

Trapezoidal roof systems are very cost effective, lightweight and suited to a wide variety of applications, including new build and refurbishment. The load-bearing capacity of corrugated steel without fire protection is 15–45 minutes depending on the structure and insulation used on the top of the steel sheet. The steel sheet bends and if the anchoring to the support is good enough it uses advantages of membrane and the load-bearing capability remains for a significant amount of time.

When there is no insulation used on top of the corrugated steel sheet, the heat goes through the metal and dissipates upwards and the steel temperature rises slower.

When corrugated steel is used as a load-bearing structure for the roof construction and insulation is installed on top of the corrugated steel board, the temperature of the metal rises very quickly. Isover FireProtect® is a simple and reliable system that limits the temperature rise in the steel sheet and helps roof to withstand longer from collapse.



**Fig. 10** System Isover FireProtect® for fire protection of corrugated steel is characterized by light weight and small height, but also a direct fixing to the corrugated steel without need of help of suspension construction

### Fire classification

Fire protection system Isover FireProtect® was officially tested in PAVUS, a.s., authorized body AO 216. It is possible to protect roof made of corrugated steel for fire resistances REI 60 and REI 90. Classification according to the latest standard EN 13501-2: 2016, testing based on EN 1365-2: 2015.

Fire resistance (min)	Thickness of fire protection cladding Isover FireProtect® 150
REI 60	30
REI 90	60



**Fig. 11** Sample after 30 minutes – fire protection system Isover FireProtect® fulfils its function for 100 %, roof is without any deformation (bending stress, the same as would be under cold conditions)



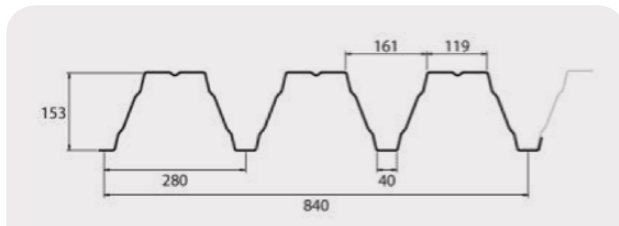
**Fig. 12** Sample after 90 minutes – roof deformation protected with Isover FireProtect® is close to limit deformation given by test standard EN 1365-2 (fluent transition from bending stress to membrane)



## Fixing

### Design guide of trapezoidal roof

Trapezoidal profiled steel sheet was tested as a simply supported beam with span 6 m. Total area load in accidental design situation under fire conditions, according to EN 1990 and EN 1991-1-2, was 1.0 kN/m<sup>2</sup>. The corresponding maximum bending moment in the middle of the roof span was  $M_{fi,A} = 4.5$  kNm/m and shear forces in the support were  $V_{fi1} = 3.0$  kN/m. The similar constructions will have the same fire resistant classification in case when calculated values of stress (internal forces) will be lower or equal to the stated values.

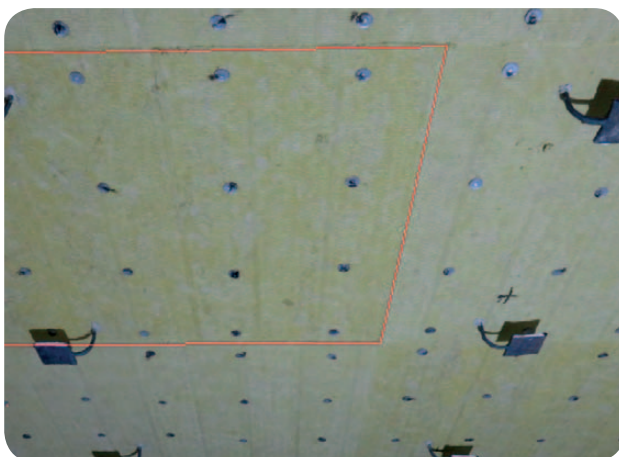


**Fig. 13** The supporting structure shall consist of trapezoidal profiled steel sheets TR 150/280/0.75 mm and with a thickness of 0.75 mm.

