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European Technical Assessment

**ETA 18/0456
of 27.05.2020**



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

46 pages including 5 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.

This version replaces

ETA 18/0456 issued on 20.09.2018.

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 the annexes of this ETA.

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 5 | Load-bearing flat concrete profiled sheet composite elements | |
| Type 7 | Load-bearing timber elements | |

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 | |
| BWR 2 Safety in case of fire | Reaction to fire | A1 | |
| | Resistance to fire | See Annex 2 to Annex 5 | |
| | Durability | Type Z ₂ | |
| BWR 4 Safety and accessibility in use | Adhesion (bond strength) | See 3.2.5 and Annex 2 to Annex 5 | |
| 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 the annexes and has been classified in accordance with EN 13501-2⁴.

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.

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.

3.2.4 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 annexes of this ETA. When a reinforcement mesh is used for the rendering application, pull off resistance of the mesh fixings is given instead of the bond strength.

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 27 May 2020

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 |
| Type 5 | Load-bearing flat concrete profiled sheet composite elements | EN 13381-5 ¹² | EN 13501-2 | Annex 4 |
| Type 7 | Load-bearing timber elements | EN 13381-7 ¹³ | EN 13501-2 | Annex 5 |

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.

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.

¹² EN 13381-5 Test methods for determining the contribution to the fire resistance of structural members. Part 5: Applied protection to concrete/profiled sheet steel composite member.

¹³ EN 13381-7 Test methods for determining the contribution to the fire resistance of structural members. Part 7: Applied protection to timber members.

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 the annexes.

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 the annexes, when relevant. 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.

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:

- a. Increase of the average temperature of the concrete slab unexposed surface below 140 °C.
- b. 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.

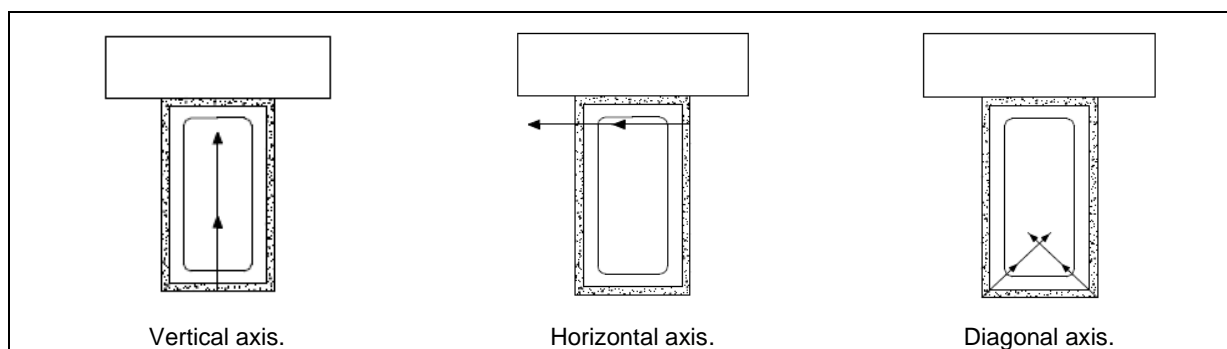


Figure A.2.2.1: Direction inside the concrete depth of a beam¹⁴.

¹⁴ 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®.

| 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 |
| 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.

