



European Technical Assessment

ETA 18/0456
of 20.09.2018



General part

Technical Assessment Body issuing the ETA: ITeC

ITeC has been designated according to Article 29 of Regulation (EU) No 305/2011 and is member of EOTA (European Organisation for Technical Assessment).

Trade name of the construction product

Perliwool®

Product family to which the construction product belongs

Rendering intended for fire resisting applications

Manufacturer

MINERAL FIBER SOLUTIONS SL
Ctra a Almacelles A-2217 km 3,84
ES-22540 Altorricón (Huesca)
Spain

Manufacturing plant(s)

According to Annex N kept by ITeC

This European Technical Assessment contains

38 pages including 3 annexes which form an integral part of this assessment

and

Annex N, which contains confidential information and is not included in the European Technical Assessment when that assessment is publicly available

This European Technical Assessment is issued in accordance with Regulation (EU) 305/2011, on the basis of

European Assessment Document EAD 350140-00-1106

General comments

Translations of this European Technical Assessment in other languages shall fully correspond to the original issued document and should be identified as such.

Communication of this European Technical Assessment, including transmission by electronic means, shall be in full.

Specific parts of the European Technical Assessment

1 Technical description of the product

Perliwool® is a wet-mix spray-applied fire protective rendering made of mineral wool and other components. The binder is included as part of the dry mix.

The rendering considered in this ETA is applied, when necessary, in conjunction with the additional components as specified in the annexes (ETA under option 3 as described in the scope of EAD 350140-00-1106).

Properties of the applied rendering such as thickness range, density, adhesion values, etc., are described in Annex 2 and Annex 3.

2 Specification of the intended use(s) in accordance with the applicable EAD

Perliwool® is intended for the fire protection uses as described in table 1, which also shows the related environmental use conditions.

Table 1: Intended use categories related to the protected element and the environmental conditions.

Fire protection uses		Environmental conditions
EAD 350140-00-1106 reference	Element intended to be protected	EAD 350140-00-1106 reference
Type 3	Loadbearing concrete elements	Type Z ₂
Type 4	Loadbearing steel elements	Type Z ₂

The environmental use categories are specified in EAD 350140-00-1106, section 1.2.3:

- Type Z₂: internal conditions with temperature of at least 0 °C and humidity lower than 85 % RH.

The provisions made in this ETA are based on a working life of Perliwool® of at least 25 years, provided that the conditions laid down in the manufacturer's instructions for the installation, use and maintenance are met. These provisions are based upon the current state of the art and the available knowledge and experience.

The indications given as to the working life cannot be interpreted as a guarantee given by the producer or Assessment Body, but are to be regarded only as a means for choosing the appropriate product(s) in relation to the expected economically reasonable working life of the works.

3 Performance of the product and reference to the methods used for its assessment

3.1 Performance of the product

The assessment of Perliwool® has been performed in accordance with the EAD 350140-00-1106.

Table 2: Performance of Perliwool®.

Product: Perliwool®		Intended use: Fire resisting applications	
Basic requirement	Essential characteristic	Performance	
	Reaction to fire	A1	
BWR 2 Safety in case of fire	Resistance to fire	See Annex 2 and Annex 3	
	Durability	Type Z ₂	
BWR 4 Safety and accessibility in use	Adhesion (bond strength)	See 3.2.5 and Annexes 2 and 3	
BWR 5 Protection against noise	Sound absorption	Thickness 35 mm	$\alpha_v = 0,80$ (H); Class B
		Thickness 54 mm	$\alpha_v = 1,00$; Class A
BWR 6 Energy economy and heat retention	Thermal conductivity, $\lambda_{90/90(23/50)}$	0,078 W/(m·K)	

The rest of characteristics included in EAD 350140-00-1106 have not been assessed in this ETA.

3.2 Methods used for the assessment

3.2.1 Reaction to fire

The rendering has been tested according to EN ISO 1182¹ and EN ISO 1716². Classification is given in accordance with EN 13501-1³ and Regulation (EU) 2016/364.

3.2.2 Resistance to fire

The resistance to fire has been determined following the test and evaluation methods given in Annex 2 and Annex 3 and has been classified in accordance with EN 13501-2⁴.

¹ EN ISO 1182 Reaction to fire tests for products. Non-combustibility test.

² EN ISO 1716 Reaction to fire tests for products. Determination of the gross heat of combustion (calorific value).

³ EN 13501-1 Fire classification of construction products and building elements. Part 1: Classification using data from reaction to fire tests.

⁴ EN 13501-2 Fire classification of construction products and building elements. Part 2: Classification using data from fire resistance tests, excluding ventilation services implemented.

3.2.3 Primers compatibility

Anti-corrosive two-component epoxy primers for use on load-bearing steel elements have been tested and assessed to be compatible with the rendering in accordance with section 2.2.14.4 of EAD 350140-00-1106.

3.2.4 Durability

Durability of the rendering has been assessed according to EAD 350140-00-1106, section 2.2.12, in relation to its fire protective intended uses as defined in table 1.

3.2.5 Adhesion (bond strength)

Adhesion (bond strength) has been determined in accordance with EAD 350140-00-1106, section 2.2.7, and EGOLF EA 05⁵. The adhesion of the rendering depends on the installed thickness and the preparation of the substrate. Bond strength guidance values of the rendering and the conditions under which they were achieved are given in the Annex 2 and Annex 3.

3.2.6 Sound absorption

The sound absorption of Perliwool® has been tested according to EN ISO 354⁶ at a rendering thickness of 35 mm and 54 mm. The weighted sound absorption coefficient (α_w) and rating have been determined in accordance with EN ISO 11654⁷.

3.2.7 Thermal conductivity

Thermal conductivity has been assessed according to Annex D of EAD 350140-00-1106, tested to EN 12667⁸; the declared values have been determined according to EN ISO 10456⁹.

Table 3: Thermal characteristics.

$\lambda_{10,dry,90/90}$	0,060	(W/m·K)	Conductivity fractile value at 10 °C, dry conditions, representing at least 90% of the production with a confidence level of 90%
$u_{23,50}$	0,065	(kg/kg)	Moisture content mass by mass at 23 °C / 50% R.H.
$f_{u,1}$	3,99	(kg/kg)	Moisture content conversion coefficient mass by mass (dry – 23/50)
$\lambda_{D,90/90(23/50)}$	0,078	(W/m·K)	Design value of conductivity at 23 °C and 50% R.H.

3.2.8 Technical characterisation

The ETA is issued for the rendering based on data/information deposited with the ITeC in accordance with section 2.3.2 of EAD 350140-00-1106.

⁵ EGOLF EA 05 Fire testing. Method for the measurement of bonding properties of fire protection materials applied to steel, concrete and steel/concrete composite structures (SM5:1999).

⁶ EN ISO 354 Acoustics. Measurement of sound absorption in a reverberation room.

⁷ EN ISO 11654 Acoustics. Sound absorbers for use in buildings. Rating of sound absorption.

⁸ EN 12667 Thermal performance of building materials and products. Determination of thermal resistance by means of guarded hot plate and heat flow meter methods. Products of high and medium thermal resistance.

⁹ EN ISO 10456 Building materials and products. Hygrothermal properties. Tabulated design values and procedures for determining declared and design thermal values.

4 Assessment and verification of constancy of performance (AVCP) system applied, with reference to its legal base

According to the Decision 1999/454/EC of the European Commission, the system of AVCP (see EC Delegated Regulation (EU) No 568/2014 amending Annex V to Regulation (EU) 305/2011) given in the following table applies.

Table 4: AVCP System.

Product(s)	Intended use(s)	Level(s) or class(es)	System(s)
Fire protective products	For fire compartmentation and/or fire protection or fire performance	Any	1

5 Technical details necessary for the implementation of the AVCP system, as foreseen in the applicable EAD

All the necessary technical details for the implementation of the AVCP system are laid down in the Control Plan deposited with the ITeC and agreed in accordance with EAD 350140-00-1106.

The Control Plan is a confidential part of the ETA and only handed over to the notified product certification body involved in the assessment and verification of constancy of performance.

The factory production control operated by the manufacturer shall be in accordance with the above-mentioned Control Plan.

Issued in Barcelona on 20 September 2018

by the Catalonia Institute of Construction Technology.



Ferran Bermejo Nualart
Technical Director, ITeC

ANNEX 1. Resistance to fire performance and installation provisions

A.1.1 Overview of the assessed resistance to fire performance

The assessed constructive elements fire protected with Perliwool® are shown in table A.1.1.

Table A.1.1: Fire protected constructive elements.

