



COPINGS AND CONNECTIONS

Optimum Protection for Walls, Roof Edges, Cornices and Window Sills

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6th edition

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Foreword

This document describes the use of copings and connections made of RHEINZINK titanium zinc. Although it forms the basis for proper planning and classical application solutions, it is no more than a guide for users. The detailed drawings included here describe solutions which are feasible at a practical level.

We should like to explicitly point out that in actual practice it may not be possible to create the types of copings and connections illustrated in this document – or not to their full extent. In this context every situation should be examined in detail by the planner in charge. It is necessary here to take account of the system-specific effects on the property and local/climatic conditions as well as the requirements in terms of building physics. Compliance with the application techniques and specifications described here does not release users from any responsibility in this regard.

This document is based on our practical experience and represents the latest findings from research and development, recognised standards and state-of-the-art technology. We reserve the right to make changes at any time in the course of further development.

Please also note our information on the material and its processing on our websites.

If you have any queries or suggestions, please contact your customer advisor or get in touch with your local RHEINZINK sales office. All contact data can be found on our homepage www.rheinzink.com/contact

Datteln, May 2020

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● bright rolled

● blue-grey

● graphite-grey

RHEINZINK-CLASSIC

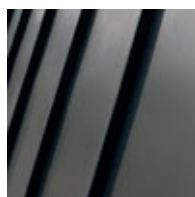
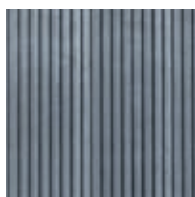
RHEINZINK-prePATINA

ORIGINAL.
EXPRESSIVE.
PATINATES OVER TIME.

PRE-WEATHERED.
SELF-HEALING.
NATURAL.

ONE BRAND –
5 PRODUCT LINES

THE PERFECT
SOLUTION
FOR EVERY
REQUIREMENT



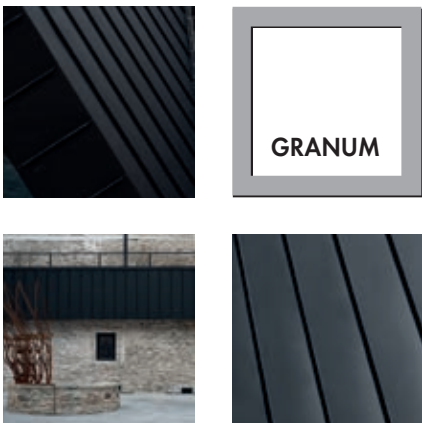
TITANIUM ZINC BRIGHT ROLLED:
PATINATES OVER THE YEARS. NATU-
RAL, VARIABLE SURFACE CHARACTER.

THE ONLY NATURALLY PRE-WEATH-
ERED SURFACE IN THE WORLD.
ZINC TYPICAL PATINA EX WORKS.
100% NATURAL, 100% RECYCLABLE.

- skygrey
- basalte

RHEINZINK-GRANUM

NOBLE.
MATTE FINISH.
MULTIFACETED.

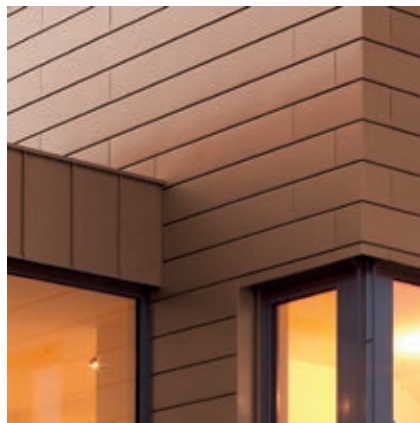


SKYGREY AND BASALTE. PURE, GREY ELEGANCE. URBAN DESIGN. PHOSPHATED SURFACE WITH COUNTLESS DESIGN OPPORTUNITIES.

- gold
- brown
- blue
- red
- green
- black

RHEINZINK-PRISMO

GLAZED.
DYNAMIC.
ADAPTABLE.



AESTHETIC, HARMONIOUS MATCH WITH ITS SURROUNDINGS. SUBTLE COLOUR VARIETY FOR A UNIQUE LOOK. SEMI-TRANSPARENT.

- pure-white
- pearl-gold
- moss-green
- nut-brown
- blue
- tile-red
- black-grey

RHEINZINK-artCOLOR

COLOURFUL.
LIVELY.
CREATIVE.



CREATIVE DESIGN POSSIBILITIES. INDIVIDUAL, EXPRESSIVE COLOUR COMPOSITIONS. COATED COLOUR VARIETY.

WALL COPINGS

1. Wall Copings

1.1 Copings with the Example of Fascia and Wall Copings

General

RHEINZINK copings offer optimum, long-term protection for various types of walls, roof edges, cornices and window sills. Any ingress of moisture into these components from precipitation is reliably prevented, so avoiding consequential damage such as the penetration of damp or flaking. The prerequisite for successful realisation is planning that has been carefully coordinated to each situation. RHEINZINK copings are installed on a continuous substructure and fixed in place indirectly.

The example of RHEINZINK copings for walls and roof edges has been taken here to illustrate the planning principles which should generally be followed when installing all types of RHEINZINK copings, and to describe the options available for their use.

The term "coping width" stands for the longest occurring edge of a building profile. This applies to profiles that are installed either horizontally or vertically (see Fig. 1).

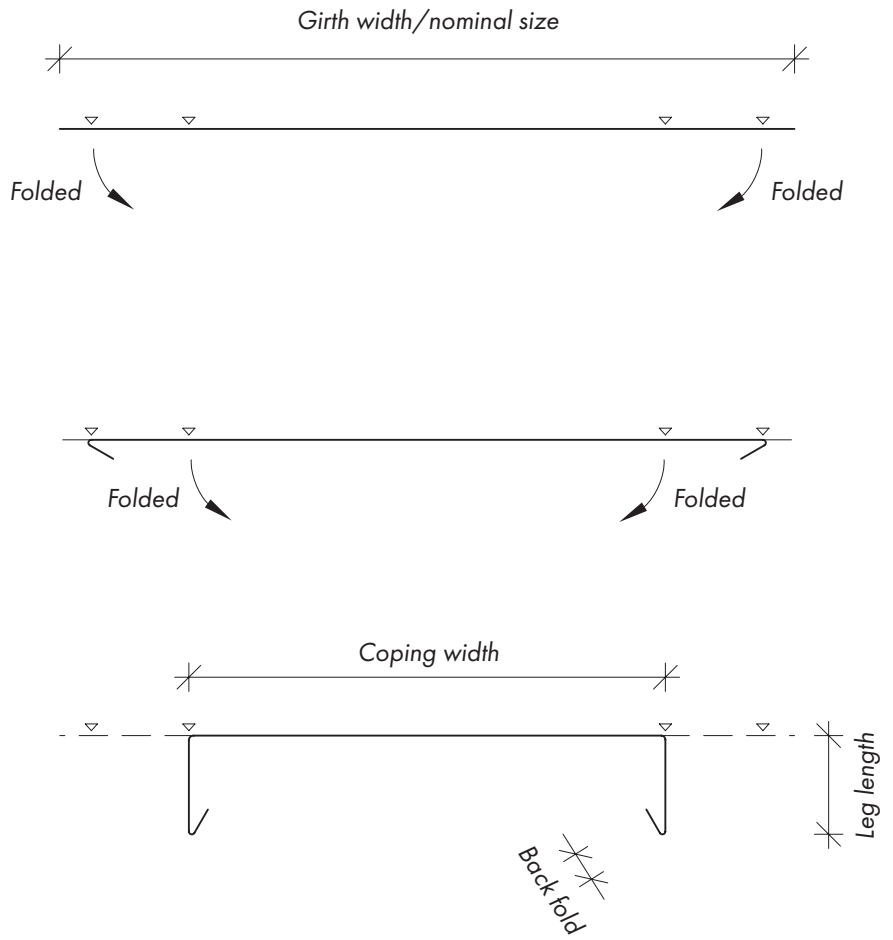


Fig. 1: Explanation of terms

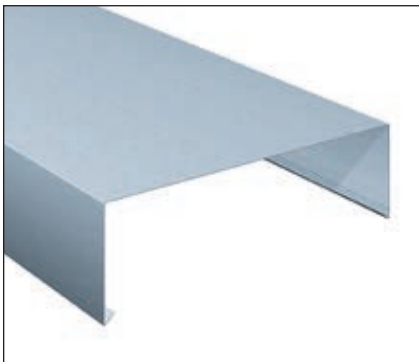


Fig. 2: Wall coping profile

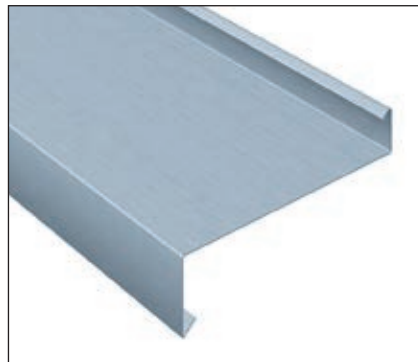


Fig. 3: Window sill flashing profile

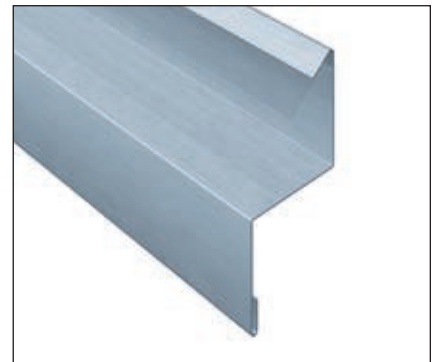


Fig. 4: Cornice coping profile

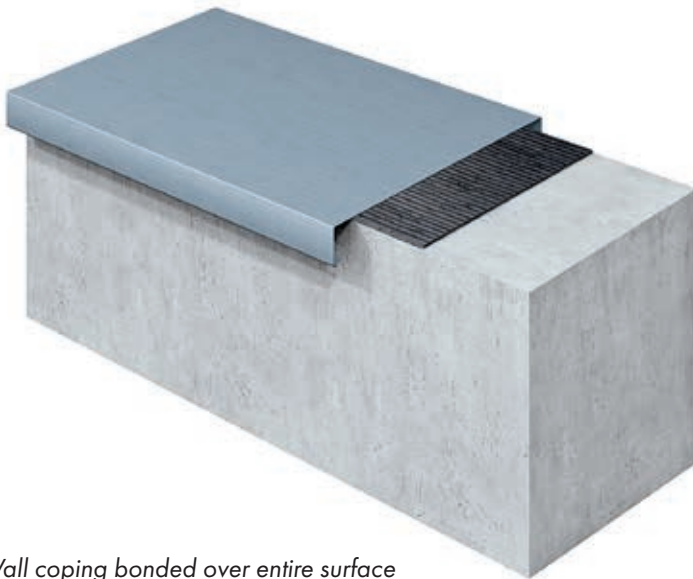


Fig. 5: Wall coping bonded over entire surface

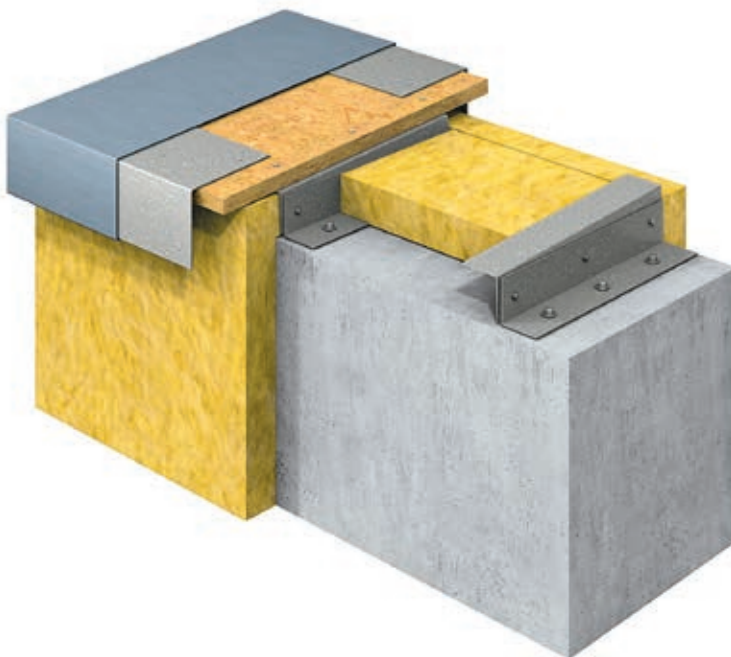


Fig. 6: Benefits for tolerance compensation are offered by this wall coping with a multisection metal substructure

Coping width a mm	Minimum thickness	
	when fixed with continuous cleats mm	when bonded without continuous cleats mm
a < 300	0.70	0.80
a < 500	0.80	1.00
a ≥ 500	1.00	1.00

Table 1: Coping widths and material thicknesses

1.2 Profile Geometry

RHEINZINK offers a wide range of options in terms of profile geometry. We would be pleased to supply you with customised profiles (provided that manufacture is possible for the folding techniques required). Segmentation or prefabrication allows rounded forms to be produced.

1.3 Dimensional Specifications

1.3.1 Coping Widths and Metal Thicknesses

For aesthetic reasons wall copings are normally manufactured in lengths of at least 3 m, i.e. to avoid too many cross joints, and fixed in place indirectly. The metal thickness depends on a number of factors:

- width of coping/edge length
- requirements on flatness of finished surface.

Table 1 makes recommendations about the coping width and metal thickness with regard to aesthetic design to ensure a flat surface. Especially in the case of higher metal thicknesses, bends at the joints should be made using a segmental edging bench.