Mounting and fixing must be according to the metal sheet manufacturer recommendations and instructions. The trapezoidal profiles are fixed to the supports by two self-drilling screws  $\varnothing 5.5$  mm  $\times$  19 mm (galvanized carbon steel, hardened) in each wave. The trapezoidal steel sheets are fixed to each other by self-drilling screws  $\varnothing 4.8$  mm  $\times$  19 mm (galvanized carbon steel), in spacing of 500 mm.

### Fire protection cladding

Assembly of slabs Isover FireProtect® 150 in thickness 30 mm (REI 60) or 60 mm (REI 90) is quick, simple and secure with easily worked materials and simple fixing – stud-welded pins ( $\varnothing 2,7$  mm, washer  $\varnothing 30$  mm, length 32–33 mm for REI 60 or 62–63 mm for REI 90) or pins and washers (with the same dimension as described for stud-welded pins) in maximal distance of 300 mm to the bottom waves of the trapezoidal steel profile. Maximum distance from the cladding joints (edges of slabs) is 75 mm. Approximate pin's quantity is 13 pcs/m<sup>2</sup>.



**Fig. 14** View to finished fire protection cladding of trapezoidal metal sheet, dimension 1  $\times$  1,2 m of slab Isover FireProtect® 150 highlighted by red line

### Trapezoidal roofs carried by steel beams

Fire protection of steel beams carrying a trapezoidal roof is often required in practice. Protection of steel beams is carried out using Isover FireProtect® with the thickness given by the section factor  $A_p/V$  and critical steel temperature. The trapezoidal roof protection is provided by slabs Isover FireProtect® 150 with the thickness of 30 mm or 60 mm.



**Fig. 15** The four side fire protection of a steel beam (using the Isover FireProtect® 150 slabs to backfill a trapezoidal profile)



**Fig. 16** The three side fire protection of a steel member in combination with the fire protection of a trapezoidal profile sheet. The thickness of the fire protection cladding Isover FireProtect® on the metal sheet corresponds to:

- the thickness of the fire protection cladding on the steel member (in case there is no fire resistance requirement to the metal sheet),
- the thickness of 30 mm (in case of the fire resistance requirement REI 60 to the trapezoidal metal roof) or 60 mm (REI90),
- the thickness of the fire protection cladding as stated in the design tables on page 26 (in case of the concrete ceiling poured in trapezoidal metal sheets).

# 6. FIRE PROTECTION OF CONCRETE

## Fire resistance increase of concrete members and slabs according to EN 13501-2

Concrete is specified in buildings and civil engineering projects for several reasons, sometimes cost, and sometimes speed of construction or architectural appearance, but one of concrete's major inherent benefits is its performance in fire, which may be overlooked in the race to consider all the factors affecting design decisions. Concrete usually performs well in building fires, however, concrete structures must still be designed for fire effects. Structural components still must be able to withstand dead and live loads without collapse even though the rise in temperature causes a decrease in the strength and modulus of elasticity for concrete and steel reinforcement. In addition, fully developed fires cause expansion of structural components and the resulting stresses and strains must be resisted. This rise in temperature dramatically reduces the mechanical properties of concrete and steel.

Ordexal® B system is designed to increase the fire resistance of concrete slabs (decks) up to R 360 and of concrete beams up to R 240 according to EN 13381-3: 2015. The additional fire protection of the hollow core or massive concrete slabs/beams slows down the temperature rise of reinforcing steels. The goal is to maintain the bearing capability in the side on tension.

### Composition

Ordexal® B system consists of mineral wool slabs Isover Pyro of 20 mm thickness and heat-resistant cement-based adhesive Dexaflamm B. The slabs are glued in their full surface to the reinforced concrete structure by the heat-resistant adhesive.

### Fire protection slabs

Mineral wool slabs of 20 mm thickness, with nominal density 190 kg/m<sup>3</sup>, supplied in basic dimensions 500 × 1000 mm, pack of 10 pieces in foil. The slabs can be cut by a standard lagger knife, circular saw with sintered carbide blade and extraction or a hand saw with fine teeth.