Intended use according to EAD		Test standard	Classification	Installation details
Type 3	Loadbearing concrete elements	EN 13381-3 ¹⁰	EN 13501-2	Annex 2
Type 4	Loadbearing steel elements	EN 13381-4 ¹¹	EN 13501-2	Annex 3

A.1.2 Installation provisions related to the elements protected with Perliwool®

The product installation should be carried out in accordance with the manufacturer's instructions and the provisions given in this ETA.

The product is intended for environmental use category Type Z₂. Special provisions shall be taken for temporary protection of the rendering exposed to outdoor conditions during construction.

Before application the substrate should be inspected and prepared. Surfaces to be sprayed shall be free from oil, grease, primers, sealing agents or of any other substance that will impair adhesion. If dirt is detected on the substrate, it is recommended to clean the substrate by spraying water with a hose.

Clips, hangers, supports, sleeves and other attachments to the substrate can be placed by others prior or after the application of Perliwool®. Ducts, piping, conduits or other suspended equipment can be installed after the application of Perliwool®, in which case later inspection will be required and, when necessary, reparation of the rendering.

A.1.3 Verifications on site

The thickness should be measured at sufficient points to determine the mean and minimum thickness. A suitable method for thickness measurement is given in EAD 350140-00-1106, section 2.3.4.

The density of the hardened rendering should be measured within the tolerances specified in Annex 2 and Annex 3.

The bond strength of the rendering to the substrate should be tested on site. A suitable method is EGOLF Agreement EA 05, which can be used as a base for the site tests. The person responsible for the works will decide on the adequacy of the site tests results taking into account the reference values given in Annex 2 and Annex 3. For their acceptability, the recommendations given in EAD, section G.4, or other existing criteria can be applied, under the responsibility of the person responsible for works.

¹⁰ EN 13381-3 Test methods for determining the contribution to the fire resistance of structural members. Part 3: Applied protection to concrete members.

¹¹ EN 13381-4 Test methods for determining the contribution to the fire resistance of structural members. Part 4: Applied passive protection to steel members.

ANNEX 2. Specification and assessment of the fire performance of loadbearing concrete elements protected with Perliwool® (intended use Type 3)

A.2.1.1 Classification of loadbearing concrete slabs and walls

The constructive elements described in this annex have been tested at two different thicknesses of Perliwool® protection (10,9 mm and 15,0 mm), and are assessed according to EN 13381-3 and classified according to EN 13501-2.

The equivalent thickness of concrete and the insulation performance are given in section A.2.1.3.

A.2.1.2 Installation requirements

The product installation should be carried out in accordance with the provisions in A.1.2 and the following specification.

A.2.1.2.1 Supporting structural element

Perliwool® can be applied on concrete slabs exposed to fire from one side, both in horizontal (floors) and vertical (walls) orientation. Specification of the supporting structural element is given in tables A.2.1.1 and A.2.1.2.

Table A.2.1.1: Specification of the concrete structural element protected with 10,9 mm thickness of Perliwool®.

Element	Characteristics	Mounting and fixing
Loadbearing concrete slab and wall	Thickness of the slab/wall ≥ 130 mm	Reinforced concrete
	Density: $2280 \text{ kg/m}^3 \pm 15 \%$	Concrete released from the mould without agent
	Compressive strength $\geq 20 \text{ N/mm}^2$	Surface free of oil, grease, dust, etc.
	Made with calcareous aggregate.	

Table A.2.1.2: Specification of the concrete structural element protected with 15,0 mm thickness of Perliwool®.

Element	Characteristics	Mounting and fixing
Loadbearing concrete slab and wall	Thickness of the slab/wall ≥ 150 mm	Reinforced concrete
	Density: $2300 \text{ kg/m}^3 \pm 15 \%$	Concrete released from the mould without agent
	Compressive strength $\geq 30 \text{ N/mm}^2$	Surface free of oil, grease, dust, etc.
	Made with any type of aggregate.	

A.2.1.2.2 Fire protective rendering

Perliwool® is directly applied on the concrete structure in one coat of regular thickness to reach the requested thickness according to this annex. Hairline cracks in the dry rendering are not accepted.

Specification of the fire protective rendering is given in table A.2.1.3.

Table A.2.1.3. Specification of the applied rendering.

Product	Characteristics	Mounting and fixing
Perliwool® (Hardened rendering)	Thickness: 10,9 mm and 15,0 mm Density: 300 kg/m ³ ± 15 %	Rendering is kept without finishing after application. Spray-applied rendering without: - Primer or bonding agent - Topcoat or sealing coat - Mechanical fixings or reinforcement ⁽¹⁾ - Additives out of dry mix

⁽¹⁾ For the rendering applied at 10,9 mm on a concrete structure according to table A.2.1.1, an expanded metal mesh according to EN 13658, made of galvanised steel with a thickness of 0,3 mm and a mass per unit area of 1,17 kg/m², is fixed with steel nails to the concrete every 60 cm both longitudinally and transversally, prior to the rendering application.

A.2.1.2.3 Bonding properties of Perliwool® on concrete slabs and walls

Assessment of the bonding properties of Perliwool®, when directly applied on concrete structures, has been carried out according to EGOLF EA 05 procedure.

The indicated values are representative of adhesive failure at the surface between the concrete substrate and the applied thickness of protective sprayed product Perliwool®. These values are guidance values, and they do not reflect a statistical evaluation, nor minimum guaranteed values.

Table A.2.1.4. Tensile bond strength on concrete substrates.

Surface	Thickness of Perliwool® (mm)	Mean tensile bond strength (MPa)	Failure mode
Concrete substrate according EGOLF SM5	10,9 – 15,0	0,019	Adhesion

A.2.1.3 Assessment of the fire performance of Perliwool® on concrete slabs and walls

A.2.1.3.1 General

The method used to assess the fire protection performance of Perliwool® when applied on concrete elements is according to section 13 of EN 13381-3.

A.2.1.3.2 Insulation performance

The insulation criteria according to EN 1363-1 were kept until the end of the resistance to fire test at both assessed thicknesses (10,9 mm and 15,0 mm), thus maintaining its separating function:

- Increase of the average temperature of the concrete slab unexposed surface below 140 °C.
- Increase of the maximum temperature of the concrete slab unexposed surface below 180 °C.

A.2.1.3.3 Stickability performance

The stickability of Perliwool® when applied on concrete slabs and walls is determined according to the requirements of paragraph 13.5 of EN 13381-3.

At no time the maximum recorded temperatures of the concrete exposed surface were more than 50% above the mean value of the recorded temperatures of the concrete exposed surface (no stickability failure occurs at any of the assessed thicknesses; 10,9 mm and 15,0 mm).

A.2.1.3.4 Protection of concrete slabs and walls

The insulation efficiency of the 10,9 mm and 15,0 mm thickness protective material when applied on concrete slabs and walls according to tables A.2.1.1 and A.2.1.2, subject to the thermal exposure under the standard time-temperature curve as defined in paragraph 5.1.1 of EN 1363-1, is given in the next tables in a range of concrete temperatures.

Table A.2.1.5: Concrete depth vs design temperature for 10,9 mm thickness of Perliwool®.

Time period (minutes)	Depth of design temperatures inside the concrete (mm)						
	150 °C	200 °C	250 °C	300 °C	350 °C	400 °C	450 °C
120	8	-	-	-	-	-	-
150	17	5	-	-	-	-	-
180	34	14	4	-	-	-	-
210	53	25	12	4	-	-	-
240	-	44	24	11	3	-	-
270	-	54	35	20	10	3	-
300	-	-	47	30	17	8	1

Table A.2.1.6: Concrete depth vs design temperature for 15,0 mm thickness of Perliwool®.

Time period (minutes)	Depth of design temperatures inside the concrete (mm)							
	100 °C	150 °C	200 °C	250 °C	300 °C	350 °C	400 °C	450 °C
30	3	-	-	-	-	-	-	-
60	18	6	-	-	-	-	-	-
90	47	15	6	-	-	-	-	-
120	65	28	15	6	-	-	-	-
150	-	45	25	15	6	-	-	-
180	-	57	39	24	14	6	-	-
210	-	68	51	35	23	14	6	-
240	-	-	60	47	32	22	14	6

A.2.1.3.5 Equivalent thickness of concrete for slabs and walls

The equivalent thickness of concrete induced by the protective rendering Perliwool® is determined according to Annex C of EN 13381-3 and given in table A.2.1.7 (with a thickness of 10,9 mm on concrete slabs and walls according to table A.2.1.1) and table A.2.1.8 (with a thickness of 15,0 mm on concrete slabs and walls according to table A.2.1.2).

Table A.2.1.7. Equivalent thickness of concrete induced by 10,9 mm of Perliwool®.

Time period (minutes)	30	60	90	120	180	240
Equivalent thickness of concrete (mm)	68	74	87	96	93	89

Table A.2.1.8. Equivalent thickness of concrete induced by 15,0 mm of Perliwool®.