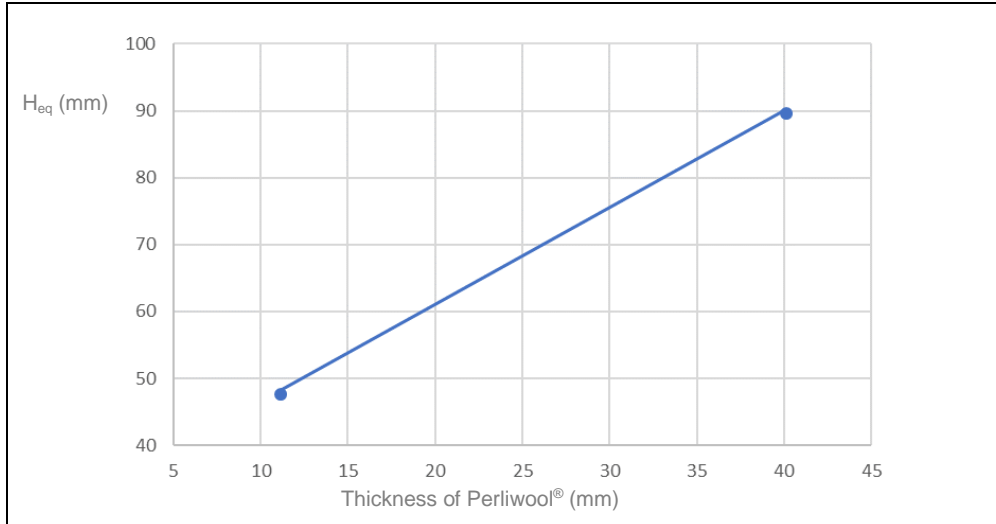


Figure A.2.2.2: Equivalent thickness of concrete (30 minutes).

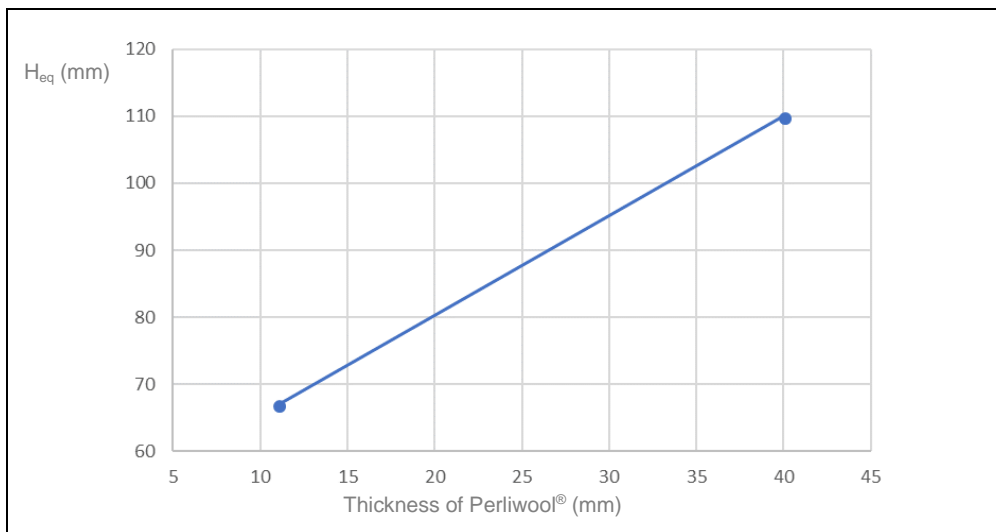


Figure A.2.2.3: Equivalent thickness of concrete (60 minutes).