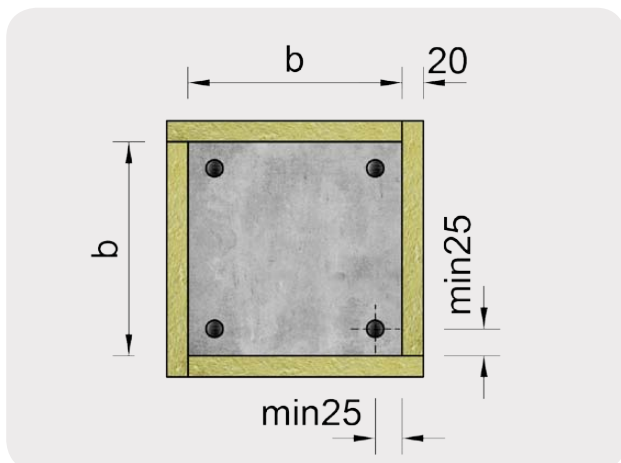
### Adhesive description

The heat resistant adhesive Dexaflamm B is supplied in 15 or 50 kg plastic barrels or 25 kg paper bags. The cement is prepared by mixing the content of the barrel of dry mixture (50 kg) to about 12 litres of clean water by a stirrer, drill extender or mixer with forced mixing. The mixing time is 2-5 min. After mixing let the compound leave to stand for about 5 minutes and then mix briefly again. When mixing small quantities, observe the ratio of dry mixture and water. Time of processability is about 90 minutes.

## Design tables

**1.** Rectangular **reinforced concrete columns** protected with system ORDEXAL® B in thickness 20 mm exposed to fire from one or more sides.

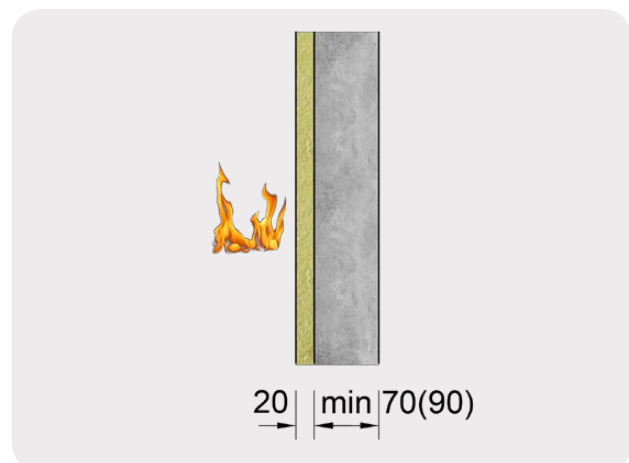
Fire resistance (min)	Minimum dimension of column (mm)	
	Width of diameter of column b	Axial distance of reinforcement a
R 60	b = 200	a = 25
R 120	b = 250	a = 25
R 180	b = 350	a = 25



**2.** **Concrete non-bearing walls with or without reinforcement**, protected with system ORDEXAL® B in thickness 20 mm exposed to fire from one side

Fire resistance (min)	Minimum thickness of the concrete wall d (mm)
EI 120	70
EI 180	90

Note: When exposed to fire from one or the other side, fire protection system has to be applied from both sides of the wall



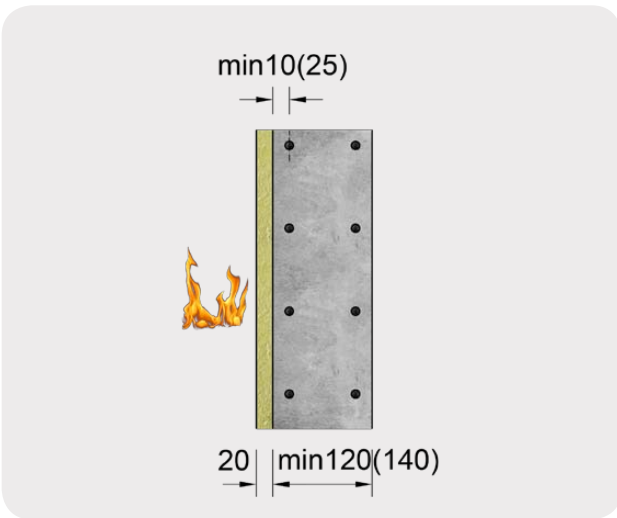


3.