Time period (minutes)	30	60	90	120	180	240
Equivalent thickness of concrete (mm)	53	64	69	70	67	61

A.2.2.1 Classification of loadbearing concrete beams and columns

The constructive elements described in this annex have been tested at two different thicknesses of Perliwool® protection (11 mm and 40 mm), and are assessed according to EN 13381-3 and classified according to EN 13501-2.

The equivalent thickness of concrete and the insulation performance are given in section A.2.2.3.

A.2.2.2 Installation requirements

The product installation should be carried out in accordance with the provisions in A.1.2 and the following specification.

A.2.2.2.1 Supporting structural element

Perliwool® can be applied on concrete beams and columns exposed to fire from more than one side. Specification of the supporting structural element is given in table A.2.2.1.

Table A.2.2.1: Specification of the concrete structural element protected with Perliwool®.

Element	Characteristics	Mounting and fixing
Loadbearing concrete beam and column	Height of the section ≥ 450 mm*	Reinforced concrete.
	Width of the section ≥ 150 mm	Concrete release from the mould without agent.
	Density: $2280 \text{ kg/m}^3 \pm 15\%$	Surface free of oil, grease, dust, etc.
	Compressive strength $\geq 20 \text{ N/mm}^2$	Surface must be scrapped before rendering application.
	Made with calcareous aggregate.	
	* The height may be decreased provided the section surface remains the same or is higher, by increasing the width.	

A.2.2.2.2 Fire protective rendering

Perliwool® is directly applied on the apparent sides of the concrete structure to be protected by following their shape, sprayed in one coat of regular thickness to reach the requested thickness according to this annex. Hairline cracks in the dry rendering are not accepted.

Specification of the fire protective rendering is given in table A.2.2.2.

Table A.2.2.2: Specification of the applied rendering.

Product	Characteristics	Mounting and fixing
Perliwool® (Hardened rendering)	Thickness: 11 mm and 40 mm Density: 300 kg/m ³ ± 15 %	Rendering is kept without finishing after application. Spray-applied rendering without: - Primer or bonding agent - Topcoat or sealing coat - Mechanical fixings or reinforcement ¹ - Additives out of dry mix

A.2.2.2.3 Bonding properties of Perliwool® on concrete beams and columns

Assessment of the bonding properties of Perliwool®, when directly applied on concrete structures, has been carried out according to EGOLF EA 05 procedure.

The indicated values are representative of adhesive failure at the surface between the concrete substrate and the applied thickness of protective sprayed product Perliwool®. These values are guidance values, and they do not reflect a statistical evaluation, nor minimum guaranteed values.

Table A.2.2.3. Tensile bond strength on concrete substrates.

Surface	Thickness of Perliwool® (mm)	Mean tensile bond strength (MPa)	Failure mode
Concrete substrate according EGOLF SM5	11 – 40	0,019	Adhesion

A.2.2.3 Assessment of the fire performance of Perliwool® on concrete beams and columns

A.2.2.3.1 General

The method used to assess the fire protection performance of Perliwool® when applied on concrete elements is according to section 13 of EN 13381-3.

A.2.2.3.2 Insulation performance

The average temperature of the 11 mm protected concrete beam unexposed surface exceeded 140 °C the initial temperature at minute 66, failing to meet the criteria in EN 1363-1.

The insulation criteria according to EN 1363-1 were kept for the 40 mm protected concrete beam until the end of the resistance to fire test (300 minutes).

A.2.2.3.3 Stickability performance

The stickability of Perliwool® when applied on concrete beams and columns is determined according to the requirements of section 13.5 of EN 13381-3.

At no time the maximum recorded temperatures on the concrete exposed surface of the 11 mm protected concrete beam were more than 50% above the mean value of the recorded temperatures of the concrete exposed surface (no stickability failure).

The maximum recorded temperature on the exposed surface of the 40 mm protected concrete beam was more than 50 % above the mean value of all recorded temperatures during the entire test (loss of stickability).

A.2.2.3.4 Protection of concrete beams and columns

The insulation efficiency of the 11 mm and 40 mm thickness protective material when applied on concrete beams and columns as specified in table A.2.2.1, subject to the thermal exposure under the standard time-temperature curve as defined in section 5.1.1 of EN 1363-1, is given in the next tables in a range of concrete temperatures within 150 °C – 450 °C along a vertical, horizontal and diagonal axis.

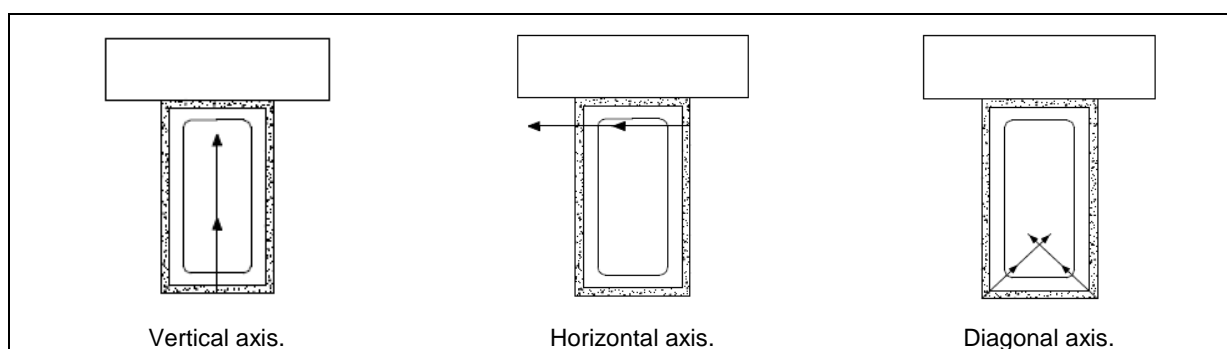


Figure A.2.2.1: Direction inside the concrete depth of a beam¹².

Table A.2.2.4: Concrete depth vs design temperature for 11 mm thickness of Perliwool®.

Vertical axis							
Time period (minutes)	Depth of design temperatures inside the concrete (mm)						
	150 °C	200 °C	250 °C	300 °C	350 °C	400 °C	450 °C
30	-	-	-	-	-	-	-
60	20	2	-	-	-	-	-
90	56	23	13	5	-	-	-
120	146	59	32	20	13	7	1
150	-	125	67	45	28	19	13
180	-	-	141	91	57	42	29
Horizontal axis							
Time period (minutes)	Depth of design temperatures inside the concrete (mm)						
	150 °C	200 °C	250 °C	300 °C	350 °C	400 °C	450 °C
30	-	-	-	-	-	-	-
60	24	3	-	-	-	-	-
90	56	27	16	6	-	-	-
120	-	59	35	24	16	8	1
150	-	-	64	46	31	22	15

¹² In case of columns, the vertical axis refers to the long axis and the horizontal to the short one.

Table A.2.2.4: Concrete depth vs design temperature for 11 mm thickness of Perliwool®.

180	-	-	-	73	56	44	33
Diagonal axis							
Time period (minutes)	Depth of design temperatures inside the concrete (mm)						
	150 °C	200 °C	250 °C	300 °C	350 °C	400 °C	450 °C
30	-	-	-	-	-	-	-
60	-	-	-	-	-	-	-
90	79	-	-	-	-	-	-
120	-	84	47	-	-	-	-
150	-	-	96	64	-	-	-
180	-	-	-	-	-	-	-

Table A.2.2.5: Concrete depth vs design temperature for 40 mm thickness of Perliwool®.

Vertical axis							
Time period (minutes)	Depth of design temperatures inside the concrete (mm)						
	150 °C	200 °C	250 °C	300 °C	350 °C	400 °C	450 °C
30	-	-	-	-	-	-	-
60	-	-	-	-	-	-	-
90	9	-	-	-	-	-	-
120	15	6	-	-	-	-	-
150	22	12	3	-	-	-	-
180	47	19	10	2	-	-	-
Horizontal axis							
Time period (minutes)	Depth of design temperatures inside the concrete (mm)						
	150 °C	200 °C	250 °C	300 °C	350 °C	400 °C	450 °C
30	-	-	-	-	-	-	-
60	-	-	-	-	-	-	-
90	-	-	-	-	-	-	-
120	9	-	-	-	-	-	-
150	23	4	-	-	-	-	-
180	51	18	-	-	-	-	-
Diagonal axis							
Time period (minutes)	Depth of design temperatures inside the concrete (mm)						
	150 °C	200 °C	250 °C	300 °C	350 °C	400 °C	450 °C
30	-	-	-	-	-	-	-
60	-	-	-	-	-	-	-
90	-	-	-	-	-	-	-
120	-	-	-	-	-	-	-
150	-	-	-	-	-	-	-
180	72	-	-	-	-	-	-

A.2.2.3.5 Equivalent thickness of concrete for beams and columns

The equivalent thickness of concrete induced by the protective rendering Perliwool[®], applied at 11 mm and 40 mm, is determined according to Annex C of EN 13381-3 and given in table A.2.2.6 for concrete beams and columns according to table A.2.2.1.