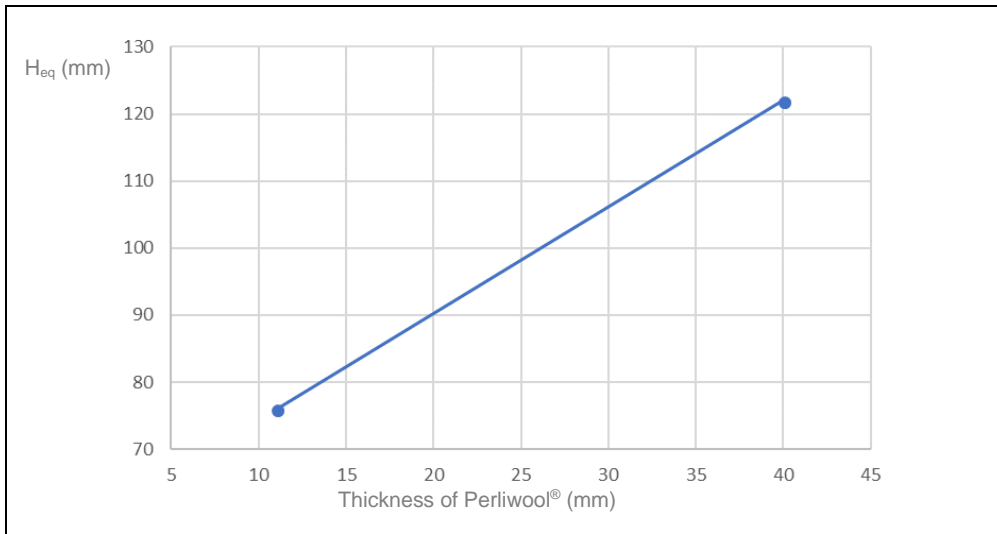


Figure A.2.2.4: Equivalent thickness of concrete (90 minutes).

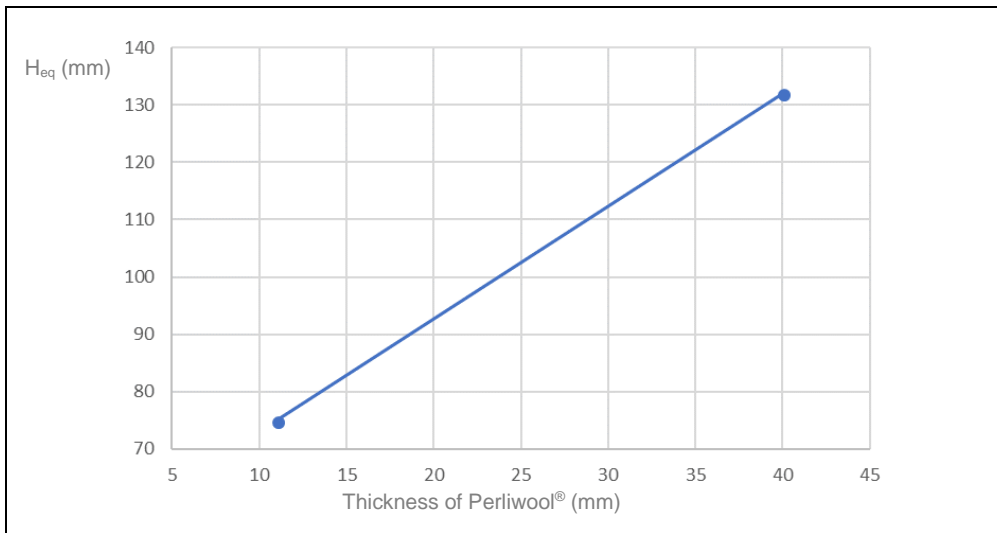


Figure A.2.2.5: Equivalent thickness of concrete (120 minutes).