**Reinforced concrete walls** protected with system ORDEXAL® B in thickness 20 mm exposed to fire from one side.

Fire resistance (min)	Minimum thickness of the wall d (mm) / Axial distance of reinforcement a (mm)
REI 120	120/10
REI 180	140/25

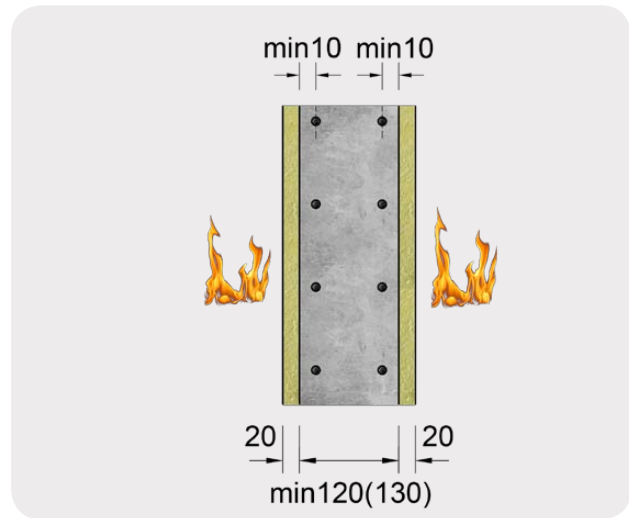
Note: When exposed to fire from one or the other side, fire protection system has to be applied from both sides of the wall



4.

**Reinforced concrete walls** protected with system ORDEXAL® B in thickness 20 mm exposed to fire from both sides.

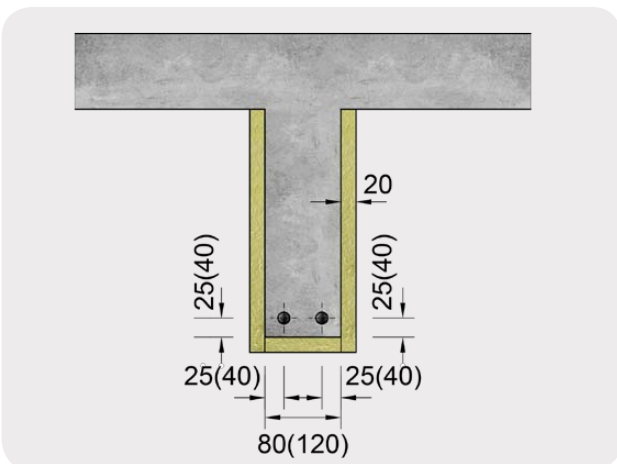
Fire resistance (min)	Minimum thickness of the wall d (mm) / Axial distance of reinforcement a (mm)
R 120	120/10
R 180	130/10



5.

**Simply supported reinforced concrete or prestressed concrete beams**, protected from three sides with system ORDEXAL® B in thickness 20 mm.

Fire resistance (min)	Minimum width of beam b (mm)/ Average axial distance of reinforcement a (mm)
R 120	80/25
R 180	120/40

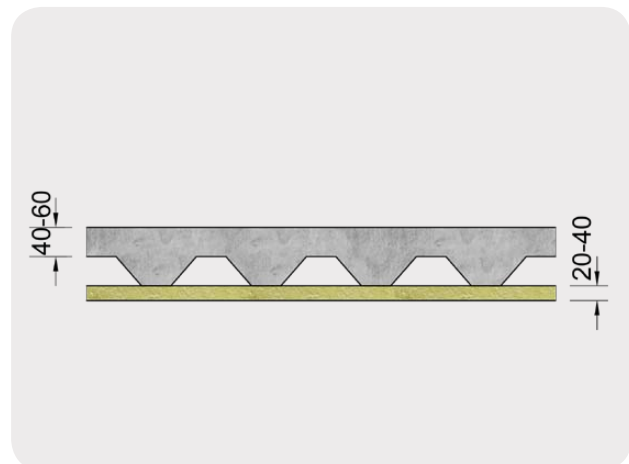


6.