As a rule, the standing seam system with a metal thickness of 0.7 or 0.8 mm is recommended for cover widths of 800 mm and more. The terminations should be created as for the eaves and ridge detailing on a monopitch roof with the standing seam technique.

We recommend installing a structured underlay with coping widths from 500 mm.

Wall copings may consist of one, two or more elements. Assembly from more than one element may offer advantages, particularly in terms of design and also expansion to a certain extent. Design benefits first and foremost include a much higher edge stiffness, so improving the linearity of the entire system. Segmentation helps to minimise stress levels in the material, e.g. with variations in exposure to sunshine.

WALL COPINGS

1.3.2 Overhangs, leg Lengths

The wall coping overhang should ensure that the drip edge is positioned at least 20 mm from the wall. In connection with rendering facades we recommend a distance of at least 40 mm between the drip edge and the finished rendering. The length of the overhang is measured from the edge of the building requiring protection (see Fig. 7). The vertical leg length is at least 50 mm.

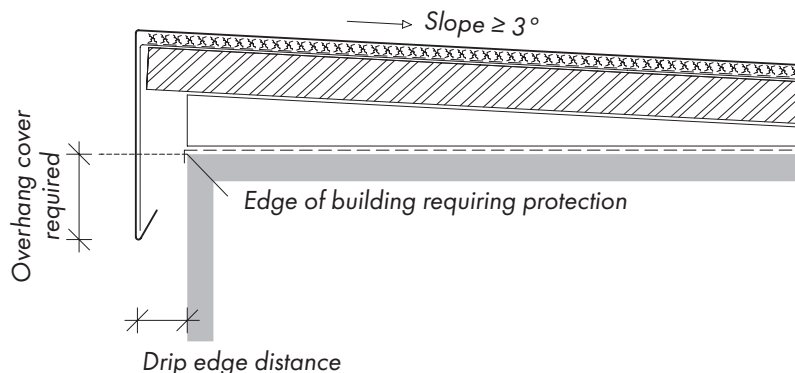


Fig. 7: Explanation of terms – Overhang and drip edge distance

1.3.3 Abutment Heights

When it is a question of connecting copings, there is wide variation in the possible situations that need to be evaluated. The requirements with cornice copings may differ from those for window sill flashings or standard wall copings.

In general the information given in the technical regulations of the trade association ZVSHK (Central Sanitary, Heating and Air Conditioning Association) should serve as the basis here (see Table 3 and Fig. 8). As this however primarily applies to roof abutments and no specific data is given for wall, cornice and window sill flashings, in practice it is recommended consulting the relevant planner, installer and client about the exact situation and execution.

Besides the abutments on the eaves and ridge side and the lateral abutments, the transitions at verges are also of importance here. In the case of metal roofs an abutment height of at least 25 mm above the water-bearing level is recommended. For flat roof waterproofing with terminations in metal the seal should be positioned min. 50 mm above the water-bearing level with roof pitches > 5° and min. 100 mm with roof pitches ≤ 5° (see Table 6, page 30).

One example for the use of the RHEIN-ZINK-soft zinc product is for connecting brick coverings to rising components. Pre-formed zinc is the durable, lead-free alternative to lead and plastic connections and is available in smooth and partially pleated versions. It consists of fine zinc pursuant to DIN EN 1179 and can be seamed and soldered.

Building height	Drip edge distance mm	Dripe edge dinctance to rendering mm	Cover required*
$h < 8$	≥ 20	≥ 40	≥ 50
$8 \leq h \leq 20$	≥ 20	≥ 40	≥ 80
$h > 20$	≥ 20	≥ 40	≥ 100

* The overhang dimensions also apply on the roof side. If the roofing foil is routed to the front edge of the facade without interruption, 50 mm overhang generally apply independent from the building height.

Table 2: Drip edge distances and overhang dimensions for copings and flashings.

Slope	L mm	E mm	R mm
$< 5^\circ$	150	150	150
$< 22^\circ$	100	100	150
$\geq 22^\circ$	80	80	150

Table 3: Abutment heights to vertical components

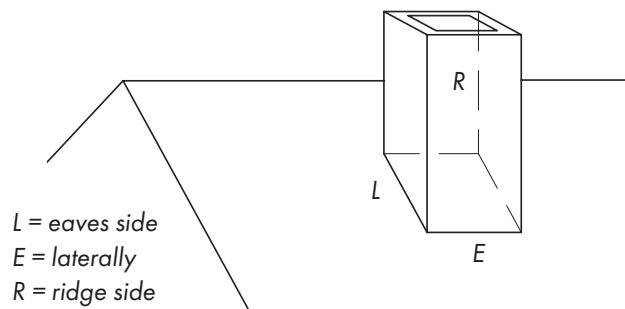


Fig. 8: Explanation of terms – Abutment heights to vertical components



Fig. 9: One-piece wall coping

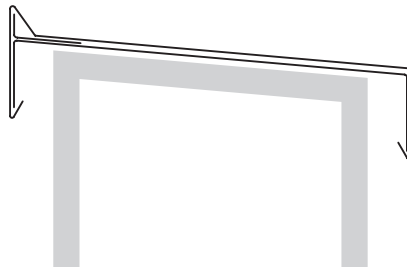


Fig. 10: One-piece wall coping with upfold

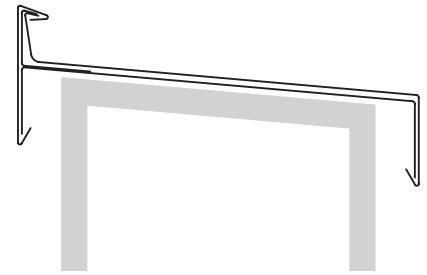


Fig. 11: Two-part wall coping

1.4 Slope

Copings should generally have a slope of min. 3° to the roof side. Installation without any slope may contribute to puddling due to the unavoidable slight unevenness and so encourage the formation of zinc hydroxide. Although the white discolouration occurring here may

spoil the final look, it does not shorten the life of the material in any way or constitute a defect. In addition, installing copings without any slope may allow atmospheric dust to collect. When it rains, this will run off both sides of the wall coping, so causing soiling.

In special cases not only an inward-facing slope should be provided but also an upfold on the outside or installation with two sections. This will be effective at preventing any undesirable runoff of water as well as any streaking on this side including with wind.

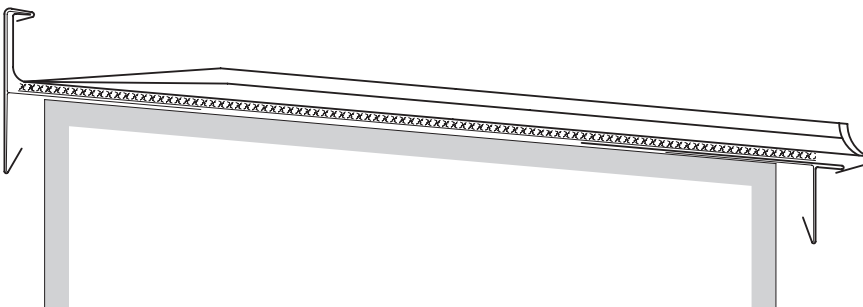


Fig. 12: Wall coping in standing seam technique

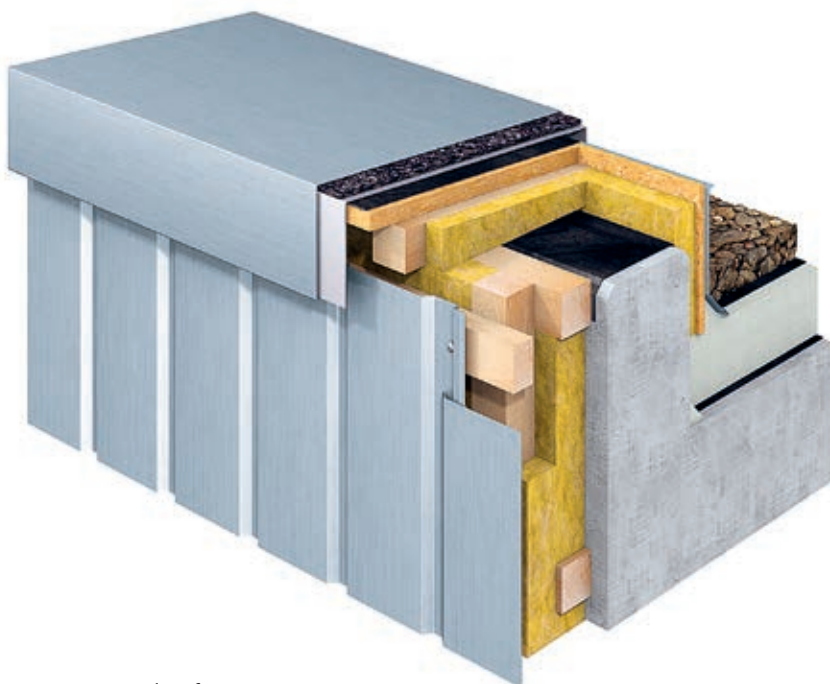


Fig. 13: Example of parapet coping

1.5 Substructure

Solid wood, derived timber boards or metal are generally used as the substructure. In the case of solid wood sheathing the board thickness should be 24 mm, and the material thickness should be min. 22 mm with derived timber board.

In particular Oriented Structural Board of the type OSB/3 or OSB/4 has proved its worth in practice. The types of derived timber board permitted here are described in the sheet metalworking regulations issued by ZVSHK or ZVDH (German umbrella association of roofers).

These boards are attached to the substructure according to the manufacturer's instructions taking into account the appropriate wind loads as per DIN 1055-4/DIN EN 1991. The fixings used here must be corrosion-resistant. Particle boards according to DIN 68763 are not suitable for this purpose.

FIXING

1.6 Fixing

Wall copings are attached to the substructure either indirectly using continuous cleats made of galvanised steel or bonded in place over the entire surface. When it comes to bonding, the use of cold-applied bitumen adhesive has proved its worth here.

1.6.1 Fixing with galvanised continuous Cleats

The cleats are generally mounted on a substructure made of solid wood, derived timber board or metal, which has itself already been affixed to the substructure. Clout nails are often used to fix the cleats in place. They are normally fixed offset with a spacing of approx. 15-20 cm. According to the trade regulations the distance between the individual fixings depends on the construction, the local conditions and wind suction forces. Experience has shown that in most cases, a continuous cleat with a material thickness of 1.0 mm will satisfy all fundamental technical requirements. If leg heights exceeding 10 cm for the wall coping are required for design reasons, the continuous cleat should be provided with a turn under to ensure greater stability and a straighter edge.

1.6.2 Fixing with cold-applied Bitumen Adhesive

It is also possible to fix wall copings in place with cold-applied bitumen adhesive (e.g. ENKOLIT®, the company Enke). This method of fixing has proved successful over many years, but the metal thickness needs to be increased (see Table 1) as the stabilising effect of the cleat is absent here. The metal thickness does not need to be increased if 20 cm wide cleats are installed with a spacing of 1 m. This is in fact urgently recommend if the planning provides for leg heights ≥ 50 mm. The essential prerequisite for use of the bonding method is a flat, dry base for adhesion as well as bonding over the entire surface.

The manufacturer's instructions for use of the adhesive must be followed.

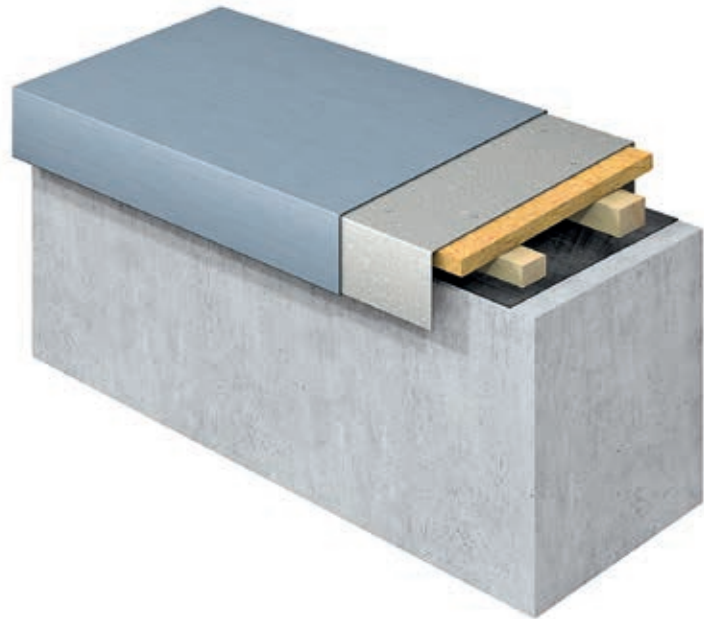


Fig. 14: Wall coping – Fixing with continuous cleats made of galvanised steel

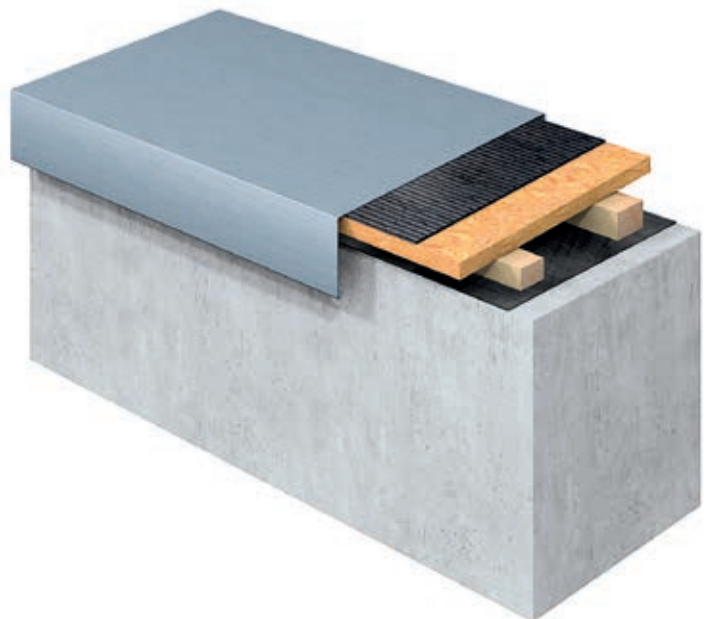


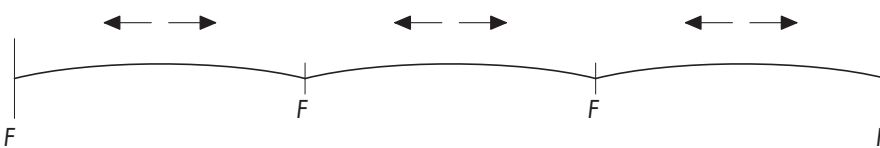
Fig. 15: Wall coping – Fixing with cold-applied bitumen adhesive