Table A.2.2.6. Equivalent thickness of concrete induced by Perliwool[®].

Time period (minutes)		30	60	90	120	180	240
Equivalent thickness of concrete (mm)	Perliwool [®] at 11 mm	48	67	76	75	65	-
	Perliwool [®] at 40 mm	90	110	122	132	130	128

The equivalent thickness of concrete H_{eq} in function of the thickness of Perliwool[®] is given in figures A.2.2.2, A.2.2.3, A.2.2.4, A.2.2.5 and A.2.2.6 for a time period of 30, 60, 90, 120 and 180 minutes respectively.

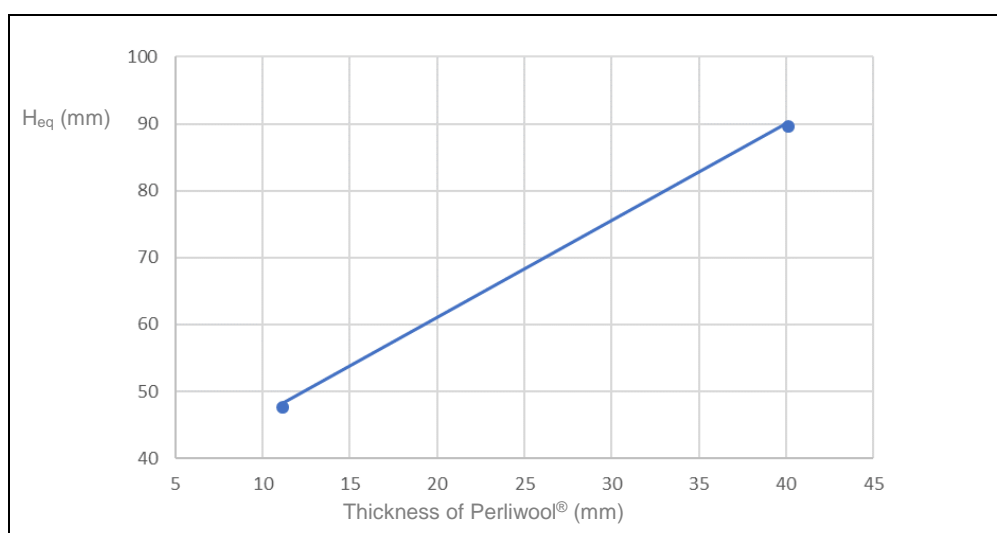


Figure A.2.2.2: Equivalent thickness of concrete (30 minutes).

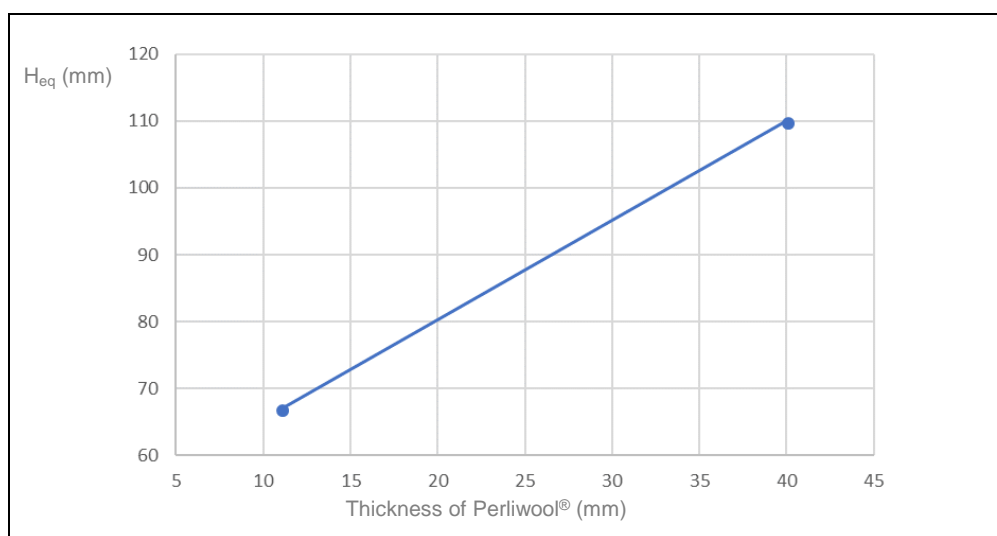


Figure A.2.2.3: Equivalent thickness of concrete (60 minutes).

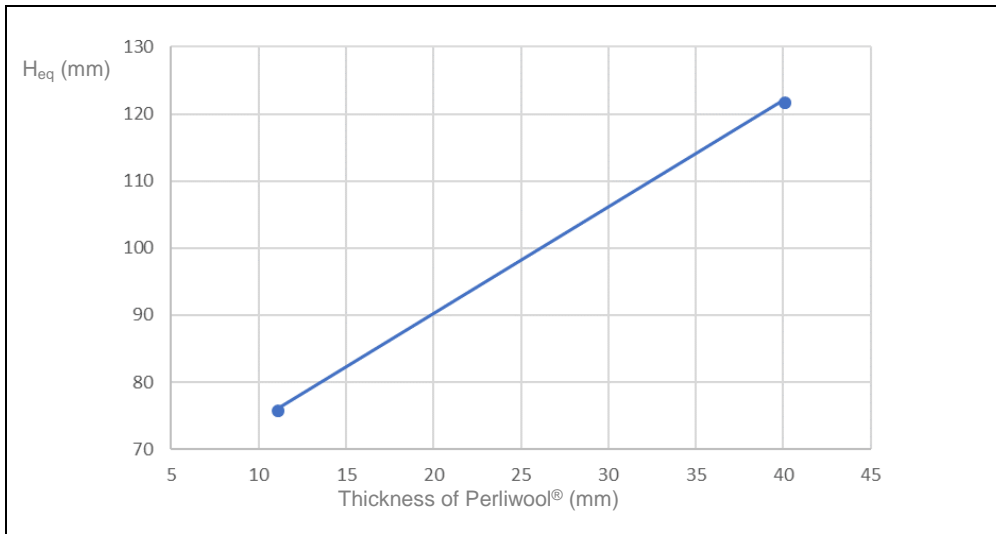


Figure A.2.2.4: Equivalent thickness of concrete (90 minutes).

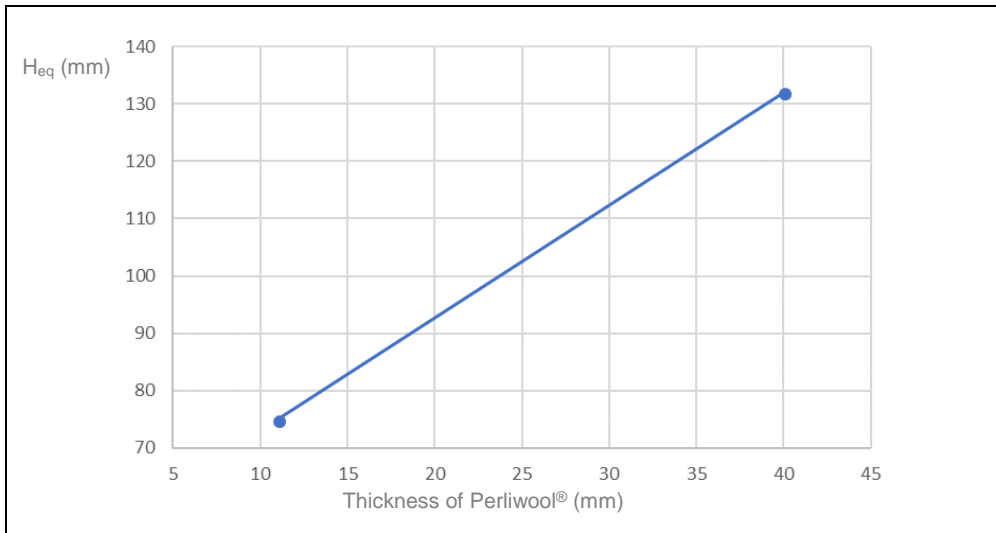


Figure A.2.2.5: Equivalent thickness of concrete (120 minutes).