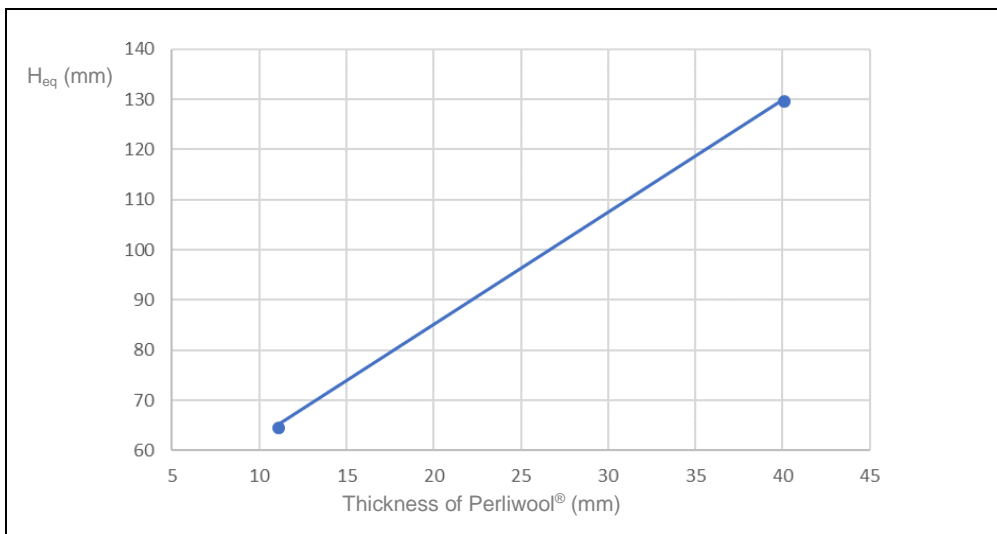


Figure A.2.2.6: Equivalent thickness of concrete (180 minutes).

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 10025¹⁵ 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.

¹⁵ 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 | - | - |

ANNEX 4. Specification and assessment of the fire performance of loadbearing concrete/profiled sheet steel composite elements protected with Perliwool® (intended use Type 5)

A.4.1 Classification

The system described in this annex has been tested and evaluated according to EN 13381-5 and classified in accordance with EN 13501-2.

The assessment of the required thickness of Perliwool® for the steel sheet to achieve the characteristic temperature of 350 °C, the equivalent thickness of concrete, as well as the insulation and stickability performance, are given in section A.4.3.

A.4.2 Installation requirements

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

A.4.2.1 Supporting structure

Perliwool® is applied directly on trapezoidal profiled steel sheets of composite slabs cast with normal weight concrete.

Corrosion protective primers or bonding agents are not required for the application of Perliwool® rendering on profiled steel sheets and thus no primers have been assessed. However, the surfaces must be bare, free of dust, oil and grease (attention must be paid to the fact that the steel sheets are normally covered by a grease protective layer, that will have to be cleaned).

The concrete slab contains a mesh of reinforcement steel bars (B 500, diameter of 4 mm, cross-section area density of 70 mm² – 100 mm² per metre of composite slab) installed at 20 mm from the upper surface of the composite slab.

The substrate must be rigid, free of deformations or excessive vibrations before Perliwool® is applied.

Specification of the composite slab components are given in Table A.4.1.

Table A.4.1: Specification of the composite slab components.

| Component | Characteristics | Mounting and fixing |
|---|---|--|
| Trapezoidal profiled galvanized steel sheet | Thickness $\geq 1,0$ mm Width of the ribs ≤ 220 mm Height of the ribs ≤ 88 mm | Surface shall be bare, free of dust, oil and grease. |
| Concrete | Compressive strength ≥ 30 N/mm ² . Density: 2300 kg/m ³ $\pm 15\%$. Siliceous aggregates. | The concrete may or may not contain additional reinforcing bars for load bearing purposes. Without release agent. |

A.4.2.2 Fire protective rendering

Perliwool® is applied on the apparent side of the profiled steel sheet to be protected, by following its corrugation, for exposure to fire from the steel side of the composite slab.

It 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

Perliwool® is directly 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.4.2.

Table A.4.2. Rendering specification.

| Component | Identification | Characteristics | Mounting and fixing |
|-----------|----------------|--|---|
| Rendering | Perliwool® | Thicknesses from 19 mm to 27 mm Hardened density: 360 kg/m ³ ± 15% | Rendering is kept without finishing after application. Spray applied rendering without: <ul style="list-style-type: none"> - Primer or bonding agent - Topcoats or sealing coats - Mechanical fixings - Additives out of dry mix |

A.4.2.3 Bonding properties of Perliwool® on composite concrete/profiled steel sheet elements

Assessment of the bonding properties of Perliwool® when directly applied on the trapezoidal profiled steel sheets of composite slabs, cast with normal weight concrete, has been carried out according to EGOLF SM5 procedure. Measurements have been done on the flat area of the trapezoidal sheet ribs.

The indicated values are mainly representative of cohesive failure through the applied thickness of protective sprayed rendering Perliwool®. These values are guidance values, and they do not reflect a statistical evaluation, nor minimum guaranteed values.