**Floors from trapezoidal metal sheet with a concrete layer 40 to 60 mm**, protected with system ORDEXAL® ZLB in thickness 20 and 40 mm.

Fire resistance (min)	Minimal thickness of concrete slab (mm)	Thickness of Isover Pyro (mm)
REI 60	40	20
REI 90	50	20
REI 180	60	40

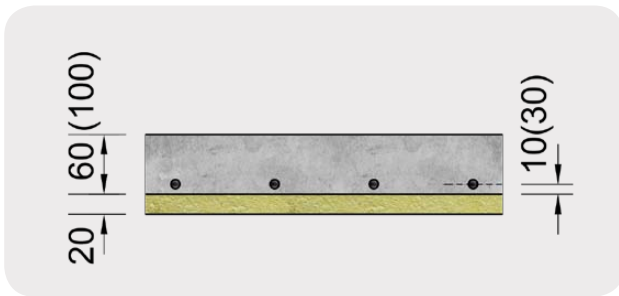
\* Thickness of the concrete slab  $h_s$  is considered the smallest value that may be rectified by replacing the effective thickness  $h_{eff}$



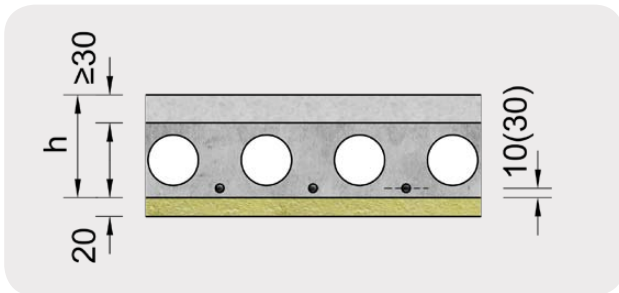
7.

Simply supported reinforcement concrete or prestressed concrete slabs with reinforcement in one direction, protected from bottom side with system ORDEXAL® B in thickness 20 mm.

Fire resistance (min)	Minimum thickness of the slab $h_s$ (mm) / Axial distance of reinforcement $a$ (mm)
REI 120	60/10
REI 180	100/30



Note: Table is valid also for hollow slab panels with effective thickness  $h_e = h[A_c/(b \cdot h)]^{0.5}$   
 Where:  $h$  is actual thickness of the panel, topping included (countable layer thickness  $\geq 30$  mm)  
 $A_c$  is area of concrete cross-section, topping included  
 $b$  width of the panel

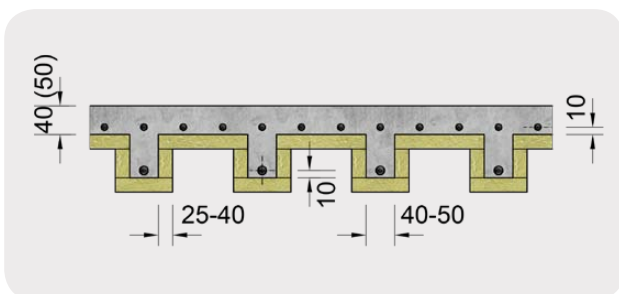


9.

Thin slabs (fixed) with thickness 40 mm and 50 mm from reinforced concrete with reinforcement in one or two directions, protected with system ORDEXAL® B in thickness 20 mm, 30 mm or 40 mm.