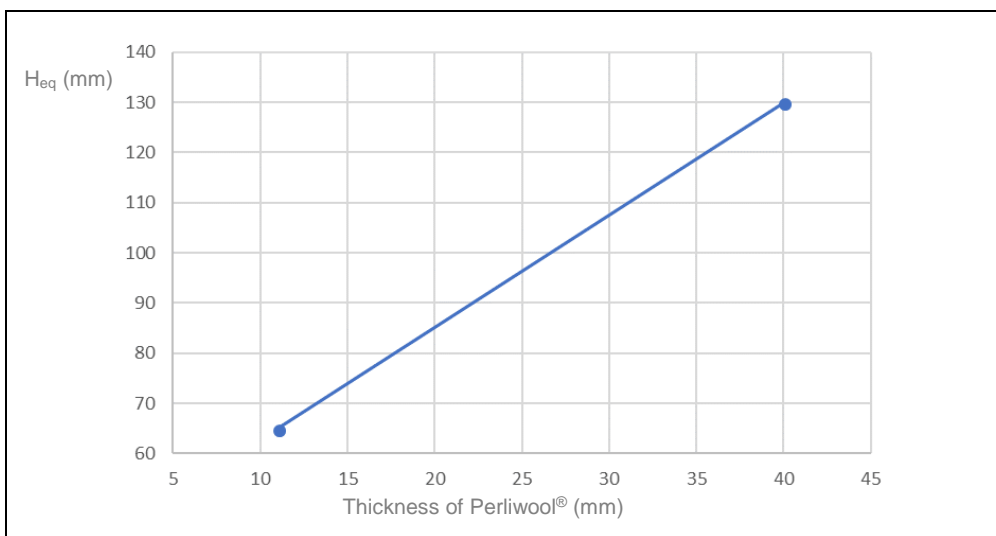


Figure A.2.2.6: Equivalent thickness of concrete (180 minutes).

ANNEX 3. Specification and assessment of the fire performance of loadbearing steel elements protected with Perliwool® (intended use Type 4)

A.3.1 Classification

The system described in this annex has been tested and evaluated according to EN 13381-4 and classified in accordance with EN 13501-2.

The assessment of the required thickness of Perliwool® rendering for the relevant resistance to fire period, at the design temperature within the range of 350 °C to 550 °C and in function of the section factor of the steel element, is given in section A.3.3.

A.3.2 Installation requirements

The product installation should be carried out in accordance with the provisions in A.1.2 and the following specification.

A.3.2.1 Supporting structure

The supporting structure consists of load-bearing steel elements with the following characteristics:

- 'H' or 'I' shaped beam and column sections.

Note: The protection thickness given for H/I sections (table A.3.3 to table A.3.12 of this ETA) also apply to steel sections of other shapes (e.g. U, L and T-sections) under consideration of the same section factor.

Hollow beam and column sections.

- Structural steel grades (S designation) in accordance with EN 10025¹³ excluding S185.
 - Section factors as given in table A.3.3 to table A.3.22 of this ETA.
- Steel elements with a section factor lower than 70 m⁻¹ shall be protected with the thickness of Perliwool® rendering given for an element with section factor equal to 70 m⁻¹.
- Three-sided fire exposure for beams and four-sided fire exposure for columns.

In case of beams or columns with fewer sides exposed to fire, thickness of the rendering can be applied according to table A.3.3 to table A.3.22 under consideration of the section factor calculated for the relevant case.

In case of four-sided fire exposure for beams see section A.3.3.

A.3.2.2 Surface of steel elements

The steel sections must be blast cleaned to ISO 8501-1 SA2½ or equivalent. The surface shall be bare, clean, dry and free of dust.

Perliwool® can be applied directly on the steel elements or on the steel coated with a two component epoxy primer.

¹³ EN 10025-1 to 6. *Hot rolled products of structural steels.*

A.3.2.3 Fire protective rendering

Perliwool® is applied on the apparent sides of the steel structural element to be protected by following their shape. Perliwool® is sprayed according to table A.3.1 to reach the requested thickness according to this annex. Hairline cracks in the dry rendering are not accepted. Specification of the fire protective rendering is given in table A.3.1.

Table A.3.1: Specification of the applied rendering.

Product	Characteristics	Mounting and fixing
Perliwool® (Hardened rendering)	Thickness: 20 mm to 53 mm Density: 300 kg/m ³ ± 15 %	Rendering is kept without finishing after application. For minimum thickness application, it is sprayed in one single layer. For medium thickness application, it is sprayed in two layers. For maximum thickness application, it is sprayed in three layers. Spray-applied rendering without: <ul style="list-style-type: none"> - Bonding agent - Topcoat or sealing coat - Mechanical fixings or reinforcement - Additives out of dry mix

A.3.2.4 Bonding properties of Perliwool® on steel elements

Assessment of the bonding properties of Perliwool®, when applied on steel structures, has been carried out according to EGOLF EA 05 procedure.

The indicated values are representative of cohesive failure (near the rendering surface) within the sprayed thickness of Perliwool®. These values are guidance values, and they do not reflect a statistical evaluation, nor minimum guaranteed values.

Table A.2.2: Tensile bond strength on steel substrates.

Surface	Thickness of Perliwool® (mm)	Mean tensile bond strength (MPa)	Failure mode
Steel substrate according EGOLF EA 05	20	0,007	Cohesive
	53	0,012	Cohesive

A.3.3 Assessment of the fire performance of Perliwool® on steel structures

The assessment of the fire resistance performance of Perliwool® when applied on steel structures has been done according to EN 13381-4, Annex E.5 Numerical Regression Analysis.

The resistance to fire performance of I/H columns is given in tables A.3.3 to A.3.7.

Note: tables A.3.3 to A.3.7 can also be used for the protection of I/H beams exposed to fire at 4 sides.

The resistance to fire performance of I/H beams is given in tables A.3.8 to A.3.12.

The resistance to fire performance of hollow section (HS) columns is given in tables A.3.13 to A.3.17, calculated in accordance with Annex A, section A.3, of EN 13381-4.

Note: tables A.3.13 to A.3.17 can also be used for the protection of HS beams exposed to fire at 4 sides.

The resistance to fire performance of hollow section beams is given in tables A.3.18 to A.3.22, calculated in accordance with Annex A, section A.3, of EN 13381-4.

Table A.3.3: Resistance to fire of I/H-section columns for design steel temperature 350 °C.

Section factor A_m/V (m ⁻¹)	Fire resistance classification							
	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min
	Perliwool® thickness (mm) for a design temperature of 350 °C							
70	19	19	19	19	23	34	44	-
80	19	19	19	19	26	36	46	-
90	19	19	19	19	28	38	47	-
100	19	19	19	21	30	39	48	-
110	19	19	19	22	31	40	49	-
120	19	19	19	23	32	41	49	-
130	19	19	20	24	33	41	50	-
140	19	19	21	25	33	42	50	-
150	19	19	21	26	34	42	50	-
160	19	19	22	26	34	42	51	-
170	19	19	23	27	35	43	51	-
180	19	19	23	27	35	43	51	-
190	19	19	23	27	35	43	-	-
200	19	20	24	28	36	43	-	-
210	19	20	24	28	36	44	-	-
220	19	20	24	28	36	44	-	-
230	19	21	25	28	36	44	-	-
240	19	21	25	29	36	44	-	-
250	19	21	25	29	37	44	-	-
260	19	21	25	29	37	44	-	-
270	19	22	25	29	37	44	-	-
280	19	22	26	29	37	45	-	-
290	19	22	26	29	37	45	-	-
300	19	22	26	30	37	45	-	-
310	19	22	26	30	37	45	-	-
320	19	22	26	30	37	45	-	-
330	19	22	26	30	37	45	-	-

Table A.3.4: Resistance to fire of I/H-section columns for design steel temperature 400 °C.

Section factor A_m/V (m ⁻¹)	Fire resistance classification							
	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min
	Perliwool® thickness (mm) for a design temperature of 400 °C							
70	19	19	19	19	20	29	39	49
80	19	19	19	19	23	32	41	50
90	19	19	19	19	25	34	43	-
100	19	19	19	19	27	36	44	-
110	19	19	19	20	28	37	45	-
120	19	19	19	21	29	38	46	-
130	19	19	19	22	30	38	47	-
140	19	19	19	23	31	39	47	-
150	19	19	20	24	32	40	47	-
160	19	19	21	24	32	40	48	-
170	19	19	21	25	33	40	48	-
180	19	19	22	25	33	41	48	-
190	19	19	22	26	33	41	49	-
200	19	19	22	26	34	41	49	-
210	19	19	23	27	34	42	49	-
220	19	19	23	27	34	42	49	-
230	19	20	23	27	35	42	49	-
240	19	20	24	27	35	42	50	-
250	19	20	24	28	35	42	50	-
260	19	20	24	28	35	42	50	-
270	19	21	24	28	35	43	50	-
280	19	21	24	28	35	43	50	-
290	19	21	25	28	36	43	50	-
300	19	21	25	28	36	43	50	-
310	19	21	25	29	36	43	50	-
320	19	21	25	29	36	43	50	-
330	19	22	25	29	36	43	51	-

Table A.3.5: Resistance to fire of I/H-section columns for design steel temperature 450 °C.