Length Change without Possibility of Expansion

State on installation



Effect



Length Change with Possibility of Expansion

State on installation



Effect

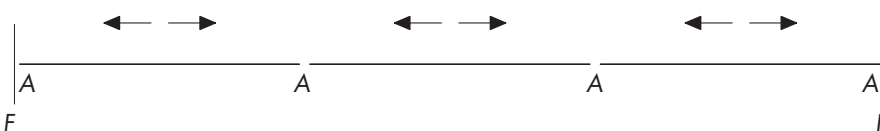


Fig. 15: Length change

F = Fixed point
A = Possibility of expansion

Example:

Length change (theoretical values)

Installation temperature RHEINZINK

15 °C

Length of coping: 6.0 m

Expansion:

$$6 \text{ m} \cdot \frac{2.2 \text{ mm}}{10 \text{ m} \cdot 10 \text{ K}} \cdot 65 \text{ K} = 8.6 \text{ mm}$$

Contraction:

$$6 \text{ m} \cdot \frac{2.2 \text{ mm}}{10 \text{ m} \cdot 10 \text{ K}} \cdot 35 \text{ K} = 4.6 \text{ mm}$$

1.7 Accommodation of Movement

Like all other materials, RHEINZINK is also subject to temperature-specific changes in length (linear expansion). The coefficient of expansion is 0.022 mm/mK in the direction of rolling. A temperature difference of 100 K (-20 °C to 80 °C) is assumed for standard applications. Length changes must not be constrained, and this means that such movement needs to be accommodated. The transition between the individual profiles must be designed so that they can expand, contract or move without restriction. This must not however impair sealing.

The maximum spacing between expansion elements for bonded or indirectly fixed building profiles is 8 m (when using cold-applied bitumen adhesive follow the manufacturer's instructions). These lengths are halved for spacing at corners or fixed points. It is permitted to slightly exceed the guidance values specified.

Calculation formula:

$$\Delta l = l_0 \cdot \Delta \vartheta \cdot \alpha$$

Symbols:

Δl : Length change (mm)

l_0 : Design length (m)

$\Delta \vartheta$: Temperature differential from installation temperature T_{inst} (K)*

α : Coefficient of expansion: 2.2 mm/(10 m · 10 K)

* Expansion: $T_{max} - <$
Contraction: $T_{inst} - T_{min}$
 $T_{min} = -20^\circ, 253 \text{ K}$
 $T_{max} = +80^\circ, 353 \text{ K}$

CONNECTION METHODS

1.8 Connection Methods and Creation of Profile Joints

When fixing wall copings in place with continuous cleats, soft soldering is generally used to join the individual coping lengths together. Although adhesive bonding is also possible, it is rarely used in practice.

The profile joints can take a variety of forms. The key factors here are the existing slope, coping width and the required result in terms of design.

Some examples of different cross joints are illustrated. Besides the illustrated examples this detail can also take the form of a standing seam. In this case it must be ensured that linear expansion is possible. We recommend using lengths of max. 2 m, which are fixed in place at the centre. A gap of 3 - 5 mm should be left between the seams.

1.8.1 RHEINZINK-UDS-Connector

The underlapping (UDS) butt connector offers multipurpose usage. Lap strip joint connectors (UDS-Connectors) made of RHEINZINK ensure rainproof seam connections for different copings without any need for additional sealing. A special profile geometry prevents capillary penetration of rainwater. The individual lengths of the wall coping are butt-jointed together on the RHEINZINK-UDS-Connector (butt joint approx. 10 mm with 3 m profile lengths). The open joint allows the coping profiles to move freely, so dispensing with the need for expansion elements.

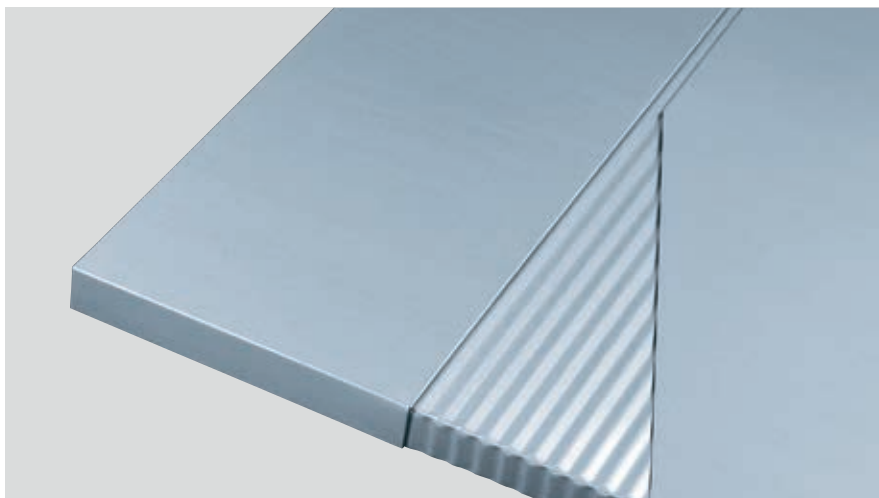


Fig. 17: The UDS-Connector is available in RHEINZINK's three finishes.

Applications

RHEINZINK's corrugated UDS-Connector can be used on transverse slopes $\geq 3^\circ$ with:

- Wall copings
- Roof edge copings
- Cornice copings
- Window sill flashings

Product Dimensions

Metal thickness: 0.80 mm and 1.00 mm
 Profile width: 250 mm and 333 mm
 Standard length: 3.0 m (other lengths on request)

The UDS-Connector is available in RHEINZINK's three surface qualities.

Where the coping profiles join, the continuous cleat is interrupted by the folded RHEINZINK-UDS-Connector, which ensures that the connection is rainproof. The ends of the profile are installed with an open butt joint approx. 10 mm wide.

If an even greater degree of tightness to rain is required, the connection can be additionally sealed with ENKOLIT® cold-applied bitumen adhesive at the overlaps.

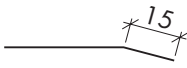
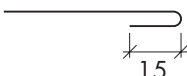
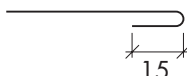
Coping width, mm	≤ 400	> 400 to ≤ 600
Width of butt strap, mm	250	333
Design of abutting edges	Cranked edge  Single turnover 	Single turnover 

Table 4: Butt joints with different coping widths

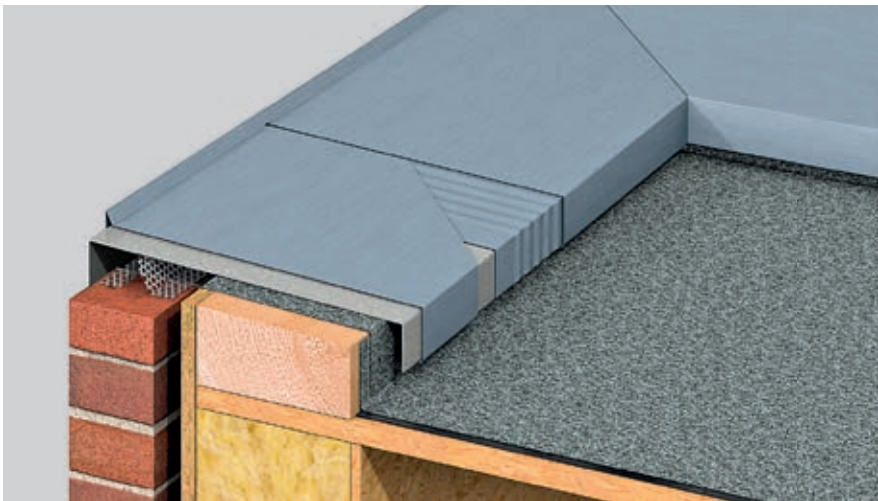


Fig. 18: UDS-Connector for a wall coping with inside corner

Processing

Profiled RHEINZINK strips can be cut, folded and curved using standard metal working machines and tools. Bending brakes and presses should be set to a

metal thickness of 3 mm. A single turnover is recommended for an aesthetically pleasing result.

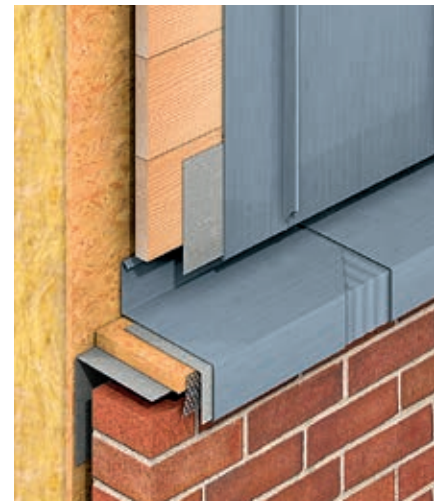


Fig. 19: UDS-Connector for a cornice coping

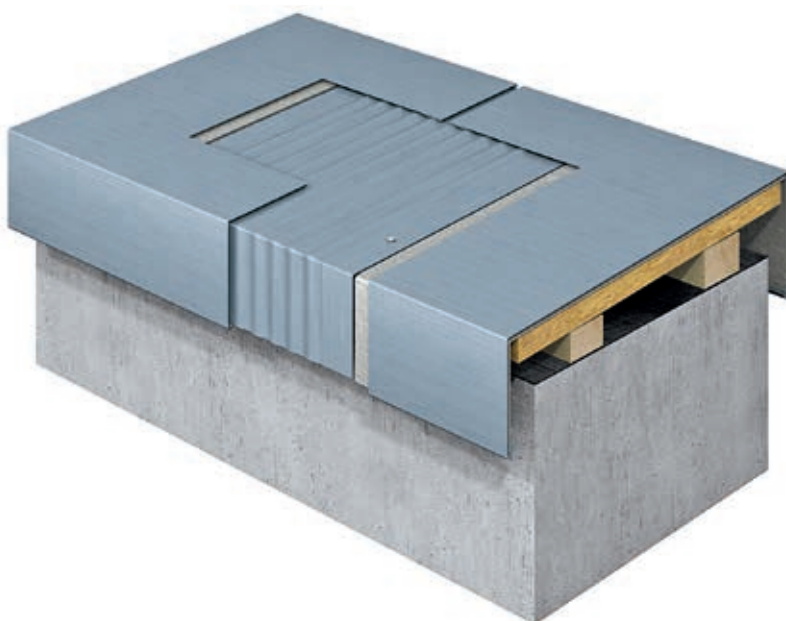


Fig. 20: RHEINZINK-UDS-Connector

Benefits of UDS-Connector

- Rainproof connection for all copings
- No soldering required
- No streaking
- No additional sealing required
- Expansion accommodated
- Fast installation
- Made of RHEINZINK QUALITY ZINC



1.8.2 Expansion Joint with Cap

- Transverse slopes min. 3°/5,2%
- Rainproof

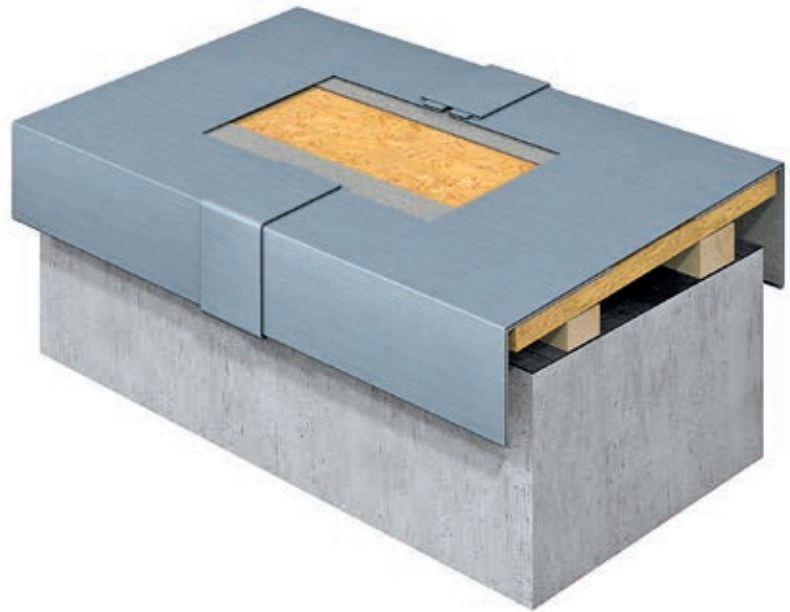


Fig. 21: Expansion joint with cap

1.8.3 Expansion Joint with coiled Expansion Element

- Transverse slopes min. 3°/5,2%
- Waterproof
- Cap fixed on one side by soldering