Fire resistance (min)	Minimum thickness of reinforced slab $h_s$ (mm)/ Axial distance of reinforcement $a$ (mm)	Fire protection thickness of ORDEXAL® B (mm) applied from the bottom side
REI 60	40/10	20
REI 90	50/10	20
REI 90	40/10	30
REI 120	50/10	30
REI 120	40/10	40
REI 120	50/10	40

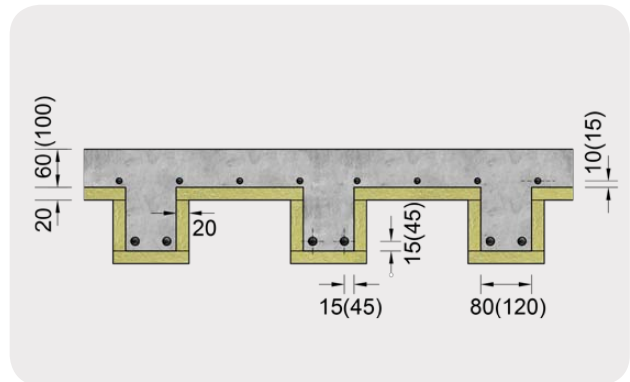
Values are not valid for prestressed concrete!



8.

Simply supported reinforcement concrete or prestressed concrete ribbed slabs, protected with system ORDEXAL® B in thickness 20 mm.

Fire resistance (min)	Minimum thickness of reinforced slab $h_s$ (mm)/ Axial distance of reinforcement $a$ (mm)	Minimum width of the rib $b$ (mm)/ Axial distance of reinforcement $a$ (mm)
REI 120	60/10	80/15
REI 180	100/15	120/45

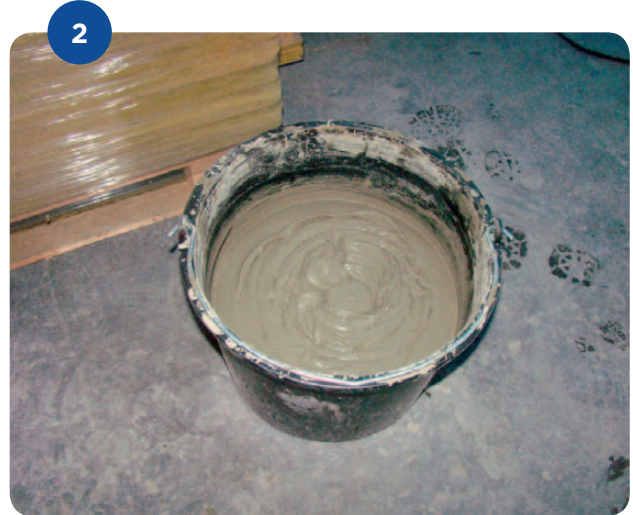


## 6. FIRE PROTECTION OF CONCRETE

Pictorial instructions for the installation of system ORDEXAL® B



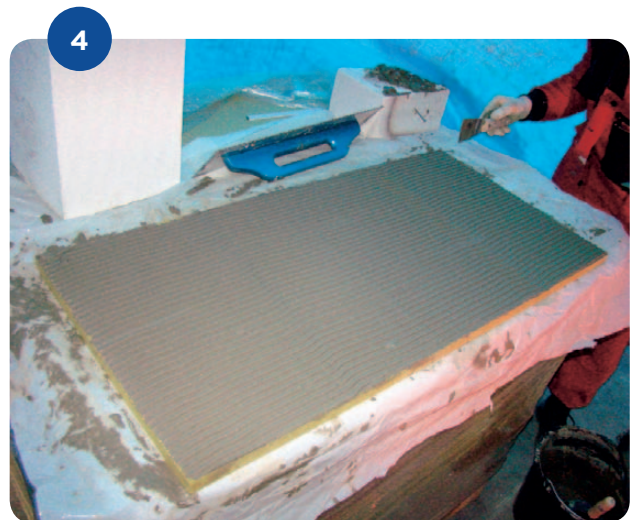
**Inspect the slab and the tools used**



**Prepare Dexaflamm B adhesive**



**Apply an adequate amount of the adhesive on the slab**



**Spread the adhesive with a notched trowel over the entire surface of the slab**

5



Press the first slab to the baseline and remove any excessive adhesive

6



Check the bonding over the entire surface - Dexaflamm B adhesive is slightly pushed out and visible

7



Installation of the first row of slabs - inspect the straightness of the row

8



Install other slabs by pressing them against the edge of the already installed slabs (the edges are not glued)