Section factor A_m/V (m ⁻¹)	Fire resistance classification							
	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min
	Perliwool® thickness (mm) for a design temperature of 450 °C							
70	19	19	19	19	19	26	34	43
80	19	19	19	19	20	29	37	46
90	19	19	19	19	23	31	39	48
100	19	19	19	19	25	33	41	49
110	19	19	19	19	26	34	42	50
120	19	19	19	19	27	35	43	51
130	19	19	19	21	28	36	44	-
140	19	19	19	21	29	37	44	-
150	19	19	19	22	30	37	45	-
160	19	19	19	23	30	38	45	-
170	19	19	20	23	31	38	46	-
180	19	19	20	24	31	39	46	-
190	19	19	21	24	32	39	46	-
200	19	19	21	25	32	39	47	-
210	19	19	22	25	32	40	47	-
220	19	19	22	25	33	40	47	-
230	19	19	22	26	33	40	47	-
240	19	19	22	26	33	40	48	-
250	19	19	23	26	33	41	48	-
260	19	19	23	26	34	41	48	-
270	19	20	23	27	34	41	48	-
280	19	20	23	27	34	41	48	-
290	19	20	24	27	34	41	48	-
300	19	20	24	27	34	41	48	-
310	19	20	24	27	34	42	49	-
320	19	20	24	28	35	42	49	-
330	19	21	24	28	35	42	49	-

Table A.3.6: Resistance to fire of I/H-section columns for design steel temperature 500 °C.

Section factor A_m/V (m ⁻¹)	Fire resistance classification							
	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min
	Perliwool® thickness (mm) for a design temperature of 500 °C							
70	19	19	19	19	19	22	31	39
80	19	19	19	19	19	26	34	42
90	19	19	19	19	20	28	36	44
100	19	19	19	19	22	30	38	45
110	19	19	19	19	24	31	39	47
120	19	19	19	19	25	33	40	48
130	19	19	19	19	26	34	41	48
140	19	19	19	20	27	35	42	49
150	19	19	19	21	28	35	42	50
160	19	19	19	21	29	36	43	50
170	19	19	19	22	29	36	44	51
180	19	19	19	23	30	37	44	-
190	19	19	20	23	30	37	44	-
200	19	19	20	24	31	38	45	-
210	19	19	20	24	31	38	45	-
220	19	19	21	24	31	38	45	-
230	19	19	21	25	32	39	45	-
240	19	19	21	25	32	39	46	-
250	19	19	22	25	32	39	46	-
260	19	19	22	25	32	39	46	-
270	19	19	22	26	32	39	46	-
280	19	19	22	26	33	40	46	-
290	19	19	23	26	33	40	47	-
300	19	19	23	26	33	40	47	-
310	19	19	23	26	33	40	47	-
320	19	20	23	26	33	40	47	-
330	19	20	23	27	33	40	47	-

Table A.3.7: Resistance to fire of I/H-section columns for design steel temperature 550 °C.

Section factor A_m/V (m ⁻¹)	Fire resistance classification							
	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min
	Perliwool® thickness (mm) for a design temperature of 550 °C							
70	19	19	19	19	19	19	27	35
80	19	19	19	19	19	23	31	38
90	19	19	19	19	19	26	33	40
100	19	19	19	19	20	28	35	42
110	19	19	19	19	22	29	36	44
120	19	19	19	19	23	30	38	45
130	19	19	19	19	25	32	39	46
140	19	19	19	19	25	32	40	47
150	19	19	19	19	26	33	40	47
160	19	19	19	20	27	34	41	48
170	19	19	19	21	28	35	41	48
180	19	19	19	21	28	35	42	49
190	19	19	19	22	29	36	42	49
200	19	19	19	22	29	36	43	50
210	19	19	19	23	29	36	43	50
220	19	19	20	23	30	37	43	50
230	19	19	20	23	30	37	44	50
240	19	19	20	24	30	37	44	51
250	19	19	21	24	31	37	44	51
260	19	19	21	24	31	38	44	-
270	19	19	21	25	31	38	45	-
280	19	19	21	25	31	38	45	-
290	19	19	22	25	32	38	45	-
300	19	19	22	25	32	38	45	-
310	19	19	22	25	32	39	45	-
320	19	19	22	25	32	39	45	-
330	19	19	22	26	32	39	46	-

Table A.3.8: Resistance to fire of I/H-section beams for design steel temperature 350 °C.

Section factor A_m/V (m ⁻¹)	Fire resistance classification							
	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min
	Perliwool® thickness (mm) for a design temperature of 350 °C							
70	20	20	20	20	23	34	44	-
80	20	20	20	20	26	36	46	-
90	20	20	20	20	28	38	47	-
100	20	20	20	21	30	39	48	-
110	20	20	20	22	31	40	49	-
120	20	20	20	23	32	41	49	-
130	20	20	20	24	33	41	50	-
140	20	20	21	25	33	42	50	-
150	20	20	21	26	34	42	50	-
160	20	20	22	26	34	42	51	-
170	20	20	23	27	35	43	51	-
180	20	20	23	27	35	43	51	-
190	20	20	23	27	35	43	51	-
200	20	20	24	28	36	43	51	-
210	20	20	24	28	36	44	51	-
220	20	20	24	28	36	44	52	-
230	20	21	25	28	36	44	52	-
240	20	21	25	29	36	44	52	-
250	20	21	25	29	37	44	52	-
260	20	21	25	29	37	44	52	-
270	20	22	25	29	37	44	52	-
280	20	22	26	29	37	45	52	-
290	20	22	26	29	37	45	52	-
300	20	22	26	30	37	45	52	-
310	20	22	26	30	37	45	52	-
320	20	22	26	30	37	45	52	-
330	20	22	26	30	37	45	52	-

Table A.3.9: Resistance to fire of I/H-section beams for design steel temperature 400 °C.

Section factor A_m/V (m ⁻¹)	Fire resistance classification							
	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min
	Perliwool® thickness (mm) for a design temperature of 400 °C							
70	20	20	20	20	20	29	39	49
80	20	20	20	20	23	32	41	50
90	20	20	20	20	25	34	43	52
100	20	20	20	20	27	36	44	53
110	20	20	20	20	28	37	45	-
120	20	20	20	21	29	38	46	-
130	20	20	20	22	30	38	47	-
140	20	20	20	23	31	39	47	-
150	20	20	20	24	32	40	47	-
160	20	20	21	24	32	40	48	-
170	20	20	21	25	33	40	48	-
180	20	20	22	25	33	41	48	-
190	20	20	22	26	33	41	49	-
200	20	20	22	26	34	41	49	-
210	20	20	23	27	34	42	49	-
220	20	20	23	27	34	42	49	-
230	20	20	23	27	35	42	49	-
240	20	20	24	27	35	42	50	-
250	20	20	24	28	35	42	50	-
260	20	20	24	28	35	42	50	-
270	20	21	24	28	35	43	50	-
280	20	21	24	28	35	43	50	-
290	20	21	25	28	36	43	50	-
300	20	21	25	28	36	43	50	-
310	20	21	25	29	36	43	50	-
320	20	21	25	29	36	43	50	-
330	20	22	25	29	36	43	51	-

Table A.3.10: Resistance to fire of I/H-section beams for design steel temperature 450 °C.

Section factor A_m/V (m ⁻¹)	Fire resistance classification							
	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min
	Perliwool® thickness (mm) for a design temperature of 450 °C							
70	20	20	20	20	20	26	34	43
80	20	20	20	20	20	29	37	46
90	20	20	20	20	23	31	39	48
100	20	20	20	20	25	33	41	49
110	20	20	20	20	26	34	42	50
120	20	20	20	20	27	35	43	51
130	20	20	20	21	28	36	44	51
140	20	20	20	21	29	37	44	52
150	20	20	20	22	30	37	45	52
160	20	20	20	23	30	38	45	53
170	20	20	20	23	31	38	46	-
180	20	20	20	24	31	39	46	-
190	20	20	21	24	32	39	46	-
200	20	20	21	25	32	39	47	-
210	20	20	22	25	32	40	47	-
220	20	20	22	25	33	40	47	-
230	20	20	22	26	33	40	47	-
240	20	20	22	26	33	40	48	-
250	20	20	23	26	33	41	48	-
260	20	20	23	26	34	41	48	-
270	20	20	23	27	34	41	48	-
280	20	20	23	27	34	41	48	-
290	20	20	24	27	34	41	48	-
300	20	20	24	27	34	41	48	-
310	20	20	24	27	34	42	49	-
320	20	20	24	28	35	42	49	-
330	20	21	24	28	35	42	49	-

Table A.3.11: Resistance to fire of I/H-section beams for design steel temperature 500 °C.