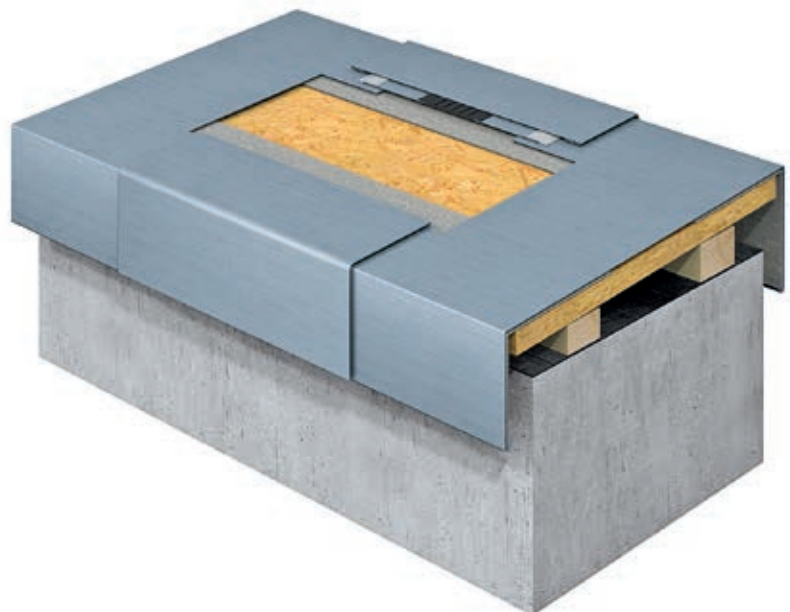


Fig. 22: Expansion joint with coiled expansion element

1.8.4 Expansion Joint with single Cross Seam

- Transverse slopes min. 3°/5,2%
- Rainproof

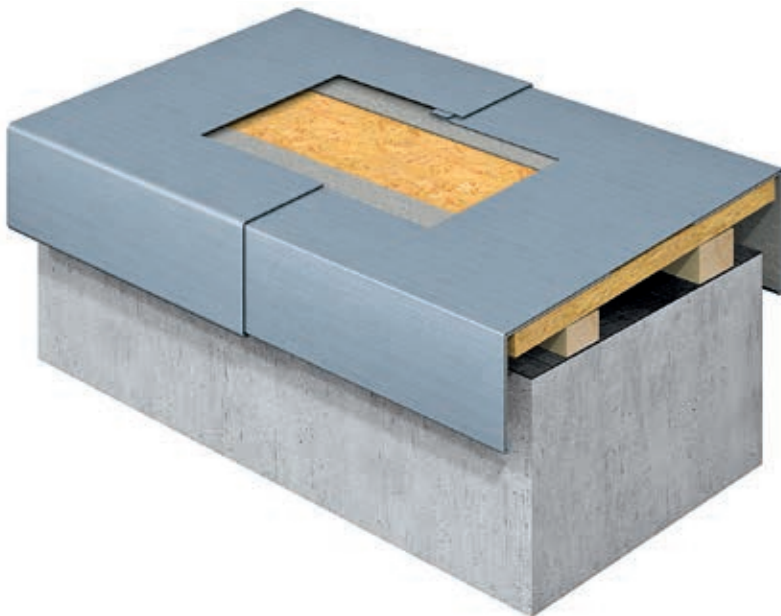


Fig. 23: Expansion joint with single cross seam



1.8.5 Expansion Joint with Butt Strap, bonded with cold-applied Bitumen Adhesive

- Transverse slopes min. 3°/5,2%
- Waterproof butt joint

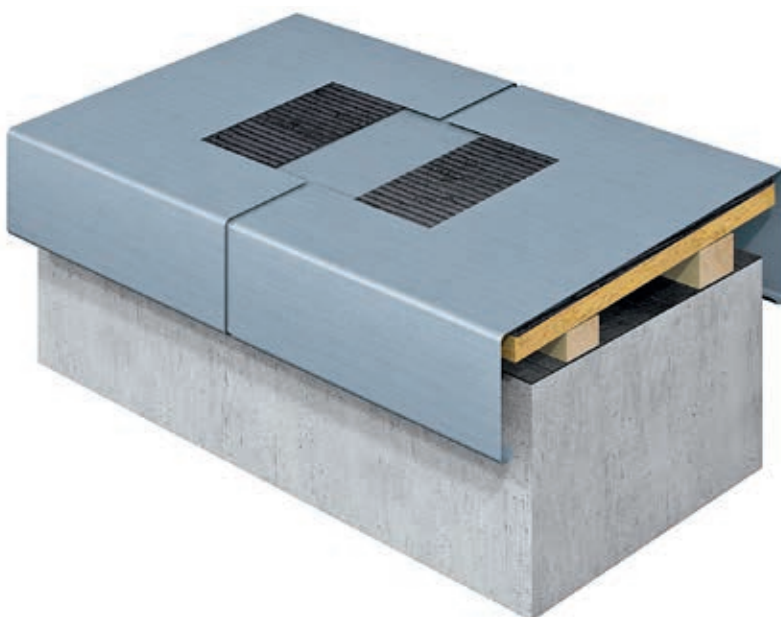
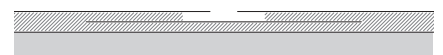


Fig. 24: Expansion joint with butt strap, bonded with cold-applied bitumen adhesive



CONNECTIONS

1.9 Connection of Metal Copings to vertical Components

Connections to the vertical components of a structure generally consist of a leg set on a component and a separate covering building profile, which is attached to the vertical component and needs to be protected from water seeping in behind. Connection is determined by the installation situation, with the connection height depending on the roof pitch and associated detailing (see section 2.3.3). We distinguish here between eaves/ridge side and lateral connections. It must be possible to accommodate the different movements of materials and components which occur without impairing the level of functionality.

In practice connections to vertical components made of lime sand brick, clinker brickwork, rendered masonry or concrete are created with cover flashings of many different types. The cover flashing is surface or flush-mounted on the wall. Joint sealant or precompressed sealing tape is normally used with this connection. In the case of surface-mounted cover flashings, fixing is at least every 250 mm, while with wall fastening rails corrosion-resistant fixings are spaced at least every 200 mm. With sealing joints it should be ensured that the sealant only adheres to two faces so that different movements can be absorbed on a long-term basis without damage.

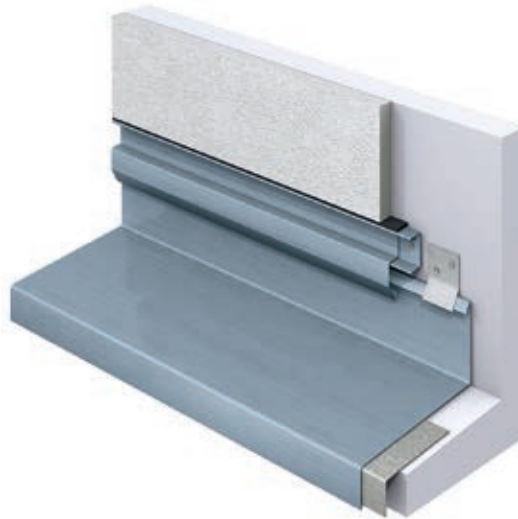


Fig. 25: Render flashing with cover flashing



Fig. 26: Cover flashing flush-mounted in wall joint



Fig. 27: Surface-mounted cover flashing with sealing tape and joint sealant

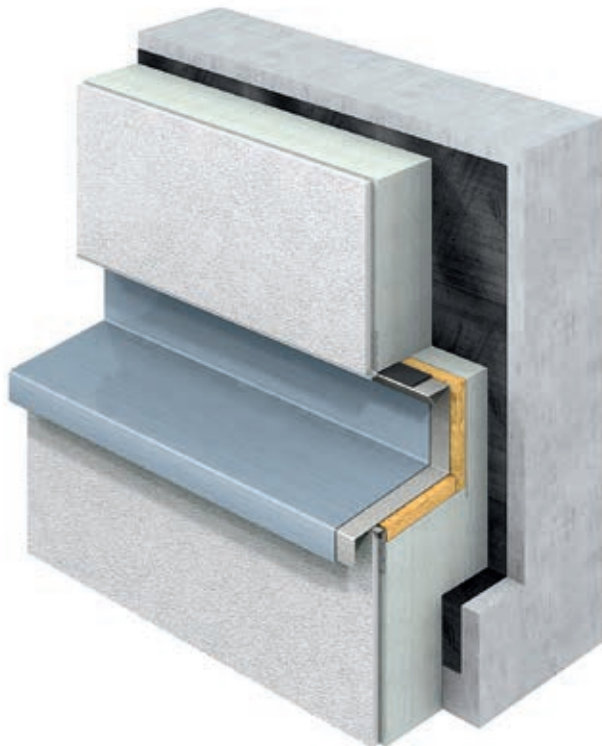


Fig. 28: Cornice construction with an exterior insulation and finishing system

1.10 Connection to Exterior Insulation and Finishing Systems

A wide range of connections to rendered surfaces and exterior insulation and finishing systems are possible and should be specified by the planner before installation. They should be designed to accommodate the different length changes occurring in the metal and render materials without any problems. The necessary overhangs must in particular be provided for, with the work sequences of the various trades involved being decided beforehand.

Render should be applied before installing titanium zinc sheeting to avoid marking being caused due to a chemical reaction with unset render.

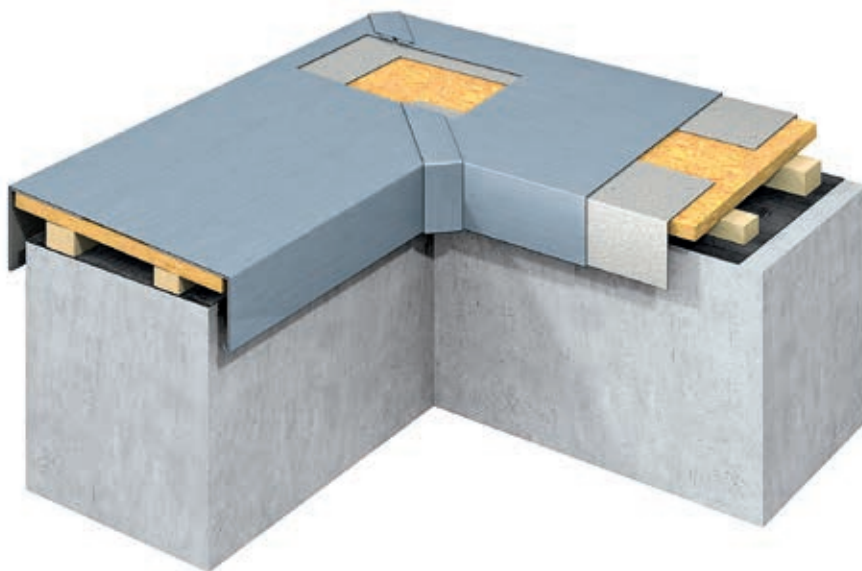


Fig. 29: Outside corner with expansion joint with cap

1.11 Creation of an outside Corner

In addition to the use of soft soldering for connection, it is also possible to construct masonry corners for example as an expansion joint with cap. Once again it is important to ensure a minimum slope of 3° to the inside of the roof edge and permit linear expansion of the material without restriction.

Alternatively, ready-to-install external corners can be ordered from RHEINZINK Service Fabrication.

CORNICE COPINGS

2. Cornice Copings

When it comes to the planning and realisation of cornice copings, the rules applicable to fascia and wall copings generally also hold good. Any divergence will be given special mention in this section.

2.1 Applications

Cornices are building components which extend horizontally from the wall and are used to visually structure facade areas, particularly in the early days of architectural design. As well as their decorative function, cornices are also meant to protect the wall below from weathering. The cornices themselves are protected by cornice copings. The individual lengths of the profiles should not exceed 3 m. These copings are generally fixed in place indirectly using continuous cleats. However, cold-applied bitumen adhesive must be used if the base layer cannot be drilled so that fixing with continuous cleats is thus not possible. This fixing method has generally proved to be highly efficient, with the facing edges not normally being very wide. Various details are available for fixing to the wall connection, although they may vary depending on the extent of weathering expected to occur and the traditional architecture of the locality. Beside the details for cover flashings described in the previous section "Connection of metal copings to vertical components", other detailing that does not always comply with the trade regulations may be used for historical buildings. One traditional solution is to use metal sheeting with a 10 mm upfold in conjunction with wall hooks and then apply render on top, making a groove with a trowel. With this solution the upfold cannot be any greater due to the lack of adhesion



Villa Neunteufel, Linz, Austria



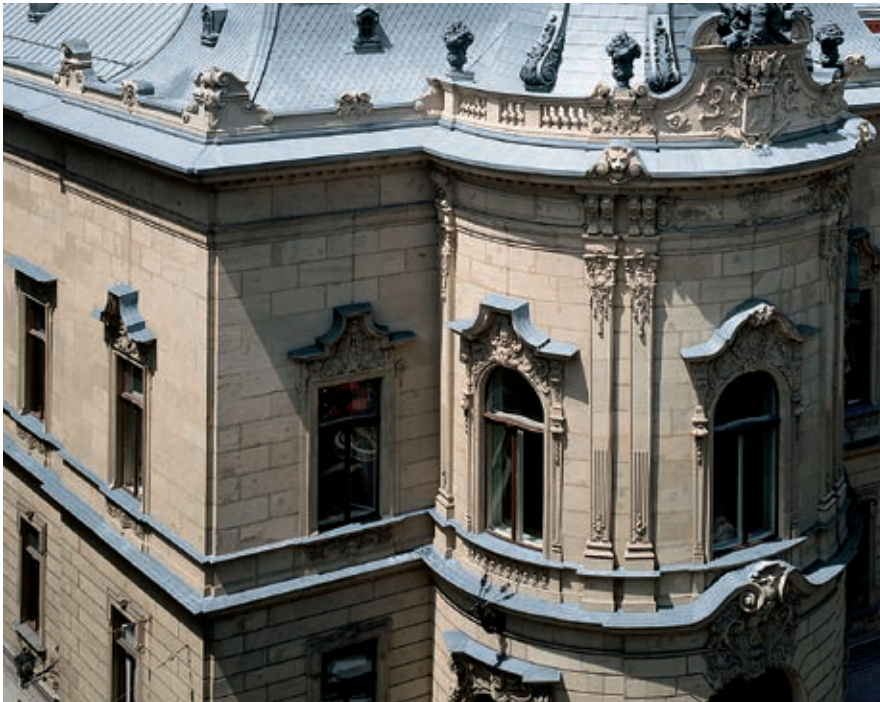
Palais Lumière, cultural/conference centre, Evian, France



Landestheater Salzburg, Salzburg, Austria

in relation to the render. This detail should therefore not be used in regions with heavy rainfall. With rendered cornices the movement distance should be 3 m (half this for corners and ends). With all other cornices the same distances apply as for wall copings. If the upper cornice faces are renovated with a new coat of render, the use of a suitable underlay is strongly recommended due to the additives generally contained in render (e.g.

for frost protection, etc.). This should not absorb or store water and is only unnecessary when using cold-applied bitumen adhesive, which itself acts as a separation layer.