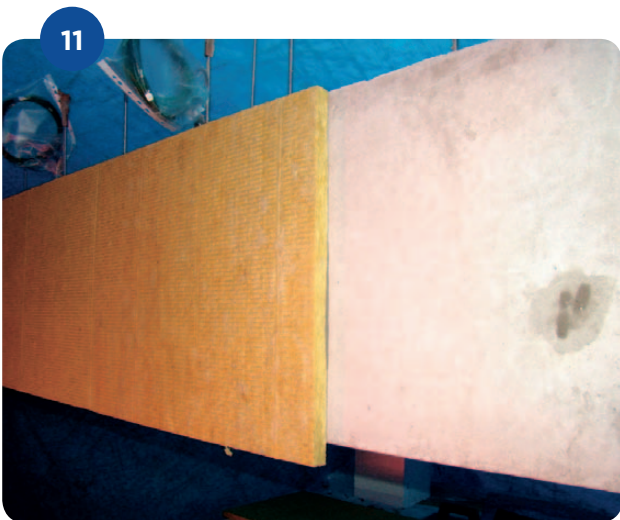




**Check the system thickness, 20 mm slab, 3-4 mm layer of adhesive**



**Finished ORDEXAL® B lining**



**In case of a beam, the sides are glued first**



**The flange is glued in the end**



# 7. FIRE RESISTANCE INCREASE OF CARBON FIBRE LAMELLAS

**ORDEXAL® KARBON ALB** is designed to increase the fire resistance of carbon fibre lamellas reinforcing and strengthening concrete structures. With a suitable design you can achieve the reinforcing function of a carbon fibre lamella **in the range of 30 to 120 minutes with reduced demands for the space needed for the protective material**. The design is developed according to the dimension table, depending on the heat resistance of the adhesive used.

## Use

**The application of ORDEXAL® KARBON ALB is suitable:** in all common heated and unheated interiors (according to EAD environment types Z1, Z2 and Y). The fire protective insulation does not overload the structure, does not crack and reduce vibrations and dynamic impacts.

**The application of ORDEXAL® KARBON ALB is not suitable:** without additional surface treatment in highly aggressive environment (aromates and organic vapours) and places with flowing or dripping water, or in non-ventilated spaces with a relative humidity above 80 %.



**WARNING** - the size and installation of **ORDEXAL® KARBON ALB cladding on the reinforcing carbon lamellas depend on the dimensions of the reinforced concrete structures and the distance of the lamella from its edges**. The minimum lateral overlap of the lamella cladding is always 100 mm. If the lamella is located at the edge of a beam or closer than 100 mm from an opening, its sides have to be clad as well! It is advisable to consult the design in advance with our experts.

## Design table

According to the tests carried out in PAVUS test laboratory, a dimension table of the thickness of **ORDEXAL® KARBON ALB** fire protective slab was developed for individual thicknesses required to observe the maximum allowable temperatures on the surface of a carbon lamella depending on time.

### Prescribed thickness of the **ORDEXAL® KARBON ALB** cladding

Fire resistance <sup>x)</sup> (minutes)	Thickness of the cladding <sup>xx)</sup> (mm) <b>ORDEXAL® KARBON ALB</b> for fire protection of strengthening carbon fibre lamellas with critical temperature 50 to 90 °C					
	R - load-bearing capacity	50°C	60°C	70°C	80°C	90°C
30		40	40	40	40	40
45		40	40	40	40	40
60		60	60	40	40	40
90		80	80	60	60	40
120		100	100	80	80	60

<sup>x)</sup> The concrete structure itself must have at least the same fire resistance before fire protection.