Table A.4.3: Tensile bond strength of Perliwool® on profiled steel sheets of composite slabs.

| Surface | Thickness of Perliwool® | Mean tensile bond strength (MPa) | Failure mode |
|---|-------------------------|----------------------------------|----------------------------------|
| Trapezoidal profiled galvanized steel sheet | 17 mm to 27 mm | 0,007 | 85 % cohesive / 15 % adhesive |

A.4.3 Assessment of the fire performance of Perliwool® on composite concrete/profiled steel sheet elements

A.4.3.1 General

The method used to assess the fire protection performance of Perliwool® when applied on composite concrete/profiled steel sheet elements is according to section 13 of EN 13381-5.

A.4.3.2 Temperature of the profiled steel sheet

The time of the steel sheet to achieve characteristic temperature of 350 °C, determined according to section 13.2 of EN 13381-5, is given in table A.4.4, and shown in figure A.4.1 in function of the thickness of Perliwool®.

Table A.4.4: Time of the steel sheet to achieve characteristic temperature of 350 °C.

| Element | Perliwool® thickness (mm) | Time _{350 °C} (min) |
|---|---------------------------|------------------------------|
| Composite slabs at minimum protection thickness | 19 | 145 |
| Composite slabs at maximum protection thickness | 27 | 181 |

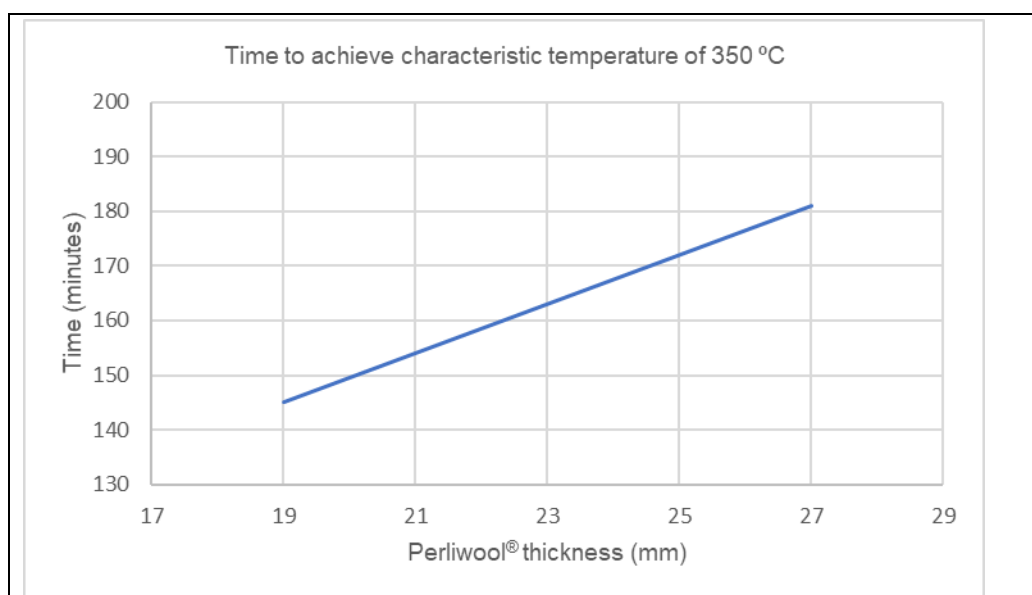


Figure A.4.1: Time of the steel sheet to achieve characteristic temperature of 350 °C in function of Perliwool® thickness.

A.4.3.3 Equivalent thickness of concrete

The effective thickness H_{eff} , the equivalent effective thickness H_e and the equivalent thickness of concrete H_{eq} induced by the protective material Perliwool® applied on trapezoidal profiled steel sheets, as well as the limiting time of exposure, have been determined according to section 13.3 of EN 13381-5, and are given in table A.4.5.