Szabó Ervin Library, Budapest, Hungary



The Royal Danish Theatre, Copenhagen, Denmark

2.2 Protection of historical Monuments

When it is a question of protecting historical monuments, there is often a need for solutions which do not represent the state of the art but preserve the original appearance of the detail. In such cases the solution should be examined beforehand as regards its feasibility and practicability and an agreement reached between the planner, installer, client and the architectural conservation authority. Particularly with renovation projects it is not always possible to comply with the guidance values given for coping overhangs due to the dimensional tolerances that frequently occur – here all specified measurements should be considered as mean values.

WINDOW SILL FLASHINGS

3. Window Sill Flashings

When it comes to the planning and realisation of window sill flashings, the rules applicable to fascia and wall copings generally also apply. As the relevant standards of the metalworking sector do not in some cases contain specific information about this question, it is necessary here to fall back on other regulations and/or values from practical experience.

3.1 Applications

Window sill flashings made of RHEINZINK are used for both new builds and renovation projects and can be combined with a wide range of building materials. On request a variety of different geometries is available from RHEINZINK. We recommend using preweathered material with a material thickness of 0.8 mm. The result will be a stylish appearance with few reflections. Material with a protective film is also available and will help prevent unintentional soiling during processing. The film should then be removed immediately after installation.

Substructure

As regards suitable substructures, there are many different options available here. They range from products made of wood or derived timber to holders in aluminium or galvanised steel sheeting. With window sill flashings it is important to ensure that the substructure covers the entire surface. The substructure should be fitted in advance, e.g. when installing an exterior insulation and finishing system. RHEINZINK copings are not recommended for structures which will be regularly walked on.

Slope

Window sills should have a transverse slope of min. 3°/5,2%.

Fixing

To prevent drumming noises, the window sill flashings should be attached to the substructure over the entire surface with cold-applied bitumen adhesive (e.g. ENKOLIT).

Another option is indirect fixing using a structured underlay (RHEINZINK-VAPOZINC) between the substructure

and the window sill flashing. This permits movement of the window sill in relation to adjacent parts of the building on all four sides while ensuring the connection is impervious to driving rain. To ensure that the front edge of the window sill flashing remains permanently straight, a continuous cleat made of galvanised steel with a metal thickness ≥ 1.0 mm is generally fixed to the substructure and the vertical leg of the coping inserted in it. To act as a drip edge, it should project at least 20 mm from the facade. For plaster façades, we recommend at least 40 mm drip edge distance to the top plaster (see Table 2).

With short window lengths, the window sill can be secured from slipping by direct attachment to the mounting frame with stainless steel screws or clamping profiles. The fixing method chosen depends on the circumstances and wind loads prevailing at the locality.

Connections

Various standards and technical regulations apply to the connection of metal

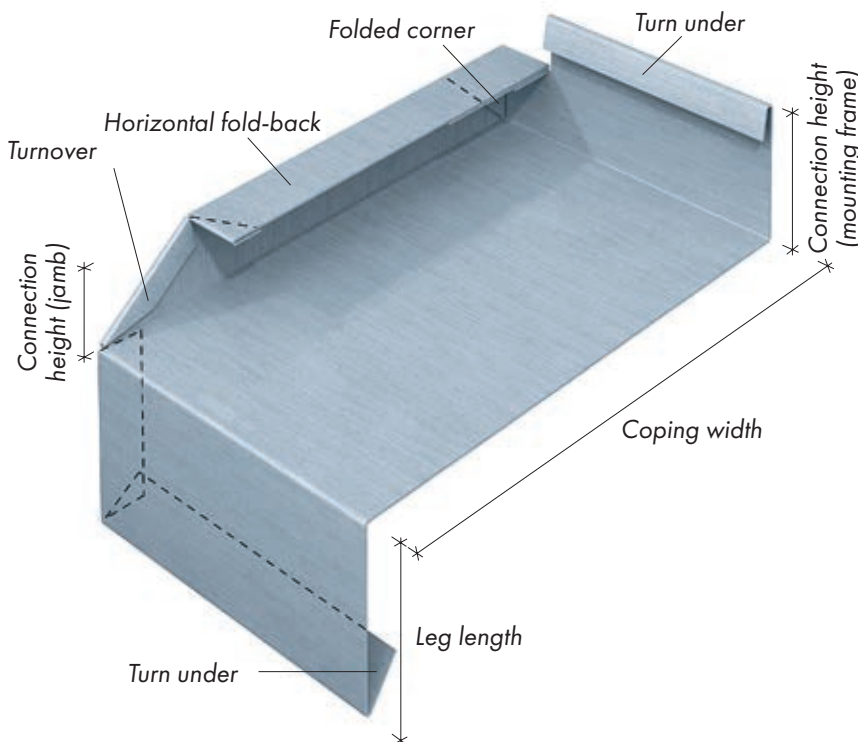


Fig. 30: Example of part of a window sill
Note: Avoid leaving any sharp edges exposed

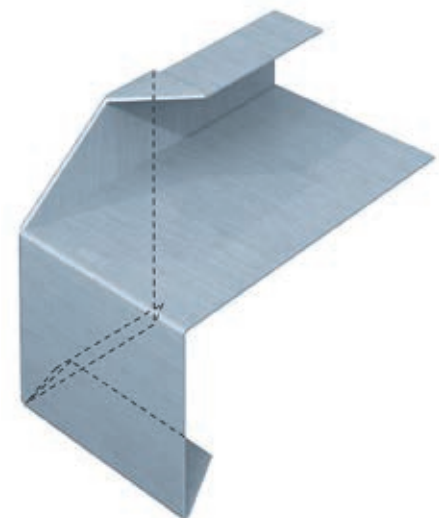


Fig. 30a: Detail improvement

window sills. Handy guidelines in this regard can be found in the publication "Leitfaden zur Planung und Montage von Fenstern und Haustüren" drawn up by the German window and door quality organisation RAL-Gütegemeinschaft Fenster und Haustüren e.V..

The main challenge when installing window sills is to create a watertight connection to adjacent parts of the building while ensuring movement of the joint to the components. This not only concerns the diffusion and convection of moisture and the accommodation of changes in temperature but in particular, the installation of a structure that is impervious to driving rain on the outside. To achieve this, the window sill should be made watertight using suitable sealants such as precompressed sealing tape at all connection points while fitting them to still permit movement. A watertight but mobile joint is created for connection to the mounting frame, jamb and underneath the window sill. A trough-shaped, rain-proof structure is required here to ensure that surface water is drained off in a controlled manner.

High-quality workmanship is ensured if a second sealing level which is impervious to driving rain is also created below the window sill. On installation the window sill flashing should not be inserted beneath the actual window profile for constructional reasons and to avoid thermal bridges.

Connection to the window sill groove (mounting frame) and to the jamb present special challenges in terms of water tightness and the accommodation of movement in materials.

Connection to Mounting Frame

The window sill upfold should be covered by the mounting frame structure to prevent the ingress of driving rain. The depth of the seam in the window profile depends on the material and the make of window: a minimum of 10 mm is recommended here. If it is not possible to create a clean connection on renovation projects, other additional sealing options will have to be used. Plans to use sealing tape or preferably retrofit overhang plates should be drawn up in detail and agreed with the planner or window manufacturer to avoid invalidating the war-

ranty. A connection height of min. 20 mm is recommended here, with a turn under where possible. Drainage of the window profile must not be impaired.

Connection to Window Jamb

A connection height of min. 20 mm is recommended for connection of the window sill to the jamb. With connection to an exterior insulation and finishing system, the horizontal foldover – the horizontal fold-back – should measure at least 18 mm to allow a sealing strip or finishing profile to be installed. Where possible, it should be completely covered with render.

If a roller shutter guide rail is fitted, this often makes installation far more difficult. The rail must end before the side upfold and should not extend to the horizontal fold-back. There must be a gap of at least 8 mm from the surface.

There is the option of installing roller shutters so they can be displaced at any time to facilitate retrofitting window sills. This should be agreed between the installer, planner and window manufacturer before proceeding with this option.

Butt Joints and Expansion

On installation it must be ensured that thermal linear expansion can be accommodated. A UDS-Connector, which is fitted completely behind the overlap of the mounting frame, should be used here.

It is also possible for the installer to produce plates modelled on the UDS-Connector. They are waterproof and attached to the jamb with a mobile joint. This structure offers the advantage that zinc window sills can be retrofitted without soiling. This method avoids marking the zinc surface during rendering and so ensures clean workmanship.

The joints of window sill flashings should not be soldered above facade claddings due to the possibility of streaking. Careful detailing with the UDS-Connector is the preferred option here. To permit linear expansion window sill flashings should not be soldered to the jamb profile.

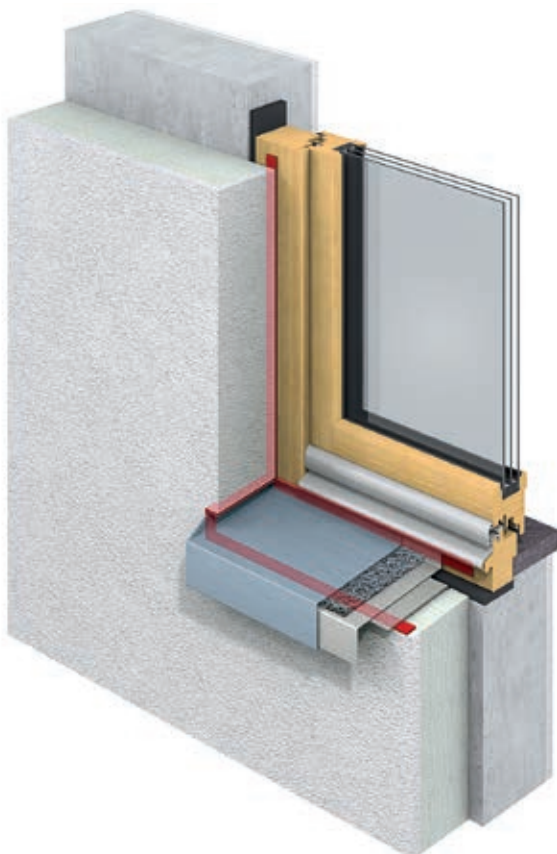


Fig. 31: Positioning of seal to prevent ingress of driving rain

3.2 Details

Connection of Window Sill to Exterior Insulation and Finishing System

This type of connection is used for both new builds and renovation projects. The holders for the window sill, with thermal breaks included, should be fitted before installation of the exterior insulation and finishing system: Pay attention to the sequence of trades: Installation of the window sill should follow rendering. When using material with a protective film, the film should be removed immediately after installation.

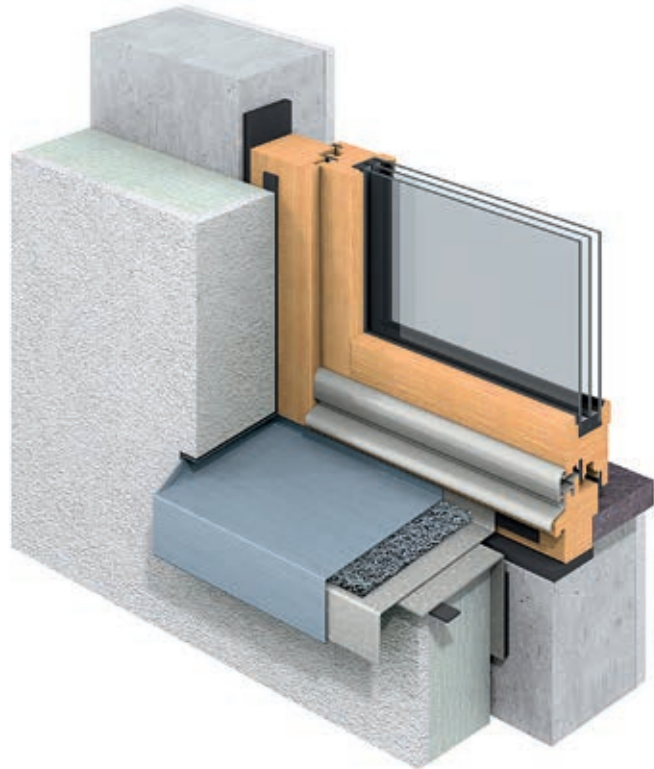


Fig. 32: Connection of window sill to exterior insulation and finishing system

Connection of Window Sill to Metal Facades (e.g. RHEINZINK-SP-Line)

The window sill, jamb and lintel should be installed before the facade. This application is suitable for either new builds or renovation work.