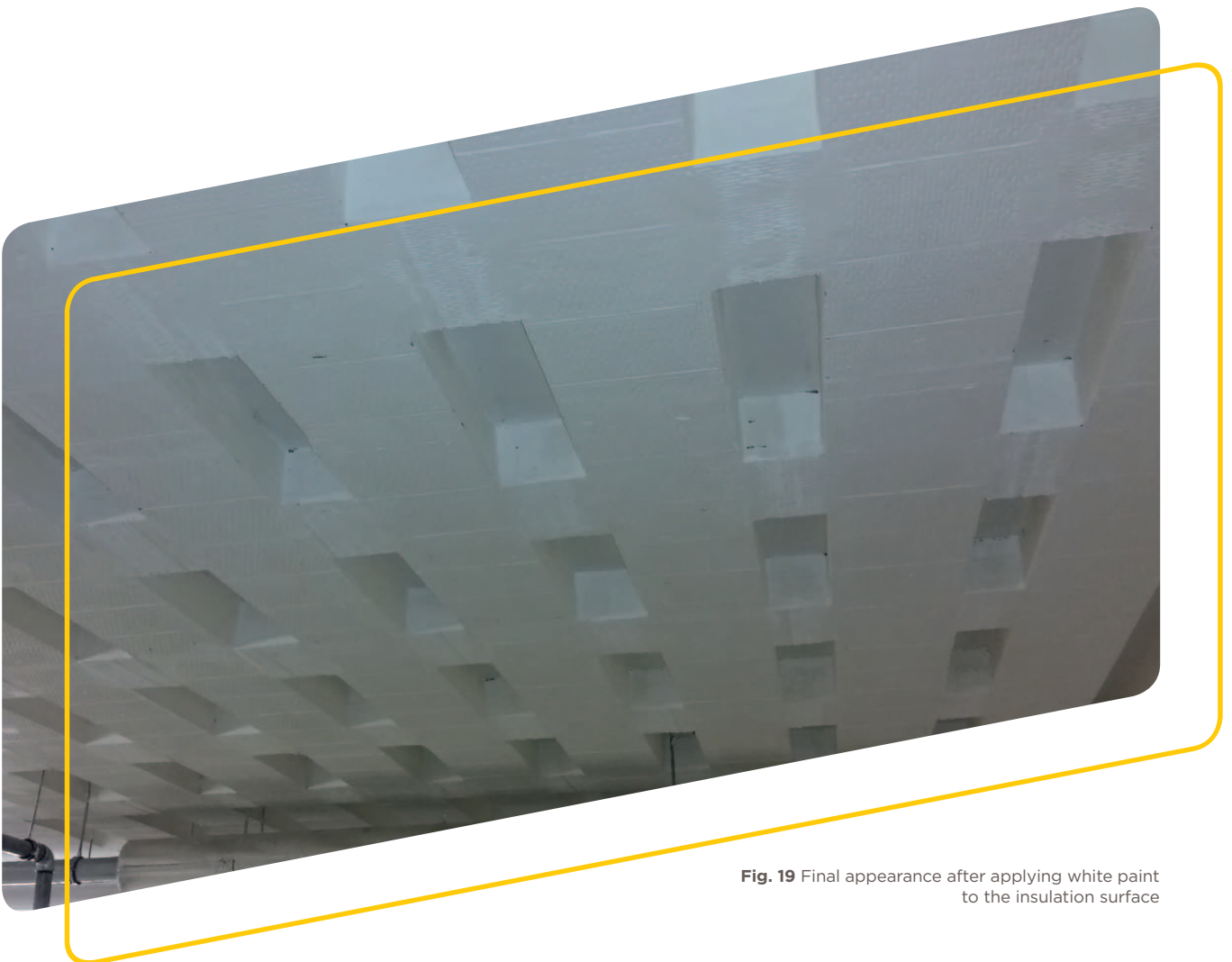
<sup>xx)</sup> The final thickness of the cladding is about 6-12 mm higher than the values given in the table (with the thickness of the adhesive).



**Fig. 17** Carbon fiber reinforced lamellas before fire protection



**Fig. 18** Semifinished fire protective cladding ORDEXAL® KARBON ALB without final surface layer



**Fig. 19** Final appearance after applying white paint to the insulation surface

# FURTHER INFORMATION ABOUT ISOVER FIREPROTECT®

For more information about Isover FireProtect®, please contact the local Isover representative in your country.



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