Section factor A_m/V (m ⁻¹)	Fire resistance classification							
	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min
	Perliwool® thickness (mm) for a design temperature of 500 °C							
70	20	20	20	20	20	22	31	39
80	20	20	20	20	20	26	34	42
90	20	20	20	20	20	28	36	44
100	20	20	20	20	22	30	38	45
110	20	20	20	20	24	31	39	47
120	20	20	20	20	25	33	40	48
130	20	20	20	20	26	34	41	48
140	20	20	20	20	27	35	42	49
150	20	20	20	21	28	35	42	50
160	20	20	20	21	29	36	43	50
170	20	20	20	22	29	36	44	51
180	20	20	20	23	30	37	44	51
190	20	20	20	23	30	37	44	51
200	20	20	20	24	31	38	45	52
210	20	20	20	24	31	38	45	52
220	20	20	21	24	31	38	45	52
230	20	20	21	25	32	39	45	52
240	20	20	21	25	32	39	46	53
250	20	20	22	25	32	39	46	53
260	20	20	22	25	32	39	46	-
270	20	20	22	26	32	39	46	-
280	20	20	22	26	33	40	46	-
290	20	20	23	26	33	40	47	-
300	20	20	23	26	33	40	47	-
310	20	20	23	26	33	40	47	-
320	20	20	23	26	33	40	47	-
330	20	20	23	27	33	40	47	-

Table A.3.12: Resistance to fire of I/H-section beams for design steel temperature 550 °C.

Section factor A_m/V (m ⁻¹)	Fire resistance classification							
	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min
	Perliwool® thickness (mm) for a design temperature of 550 °C							
70	20	20	20	20	20	20	27	35
80	20	20	20	20	20	23	31	38
90	20	20	20	20	20	26	33	40
100	20	20	20	20	20	28	35	42
110	20	20	20	20	22	29	36	44
120	20	20	20	20	23	30	38	45
130	20	20	20	20	25	32	39	46
140	20	20	20	20	25	32	40	47
150	20	20	20	20	26	33	40	47
160	20	20	20	20	27	34	41	48
170	20	20	20	21	28	35	41	48
180	20	20	20	21	28	35	42	49
190	20	20	20	22	29	36	42	49
200	20	20	20	22	29	36	43	50
210	20	20	20	23	29	36	43	50
220	20	20	20	23	30	37	43	50
230	20	20	20	23	30	37	44	50
240	20	20	20	24	30	37	44	51
250	20	20	21	24	31	37	44	51
260	20	20	21	24	31	38	44	51
270	20	20	21	25	31	38	45	51
280	20	20	21	25	31	38	45	51
290	20	20	22	25	32	38	45	52
300	20	20	22	25	32	38	45	52
310	20	20	22	25	32	39	45	52
320	20	20	22	25	32	39	45	52
330	20	20	22	26	32	39	46	52

Table A.3.13: Resistance to fire of hollow section columns for design steel temperature 350 °C.

Section factor A_m/V (m ⁻¹)	Fire resistance classification							
	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min
	Perliwool® thickness (mm) for a design temperature of 350 °C							
70	20	20	20	20	25	36	47	-
80	21	21	21	21	28	39	50	-
90	21	21	21	21	31	41	51	-
100	21	21	21	23	33	43	-	-
110	21	21	21	25	34	44	-	-
120	21	21	21	26	36	45	-	-
130	21	21	23	27	37	47	-	-
140	22	22	24	28	38	47	-	-
150	22	22	25	29	39	48	-	-
160	22	22	26	30	40	49	-	-
170	22	22	26	31	41	50	-	-
180	22	22	27	32	41	51	-	-
190	23	23	28	33	42	51	-	-
200	23	24	29	33	43	-	-	-
210	23	24	29	34	43	-	-	-
220	23	25	30	34	44	-	-	-
230	23	25	30	35	45	-	-	-
240	24	26	31	36	45	-	-	-
250	24	26	31	36	46	-	-	-
260	24	27	32	36	46	-	-	-
270	24	27	32	36	46	-	-	-
280	24	27	32	37	46	-	-	-
290	24	27	32	37	46	-	-	-
300	24	28	32	37	46	-	-	-
310	24	28	32	37	47	-	-	-
320	24	28	33	37	47	-	-	-
330	24	28	33	37	47	-	-	-

Table A.3.14: Resistance to fire of hollow section columns for design steel temperature 400 °C.

Section factor A_m/V (m ⁻¹)	Fire resistance classification							
	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min
	Perliwool® thickness (mm) for a design temperature of 400 °C							
70	20	20	20	20	21	31	42	-
80	21	21	21	21	25	35	45	-
90	21	21	21	21	28	37	47	-
100	21	21	21	21	30	39	49	-
110	21	21	21	22	32	41	50	-
120	21	21	21	24	33	42	51	-
130	21	21	21	25	34	43	-	-
140	22	22	22	26	35	45	-	-
150	22	22	23	27	36	46	-	-
160	22	22	24	28	37	46	-	-
170	22	22	25	29	38	47	-	-
180	22	22	25	30	39	48	-	-
190	23	23	26	31	40	49	-	-
200	23	23	27	31	41	50	-	-
210	23	23	28	32	41	50	-	-
220	23	24	28	33	42	51	-	-
230	23	24	29	33	42	-	-	-
240	24	25	29	34	43	-	-	-
250	24	25	30	34	44	-	-	-
260	24	25	30	35	44	-	-	-
270	24	26	30	35	44	-	-	-
280	24	26	31	35	44	-	-	-
290	24	26	31	35	44	-	-	-
300	24	26	31	35	45	-	-	-
310	24	27	31	36	45	-	-	-
320	24	27	31	36	45	-	-	-
330	24	27	31	36	45	-	-	-

Table A.3.15: Resistance to fire of hollow section columns for design steel temperature 450 °C.

Section factor A_m/V (m ⁻¹)	Fire resistance classification							
	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min
	Perliwool® thickness (mm) for a design temperature of 450 °C							
70	20	20	20	20	20	27	37	46
80	21	21	21	21	22	31	40	49
90	21	21	21	21	25	34	43	-
100	21	21	21	21	27	36	45	-
110	21	21	21	21	29	38	47	-
120	21	21	21	22	31	39	48	-
130	21	21	21	23	32	41	49	-
140	22	22	22	24	33	42	51	-
150	22	22	22	26	34	43	-	-
160	22	22	22	27	35	44	-	-
170	22	22	23	27	36	45	-	-
180	22	22	24	28	37	46	-	-
190	23	23	25	29	38	47	-	-
200	23	23	25	30	39	47	-	-
210	23	23	26	30	39	48	-	-
220	23	23	27	31	40	49	-	-
230	23	23	27	32	41	49	-	-
240	24	24	28	32	41	50	-	-
250	24	24	28	33	42	51	-	-
260	24	24	29	33	42	51	-	-
270	24	24	29	33	42	51	-	-
280	24	25	29	34	42	51	-	-
290	24	25	29	34	43	-	-	-
300	24	25	30	34	43	-	-	-
310	24	25	30	34	43	-	-	-
320	24	26	30	34	43	-	-	-
330	24	26	30	35	43	-	-	-

Table A.3.16: Resistance to fire of hollow section columns for design steel temperature 500 °C.

Section factor A_m/V (m ⁻¹)	Fire resistance classification							
	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min
	Perliwool® thickness (mm) for a design temperature of 500 °C							
70	20	20	20	20	20	24	33	42
80	21	21	21	21	21	28	36	45
90	21	21	21	21	22	31	39	48
100	21	21	21	21	25	33	41	50
110	21	21	21	21	27	35	43	-
120	21	21	21	21	28	37	45	-
130	21	21	21	21	30	38	46	-
140	22	22	22	23	31	39	48	-
150	22	22	22	24	32	40	49	-
160	22	22	22	25	33	42	50	-
170	22	22	22	26	34	43	51	-
180	22	22	22	27	35	43	-	-
190	23	23	23	27	36	44	-	-
200	23	23	24	28	37	45	-	-
210	23	23	25	29	37	46	-	-
220	23	23	25	30	38	47	-	-
230	23	23	26	30	39	47	-	-
240	24	24	26	31	39	48	-	-
250	24	24	27	31	40	49	-	-
260	24	24	27	32	40	49	-	-
270	24	24	28	32	41	49	-	-
280	24	24	28	32	41	49	-	-
290	24	24	28	32	41	50	-	-
300	24	24	28	33	41	50	-	-
310	24	24	29	33	41	50	-	-
320	24	25	29	33	42	50	-	-
330	24	25	29	33	42	50	-	-

Table A.3.17: Resistance to fire of hollow section columns for design steel temperature 550 °C.