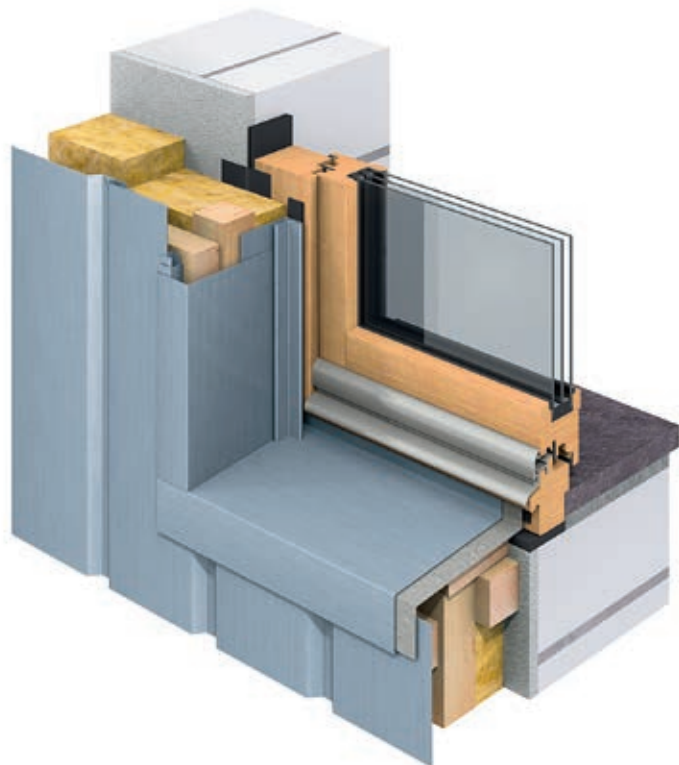


Fig. 33: Connection of window sill to RHEINZINK-SP-Line facade

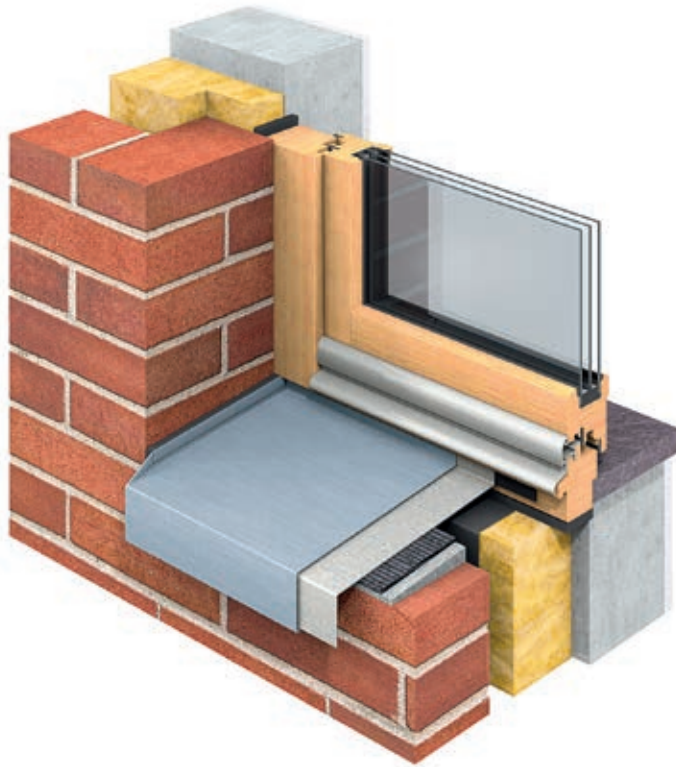


Fig. 34: Connection of window sill to brickwork

Connection of Window Sill to Brickwork

It must be ensured that the sealant in the joint only adheres to two faces so that different component movements do not cause cracking and subsequent leakage. A suitable sealing compound and back-up material should be used for separation here. These products should be pH-neutral.

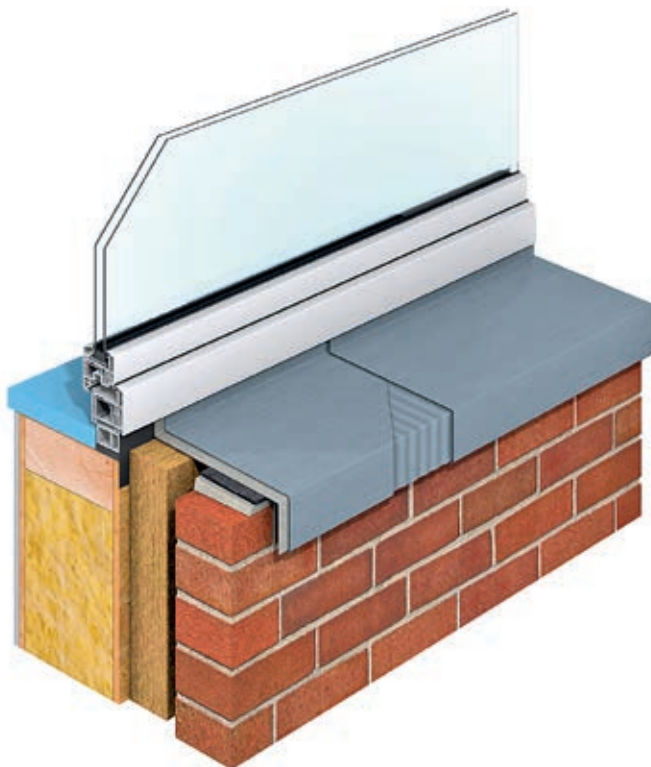


Fig. 35: Window sill butt joint with RHEINZINK-UDS-Connector

Window Sill Butt Joint with RHEINZINK-UDS-Connector

The RHEINZINK-UDS-Connector is also used to accommodate thermal linear expansion at the butt joints of window sill flashings and will look very attractive.

Note

A detailed study of the situation on site (tolerances, surrounding outer wall, etc.) is essential to ensure professional and economical execution with both existing structures and new builds. In the absence of an architect or other planner responsible for design, the contractor will be in charge of planning, so assuming responsibility for all legal consequences.

GABLE WALLS

4. Gable Walls

4.1 Copings with a longitudinal Slope – Gable Walls

Applications

Copings on gable walls may consist of one or more sections. A two-section design represents a balanced solution: It not only provides for covering of the gable wall but also connection to the main roof with an angle profile. Like fascia or wall copings, copings for gable walls are indirectly attached to the substructure with continuous cleats made of galvanised steel with a material thickness of min. 1.0 mm or using cold-applied bitumen adhesive.

4.2 Creation of Profile Joints

The relevant trade regulations do not contain any clear-cut specifications about this question. As the areas involved here are not subject to the same loads as other parts of a building, e.g. roof coverings, the following table has been drawn up on the basis of practical experience. It gives recommendations for the creation of profile joints for copings with a longitudinal slope. If any of the conditions for single overlapping with a cranked edge are not satisfied, it is recommended creating a single seam. This should always be capillary-breaking, i.e. the turn under of the upper coping is shorter (min. 10 mm) than the turn under of the lower coping. With coping widths exceeding 600 mm, similar principles as for standing seam coverings should be followed.



Standing seam covering with narrow gable coping and ventilated ridge



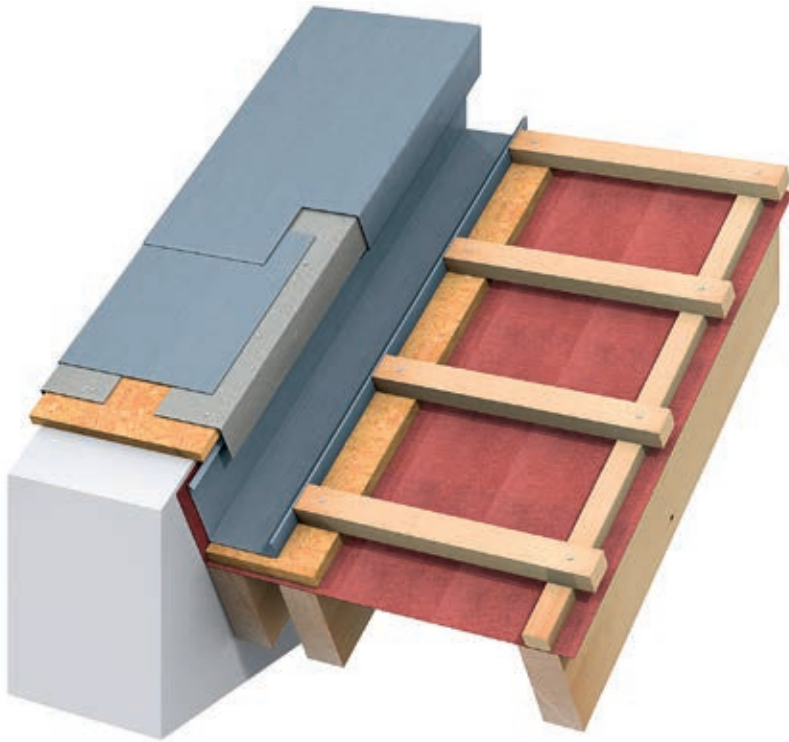
Gable cladding with coping



Standing seam covering with roof/facade and gable coping

Roof pitch	Coping width	Connection method
$\geq 15^\circ$	≤ 400 mm	Single overlap with cranked edge
$\geq 3^\circ$	≤ 600 mm	Single seam
$\geq 3^\circ$	> 600 mm	Joint created as for standing seam

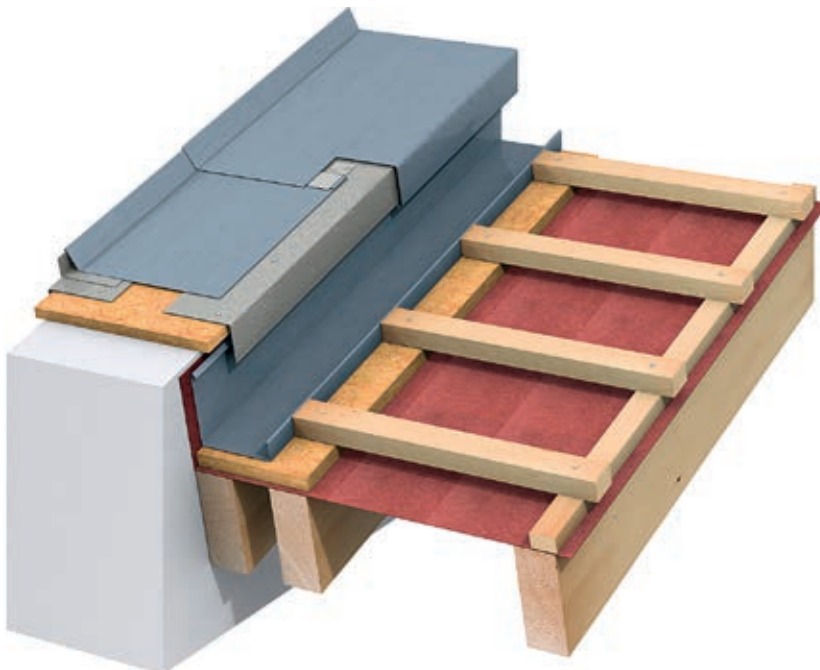
Table 5: Recommendations for the creation of profile joints for copings with a longitudinal slope (gable walls)



Cross Joint as single Overlap with cranked Edge

- Roof pitch $\geq 15^\circ$
- Coping width ≤ 400 mm
- Overlap ≥ 80 mm
- Cranked edge recommended
- Secured from slipping, e.g. riveted at side with continuous cleat

Fig. 36: Cross joint as single overlap with cranked edge



Cross Joint as a single Seam

- Roof pitch $\geq 3^\circ$
- Coping width ≤ 600 mm
- Cross joint with capillary-breaking effect:
 - Turn under of upper coping (≥ 30 mm) 10 mm shorter than turn up of lower coping (≥ 40 mm)
- Side upfold prevents streaking

Fig. 37: Cross joint as a single seam

5. Waterproofing Seals

5.1 Connection of RHEINZINK Profiles to Roof Membranes

Applications

Titanium zinc profiles can be connected to roof seals in the form of eaves or angle flashings as well as other similarly shaped profiles. These profiles are fixed in place by bonding to the membrane roof. A distinction is made here between terminations for roof edges and connection to the vertical components of a building.

Terminations for roof edges are categorised depending on whether they perform a supporting or sealing function. In the first case the zinc plate merely acts as a support and is bonded over the entire surface. In the second case the outer termination also functions as a design feature, with the seal stopping immediately before the edge of the roof. It must be ensured that the individual connections are permanently waterproof.

In the case of roof edges with a sealing function, another distinction is made as to whether the structure has internal or external drainage.

Girth and Connection

The surface to be bonded must be dry, free of contamination, grease and dust and should be primed with a product that will act as a key. The sealant must be bonded over the entire surface and consist of two layers on the flange.

A separating strip min. 100 mm in width should be loosely fitted at the transition between the edge of the adhesive and the roof seal to compensate for variations in movement between the metal parts and seal without stress. The seal should end 10 mm before the edge, and the adhesive flange fixed in place mechanically. Flashings joined to seals and their connections must all be watertight.

Connection Heights

The heights for the connection of bonded flashings to vertical components and for roof edge terminations can be found in Table 6, based on the trade regulations for seals, depending on the type of connection and roof pitch.

Fixing

See below for a description of the options available for fixing in relation to the individual structures.