Table A.4.5. Equivalent thickness of concrete.

| Element | Thickness of Perliwool® (mm) | H_{eff} (mm) | H_e (mm) | H_{eq} (mm) | Limiting time of exposure (min) |
|--|------------------------------|----------------|------------|---------------|---------------------------------|
| Composite concrete/ trapezoidal profiled steel sheet element | 19 | 87 | 159 | 72 | 204 |
| | 27 | 87 | 175 | 88 | 235 |

The equivalent thickness of concrete H_{eq} depending on Perliwool® thickness is given in figure A.4.2 and the limiting time of exposure depending on Perliwool® thickness in figures A.4.2 and A.4.3.

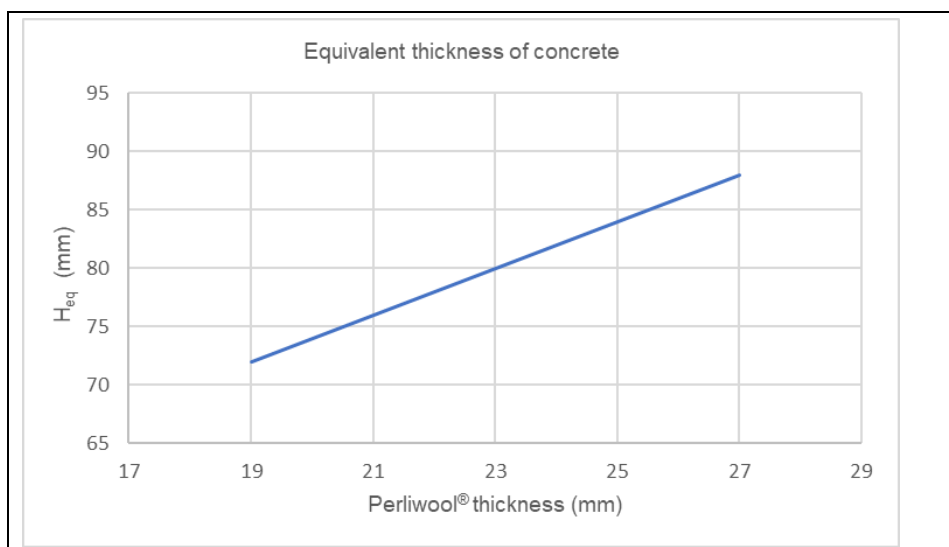


Figure A.4.2: Equivalent thickness of concrete H_{eq} in function of Perliwool® thickness.

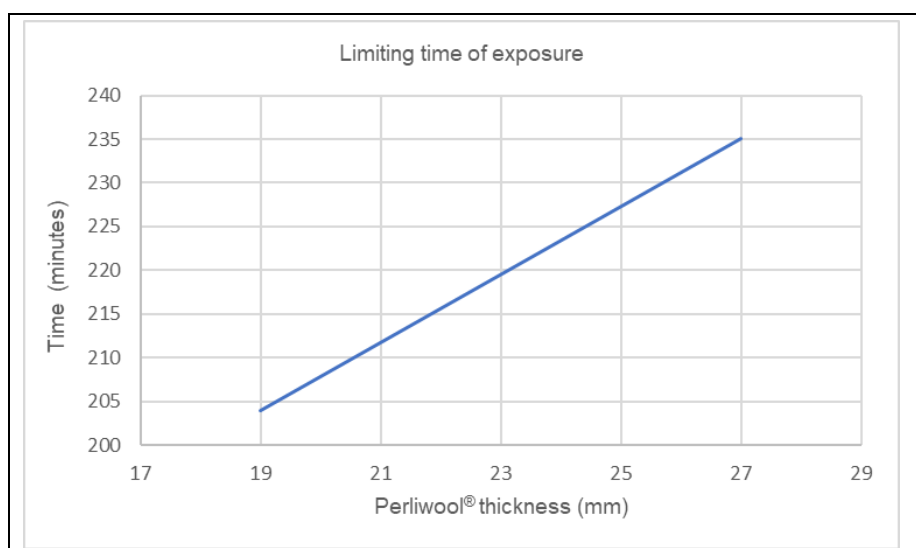


Figure A.4.3: Limiting time of exposure in function of Perliwool® thickness.