Section factor A_m/V (m ⁻¹)	Fire resistance classification							
	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min
	Perliwool® thickness (mm) for a design temperature of 550 °C							
70	20	20	20	20	20	21	29	37
80	21	21	21	21	21	25	33	41
90	21	21	21	21	21	28	36	44
100	21	21	21	21	22	30	38	46
110	21	21	21	21	24	32	40	48
120	21	21	21	21	26	34	42	50
130	21	21	21	21	28	36	44	-
140	22	22	22	22	29	37	45	-
150	22	22	22	22	30	38	46	-
160	22	22	22	23	31	39	47	-
170	22	22	22	24	32	40	48	-
180	22	22	22	25	33	41	49	-
190	23	23	23	26	34	42	50	-
200	23	23	23	27	35	43	51	-
210	23	23	23	27	36	44	-	-
220	23	23	24	28	36	45	-	-
230	23	23	25	29	37	45	-	-
240	24	24	25	29	38	46	-	-
250	24	24	26	30	38	47	-	-
260	24	24	26	30	39	47	-	-
270	24	24	26	31	39	47	-	-
280	24	24	27	31	39	48	-	-
290	24	24	27	31	40	48	-	-
300	24	24	27	31	40	48	-	-
310	24	24	27	32	40	48	-	-
320	24	24	28	32	40	48	-	-
330	24	24	28	32	40	49	-	-

Table A.3.18: Resistance to fire of hollow section beams for design steel temperature 350 °C.

Section factor A_m/V (m ⁻¹)	Fire resistance classification							
	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min
	Perliwool® thickness (mm) for a design temperature of 350 °C							
70	21	21	21	21	25	36	47	-
80	22	22	22	22	28	39	50	-
90	22	22	22	22	31	41	51	-
100	22	22	22	23	33	43	53	-
110	22	22	22	25	34	44	-	-
120	22	22	22	26	36	45	-	-
130	23	23	23	27	37	47	-	-
140	23	23	24	28	38	47	-	-
150	23	23	25	29	39	48	-	-
160	23	23	26	30	40	49	-	-
170	23	23	26	31	41	50	-	-
180	24	24	27	32	41	51	-	-
190	24	24	28	33	42	51	-	-
200	24	24	29	33	43	52	-	-
210	24	24	29	34	43	53	-	-
220	24	25	30	34	44	53	-	-
230	25	25	30	35	45	-	-	-
240	25	26	31	36	45	-	-	-
250	25	26	31	36	46	-	-	-
260	25	27	32	36	46	-	-	-
270	25	27	32	36	46	-	-	-
280	25	27	32	37	46	-	-	-
290	25	27	32	37	46	-	-	-
300	25	28	32	37	46	-	-	-
310	25	28	32	37	47	-	-	-
320	25	28	33	37	47	-	-	-
330	25	28	33	37	47	-	-	-

Table A.3.19: Resistance to fire of hollow section beams for design steel temperature 400 °C.

Section factor A_m/V (m ⁻¹)	Fire resistance classification							
	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min
	Perliwool® thickness (mm) for a design temperature of 400 °C							
70	21	21	21	21	21	31	42	52
80	22	22	22	22	25	35	45	-
90	22	22	22	22	28	37	47	-
100	22	22	22	22	30	39	49	-
110	22	22	22	22	32	41	50	-
120	22	22	22	24	33	42	51	-
130	23	23	23	25	34	43	53	-
140	23	23	23	26	35	45	-	-
150	23	23	23	27	36	46	-	-
160	23	23	24	28	37	46	-	-
170	23	23	25	29	38	47	-	-
180	24	24	25	30	39	48	-	-
190	24	24	26	31	40	49	-	-
200	24	24	27	31	41	50	-	-
210	24	24	28	32	41	50	-	-
220	24	24	28	33	42	51	-	-
230	25	25	29	33	42	52	-	-
240	25	25	29	34	43	52	-	-
250	25	25	30	34	44	53	-	-
260	25	25	30	35	44	53	-	-
270	25	26	30	35	44	53	-	-
280	25	26	31	35	44	53	-	-
290	25	26	31	35	44	-	-	-
300	25	26	31	35	45	-	-	-
310	25	27	31	36	45	-	-	-
320	25	27	31	36	45	-	-	-
330	25	27	31	36	45	-	-	-

Table A.3.20: Resistance to fire of hollow section beams for design steel temperature 450 °C.

Section factor A_m/V (m ⁻¹)	Fire resistance classification							
	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min
	Perliwool® thickness (mm) for a design temperature of 450 °C							
70	21	21	21	21	21	27	37	46
80	22	22	22	22	22	31	40	49
90	22	22	22	22	25	34	43	52
100	22	22	22	22	27	36	45	-
110	22	22	22	22	29	38	47	-
120	22	22	22	22	31	39	48	-
130	23	23	23	23	32	41	49	-
140	23	23	23	24	33	42	51	-
150	23	23	23	26	34	43	52	-
160	23	23	23	27	35	44	53	-
170	23	23	23	27	36	45	-	-
180	24	24	24	28	37	46	-	-
190	24	24	25	29	38	47	-	-
200	24	24	25	30	39	47	-	-
210	24	24	26	30	39	48	-	-
220	24	24	27	31	40	49	-	-
230	25	25	27	32	41	49	-	-
240	25	25	28	32	41	50	-	-
250	25	25	28	33	42	51	-	-
260	25	25	29	33	42	51	-	-
270	25	25	29	33	42	51	-	-
280	25	25	29	34	42	51	-	-
290	25	25	29	34	43	52	-	-
300	25	25	30	34	43	52	-	-
310	25	25	30	34	43	52	-	-
320	25	26	30	34	43	52	-	-
330	25	26	30	35	43	52	-	-

Table A.3.21: Resistance to fire of hollow section beams for design steel temperature 500 °C.

Section factor A_m/V (m ⁻¹)	Fire resistance classification							
	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min
	Perliwool® thickness (mm) for a design temperature of 500 °C							
70	21	21	21	21	21	24	33	42
80	22	22	22	22	22	28	36	45
90	22	22	22	22	22	31	39	48
100	22	22	22	22	25	33	41	50
110	22	22	22	22	27	35	43	52
120	22	22	22	22	28	37	45	53
130	23	23	23	23	30	38	46	-
140	23	23	23	23	31	39	48	-
150	23	23	23	24	32	40	49	-
160	23	23	23	25	33	42	50	-
170	23	23	23	26	34	43	51	-
180	24	24	24	27	35	43	52	-
190	24	24	24	27	36	44	53	-
200	24	24	24	28	37	45	-	-
210	24	24	25	29	37	46	-	-
220	24	24	25	30	38	47	-	-
230	25	25	26	30	39	47	-	-
240	25	25	26	31	39	48	-	-
250	25	25	27	31	40	49	-	-
260	25	25	27	32	40	49	-	-
270	25	25	28	32	41	49	-	-
280	25	25	28	32	41	49	-	-
290	25	25	28	32	41	50	-	-
300	25	25	28	33	41	50	-	-
310	25	25	29	33	41	50	-	-
320	25	25	29	33	42	50	-	-
330	25	25	29	33	42	50	-	-

Table A.3.22: Resistance to fire of hollow section beams for design steel temperature 550 °C.

Section factor A_m/V (m ⁻¹)	Fire resistance classification							
	15 min	30 min	45 min	60 min	90 min	120 min	150 min	180 min
	Perliwool® thickness (mm) for a design temperature of 550 °C							
70	21	21	21	21	21	21	29	37
80	22	22	22	22	22	25	33	41
90	22	22	22	22	22	28	36	44
100	22	22	22	22	22	30	38	46
110	22	22	22	22	24	32	40	48
120	22	22	22	22	26	34	42	50
130	23	23	23	23	28	36	44	52
140	23	23	23	23	29	37	45	53
150	23	23	23	23	30	38	46	-
160	23	23	23	23	31	39	47	-
170	23	23	23	24	32	40	48	-
180	24	24	24	25	33	41	49	-
190	24	24	24	26	34	42	50	-
200	24	24	24	27	35	43	51	-
210	24	24	24	27	36	44	52	-
220	24	24	24	28	36	45	53	-
230	25	25	25	29	37	45	-	-
240	25	25	25	29	38	46	-	-
250	25	25	26	30	38	47	-	-
260	25	25	26	30	39	47	-	-
270	25	25	26	31	39	47	-	-
280	25	25	27	31	39	48	-	-
290	25	25	27	31	40	48	-	-
300	25	25	27	31	40	48	-	-
310	25	25	27	32	40	48	-	-
320	25	25	28	32	40	48	-	-
330	25	25	28	32	40	49	-	-