Exposed areas of zinc that will come into contact with roof runoff should be provided with a porefree corrosion protection coating, e.g. Enke Multi Protect, depending on the roof seal, however especially in the case of bitumen roof sheeting. This also applies to roof drainage.

Roof pitch	Roof edge terminations	Connections to vertical components
≤ 5°	≥ 100 mm	≥ 150 mm
> 5°	≥ 50 mm	≥ 100 mm

Table 6: Connection heights for roof seals

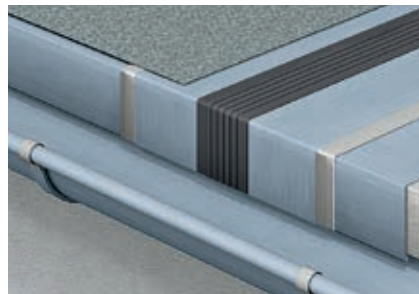


Fig. 38: Roof edge with a sealing function and external drainage

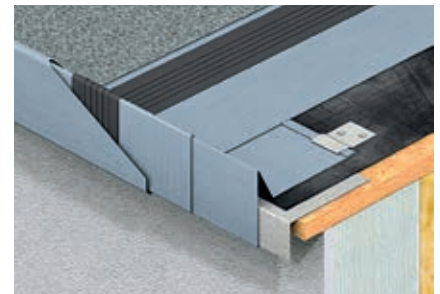


Fig. 39: Roof edge with a sealing function and internal drainage

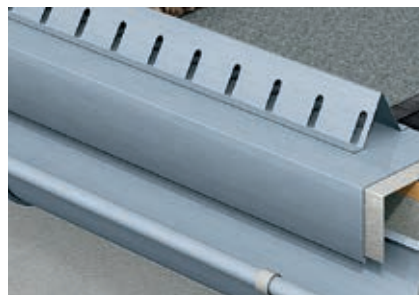


Fig. 40: Roof edge with a gravel strip

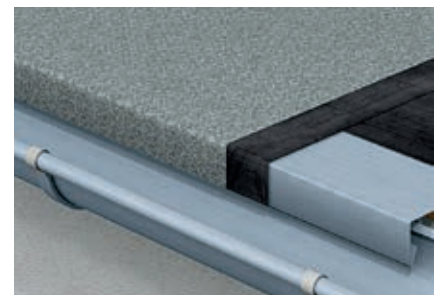


Fig. 41: Roof edge with a supporting function

5.2 Roof Edges with a sealing

Function and external Drainage

The standard length of the individual eaves flashings is 2 m or 3 m. The girth of the profile depends on the projection and the length of the vertical leg and takes into account the fact that the bonded surface on flashing connections must be at least 120 mm wide. In the case of roof edges with a gravel strip the flange must be min.

200 mm in width. The metal thickness directly depends on the girth but should be 0.8 mm with large projections.

Girth width mm	Material thick- ness min. mm
≤ 250	0,7
> 250	0,8

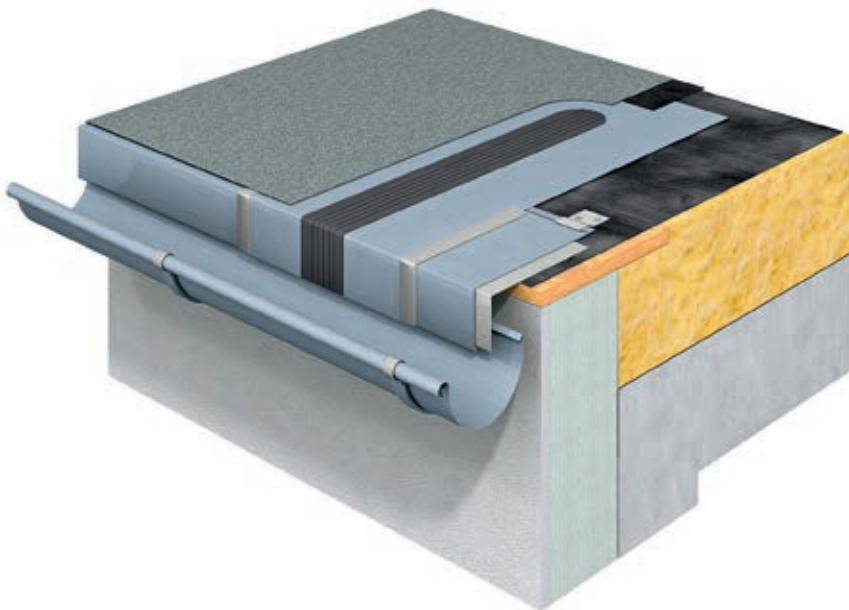


Fig. 42: Roof edge with a sealing function and external drainage



Fig. 43: Roof edge with a sealing function and external drainage – Variant with gravel strip

Fixing

Eaves flashings are fixed in place indirectly, i.e. using either horizontal clips which are hooked into the turn under of the eaves flashing, or toothed clips, with the smooth eaves flashing being clamped into these clips. The front edge of the eaves flashing is inserted in a continuous cleat or the springs of the gutter brackets. The support for the eaves flashing, the eaves board, should be recessed some 10 mm in relation to the heat insulation of the roof so as not to obstruct the runoff of water. The individual lengths of the eaves flashing are soft-soldered to join them together.

Movement

To permit linear expansion, flat roof edge expansion elements are soldered to the eaves flashings every 6 m (every 3 m from corners and ends). These elements permitting linear expansion must seat at least 60 cm on the roof area. The expansion element can be bent to fit virtually any profile specified. As in the case of the eaves flashing, thermal expansion should not be obstructed in any way, e.g. by being nailed in place. To accommodate the shear stress which is inevitable at the transition to the bonded profile flashing (here eaves flashing), a drag flashing min. 100 mm in width should be loosely fitted in this area to prevent direct adhesion between the edge of the profile and the roofing.

Slope

The eaves area must have a slight outward slope to prevent the pooling of water.

ROOF WATERPROOFING

5.3 Roof Edges with a sealing**Function and internal Drainage**

To minimise the number of cross joints, the profile lengths should not be shorter than 3 m. The girth depends on the final look required for the coping, but the metal thickness should be 0.8 mm. Like other bonded profiles, an adhesive flange of at least 120 mm is necessary here. To avoid facades being soiled by the uncontrolled runoff of rainwater, the height of the up-fold should comply with Table 6.

Fixing

Horizontal clips are used for indirect fixing at the upper edge. To ensure linearity, the front edge is inserted in a galvanised continuous cleat at least 1.0 mm thick. The individual lengths are soft-soldered together.

Movement

The information given for roof edges with a sealing function and external drainage apply accordingly here. To accommodate movement, a flat roof edge expansion element which seats at least 60 cm on the roof area should be fitted here. As regards the necessary spacing for these elements, the rule that half the distance should be used from corners and ends (i.e. incl. projecting or recessed faces) is of particular relevance in this case. The expansion elements are soldered to the roof edge profile and concealed with a cap folded along the profile in areas that are visible.

Wall Connections

In contrast to roof edge surrounds, wall connections are understood to mean the transition to a vertical wall, even where this may be rather low, e.g. as in the case of a fascia.

Note

Where roof seals include layers of gravel, it is recommended that the protective coating extends 20 mm above the surface of the gravel. A protective coating is also necessary with angle flashings under terrace coverings as in this case there is no free admission of air in the damp environment necessary to form a natural protective layer. Here too the protective coating should extend 20 mm from the water level above the terrace covering.

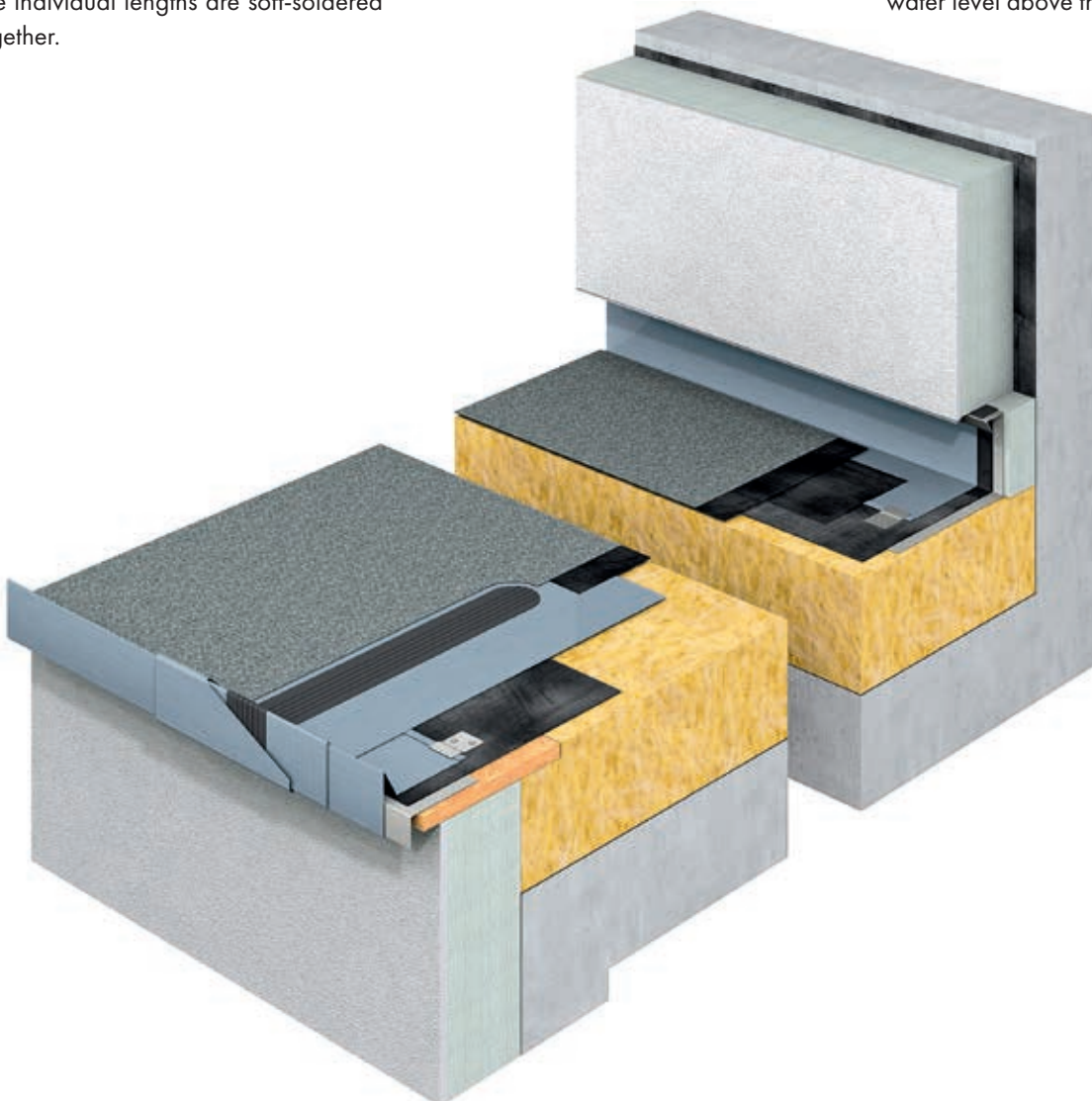


Fig. 44: Roof edge with a sealing function and internal drainage with connection to vertical wall

5.4 Roof Edges with a supporting Function for membrane Roofing

With this application eaves flashings made of RHEINZINK offer support at the transition between membrane roofing and external drainage, which tend to project slightly. This occurs on a localised basis and is particularly common with buildings of less complex design. The eaves flashings have a front termination but no water drip. They are completely covered by the roof sheeting, which thus also acts as a seal.

Individual lengths are limited to 3 m in length to permit thermal linear expansion, although in most cases this is generally reduced to 2 m. The girths and corresponding metal thicknesses depend on actual execution, but the adhesive flange positioned at roof level should however

be at least 150 mm in width. Where the eaves flashing markedly projects, the metal thickness should be a minimum of 0.8 mm irrespective of the girth.

Fixing

The individual lengths are mounted directly on the substructure using suitable fixings (generally roofing nails, 2.8 x 25 mm). This should be recessed some 10 mm in relation to the heat insulation of the roof so as not to obstruct the runoff of water. The individual lengths should overlap about 10 cm, so increasing the stability of the vertical leg. Nails are offset and spaced at approx. 50 mm. Piercing of the direct fixing does not affect water tightness as it will be entirely covered by the roof seal once glued in place.

Movement

With this simple detailing without any claim to water tightness no special provision need be made for movement if the individual lengths are limited to max. 3 m. The function of the roof seal will be improved if direct bonding does not take place at the overlap of the eaves flashings.

Slope

The eaves flashing must have a slight outward slope.