A.4.3.4 Insulation performance

The separating function (insulation) of the composite concrete/profiled steel sheet elements was maintained, in accordance with the criteria established in EN 1363-1, during 219 minutes for a protection of 19 mm Perliwool® thickness and during 241 minutes (entire fire test) for a protection of 27 mm Perliwool® thickness.

A.4.3.5 Stickability performance

No failure of stickability occurred, in accordance with section 13.4 of EN 13381-5, before the limiting time of exposure given in table A.4.5.

ANNEX 5. Specification and assessment of the fire performance of loadbearing timber elements protected with Perliwool® (intended use Type 7)

A.5.1 Classification

The system described in this annex has been tested and evaluated according to EN 13381-7 and classified in accordance with EN 13501-2.

The assessment of the start of charring at the surface of a timber member (t_{ch}) has been determined on a large scale beam according to EN 13381-7, section 13.2, and the charring rate behind a fire protection system according to EN 1995-1-2 (β_2) has been determined according to EN 13381-7, section 13.3, for a thickness of Perliwool® rendering of 38 mm. The assessment results are given in A.5.3.

A.5.2 Installation requirements

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

A.5.2.1 Supporting structure

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

- Beams and columns of minimum section 200 mm x 200 mm.
The span of the beam or height of the column, as well as the loads/stress of the construction, will be verified according to EN 1995-1-2.
Three or four sided configuration beams and columns.
- Timber products with a stiffness equal to or greater than class GL24 according to EN 14080.
Timber products of classes WPCA, WPNN, WPCS, WPSM or WLAD according to EN 14081.

A.5.2.2 Fire protective rendering

Perliwool® is applied on the apparent sides of the timber structural element to be protected by following their shape. Perliwool® is sprayed, according to table A.5.1 at the requested thickness, over a hexagonal wire mesh of galvanised steel (wire diameter of 0,7 mm and mesh opening of 13 mm), fixed to the timber element by means of metallic staples. Hairline cracks in the dry rendering are not accepted. Specification of the fire protective rendering is given in table A.5.1.

Table A.5.1: Specification of the applied rendering.

| Product | Characteristics | Mounting and fixing |
|------------------------------------|---|---|
| Perliwool® (Hardened rendering) | Thickness: 38 mm Density: 340 kg/m ³ ± 15 % | Rendering is kept without finishing after application. Spray-applied rendering on a reinforcement wire mesh. Spray-applied rendering without: - Bonding agent - Topcoat or sealing coat - Additives out of dry mix |

A.5.2.3 Bonding properties of Perliwool® on timber elements

The adhesion of the rendering on timber substrate is not relevant in accordance with section 2.2.7 of EAD 350140-00-1106, since the rendering is applied on a continuous reinforcement mesh independently fixed to the substrate. Pull off resistance of the reinforcement mesh has been determined according to section 2.2.5 of EAD 350140-00-1106, and test results are given in table A.5.2. These values are guidance values and they do not reflect a statistical evaluation.

Table A.5.2: Pull off resistance of mechanical fixings.

| Type | Description | Pull off resistance (N) |
|------------------|--|-------------------------|
| Metallic staples | “U” shape staple with 3 mm diameter and 30 mm height | 889,2 |

A.5.3 Assessment of the fire performance of Perliwool® on timber elements

The assessment of the fire resistance performance of Perliwool® when applied on load-bearing timber elements has been done according to EN 13381-7, section 13.2 and 13.3. The performance is given in the next table.

Table A.5.3: Resistance to fire performance of the load-bearing timber elements protected with Perliwool®.

| Characteristic | Symbol | Performance |
|---|-----------|-------------|
| Start of charring at the surface of a timber member | t_{ch} | 64 minutes |
| Charring rate behind a fire protective rendering | β_2 | 0,4 mm/min |

No failure of the protection for stickability occurred during the resistance to fire test (152 minutes) in accordance with section 13.4.2 of EN 13381-7.