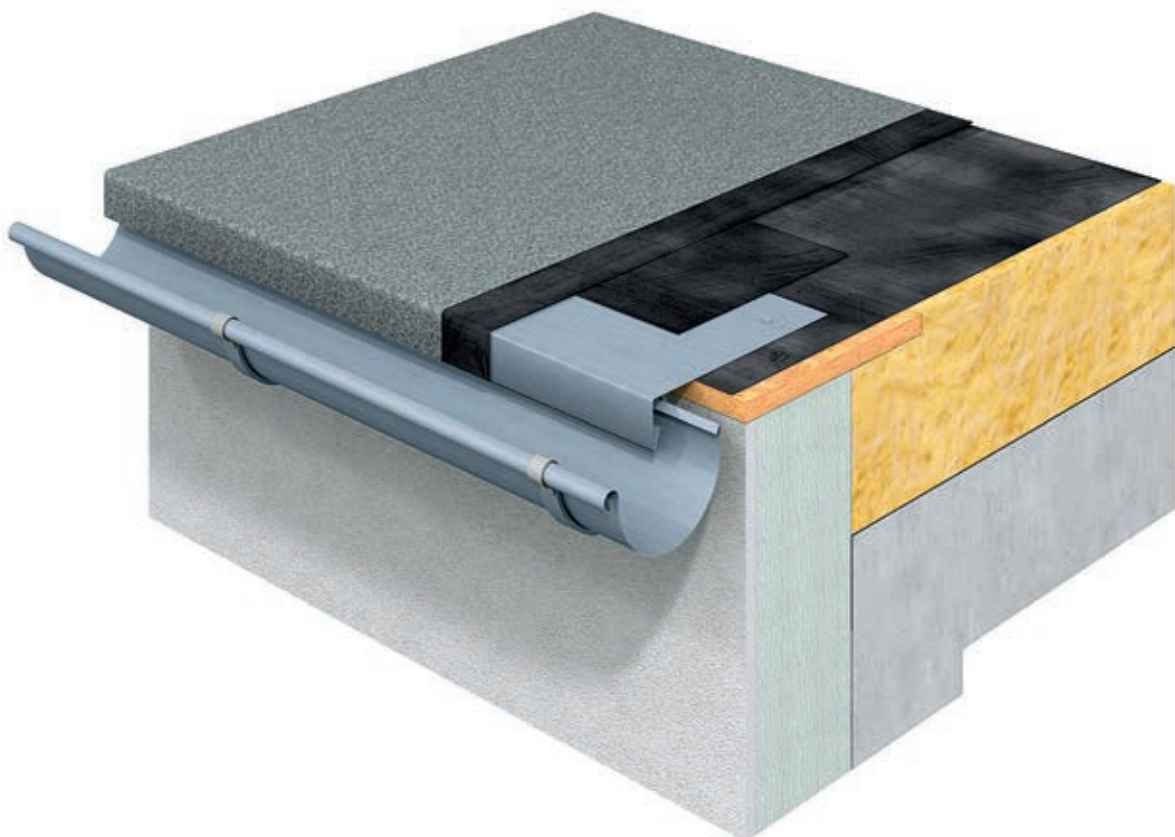


Fig. 45: Roof edge with a supporting function

6. Fire walls

6.1 Special Components – Fire Wall Copings

General

In the past the spread of fire via the roof often resulted in enormous damage, particularly in densely populated urban areas. As a key element of the fire protection concept, the fire wall is nowadays of major importance.

6.2 Legal Framework

Fire walls are used to separate or partition off fire compartments. They are designed to prevent the spread of fire to other buildings or parts of the same building. To satisfy these requirements, fire walls in Germany must be made of non-combustible building materials according to the relevant building regulations of the individual federal states and must resist fire for a minimum period of 90 minutes. It is important to note here that fire walls must not be bridged with combustible building materials or continuous air layers as they might result in the spread of flames, sparks or fumes.

The building regulations of Germany’s federal states generally state that fire walls in class 1 – 3 buildings must continuously extend at least directly to the roof covering. In the case of other buildings they must continuously extend either 0.30 m above the roof or end level with the roof covering in a reinforced concrete slab built to fire resistance class F 90 that projects 0.50 m on both sides. In buildings with membrane roofing fire walls must extend 0.50 m above the roof. With metal roofs the most effective method of preventing the spread of fire is generally a fire wall that extends above the roof.

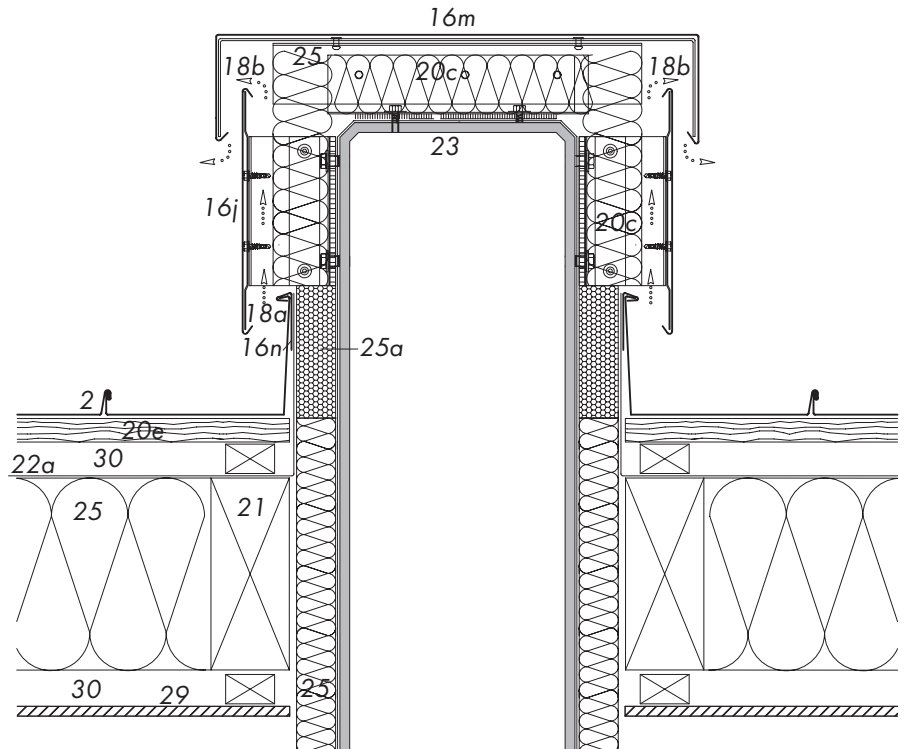


Fig. 46: Suggested design for a fire wall with RHEINZINK made of class A building materials

6.3 Applications

According to DIN EN13501-1 (DIN 4102-1) RHEINZINK is classified as a non-combustible building material belonging to Class A1. This is the best possible classification in terms of non-combustibility and means that this material is not combustible, and in the event of a fire, will not become detached and will not produce burning droplets or smoke. It is thus perfectly suitable as a coping for fire walls. Besides substructures made of metal (Fig. 46), cement-bonded particleboard as per DIN EN 633 can also be used here, although the titanium zinc and the particleboard need to be separated by a structured underlay. In this case information about the fire load to be expected should be given by the fire inspector responsible as such underlays do not exceed building material class B.

Key to Fig. 46

- 2 RHEINZINK-Double Standing Seam
- 16 RHEINZINK-Building Profile
 - j Fascia profile
 - m Wall coping
 - n Continuous clip
- 18 Support Profile
 - a Galvanised steel
 - b Aluminium
- 20 Substructure
 - c Bracket system, with thermal break*
 - e Softwood boarding, thickness min. 24 mm, width max. 160 mm
- 21 Batten/Squared Timber
- 22 Functional Layer
 - a Underlay covering
- 23 Supporting Structure
- 25 Thermal Insulation
 - a Heat insulation with high compressive strength, building material class A
- 29 Internal Lining
 - Plasterboard
- 30 Ventilation space

* Manufacturer’s guidelines must be observed.

7. Solar Systems

7.1 Special Components – Incorporation of Solar Systems Applications

The incorporation of roof-integrated solar systems in titanium zinc roofing may offer an extremely stylish solution for roofs. The often considerable height of the superstructure tapering away from the middle of the roof to the edges is thus a sophisticated design detail that combines a low facing height with a clean termination in titanium zinc.

Solar collector with
clamping profiles

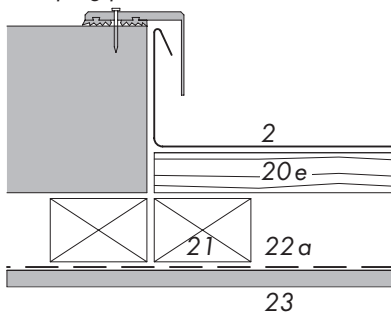


Fig. 47: Connection at verge

As there are many different manufacturers of solar collectors as well as numerous systems, it is not possible to offer a standard solution in terms of connection. The objective here is to ensure perfect detailing for sheet metalworking. It is necessary to check the information provided by solar collector manufacturers and where necessary, consult them regarding the water tightness of the connection points.

7.2 Details

Creation of the lateral connections or the connections on the eaves side does not generally cause any problem in relation to water tightness when incorporating solar collectors. The ridge-side connection can either take the form of a recessed gut-

ter or be lapped over the solar collector. Another possibility are systems where the width of the solar collectors is limited and the water drains off in guttering installed between the collectors. This system is comparable with the installation of skylights.

The example given below shows a fictitious solar collector, which is incorporated in a standing seam covering made of titanium zinc using clamping profiles.

You can also obtain further information about our RHEINZINK-PV product. These are frameless solar modules, parallel to the roof, which are fixed to the RHEINZINK standing seam roof using special seam/module clamps.

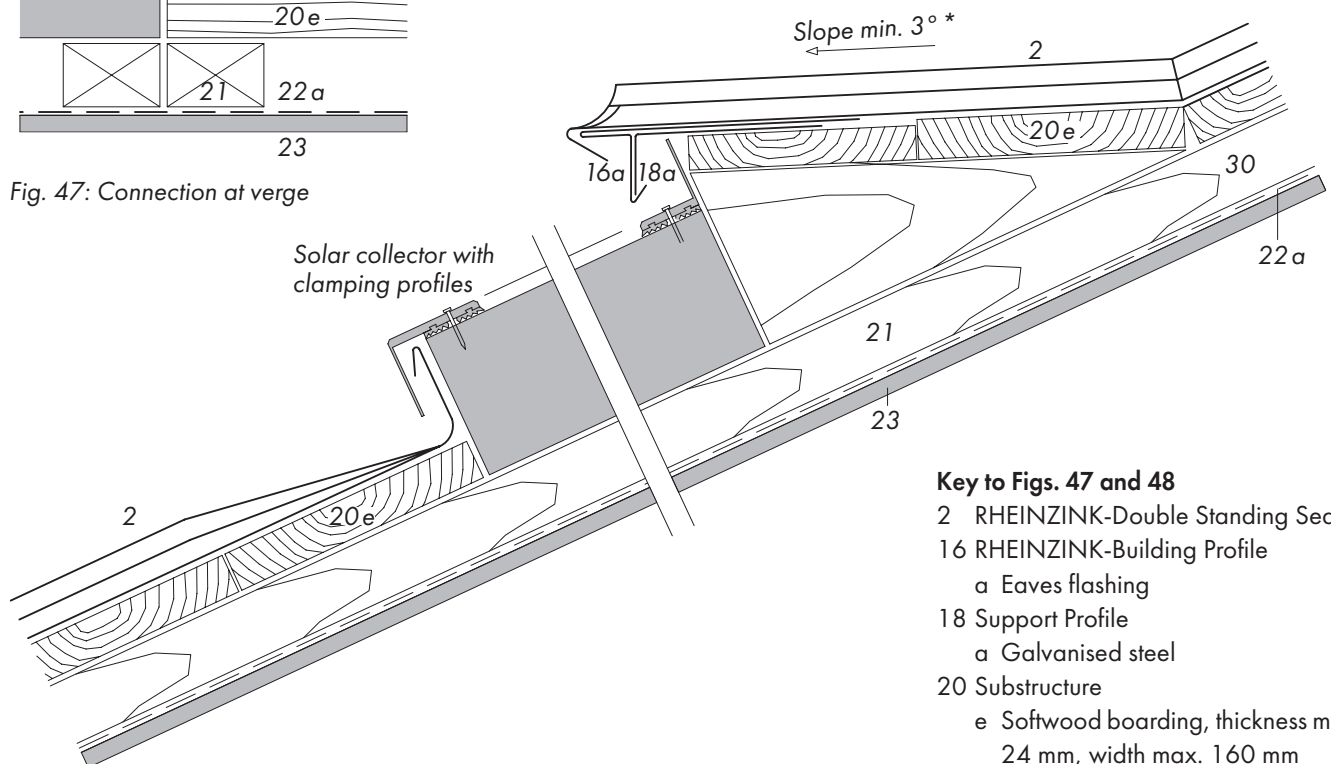


Fig. 48: Suggested design for possible incorporation of a solar collector –
Connection on eaves and ridge side

Key to Figs. 47 and 48

- 2 RHEINZINK-Double Standing Seam
- 16 RHEINZINK-Building Profile
 - a Eaves flashing
- 18 Support Profile
 - a Galvanised steel
- 20 Substructure
 - e Softwood boarding, thickness min. 24 mm, width max. 160 mm
- 21 Batten/Squared Timber
 - Squared Timber
- 22 Functional Layer
 - a Underlay covering
- 23 Supporting Structure
- 30 Ventilated Air Space

* Sealing strips included with roof pitches from 3° to 7°

8. Green Roofs

8.1 Special Components – Roof Edges with green Roofs Applications

As in the case of integrated solar collectors, the incorporation of green roof systems with titanium zinc will give a very elegant look to a building. The superstructure height tapers away from the middle of the roof to a slender face at the edges. The green roof should be built according to the manufacturer's instructions.

8.2 Details

Creation of the lateral connections and the connections on the eaves side is relatively simple in terms of sheet metalworking. The ridge-side connection is adapted to the individual situation and the final look required for the building.

See below for a suggested connection point at the eaves, ridge and verge. The green roof is drained via bracket-mounted guttering at the front to prevent the zinc panels being marked by streaking. The

dimensioning of such gutters depends on the volume of water to be drained and is not the responsibility of RHEINZINK. It is generally possible to drain off the rainwater from the green roof to the guttering via the zinc panels. This may soil the surface but will have no adverse effect on the longevity of the material. Controlled drainage is recommended.

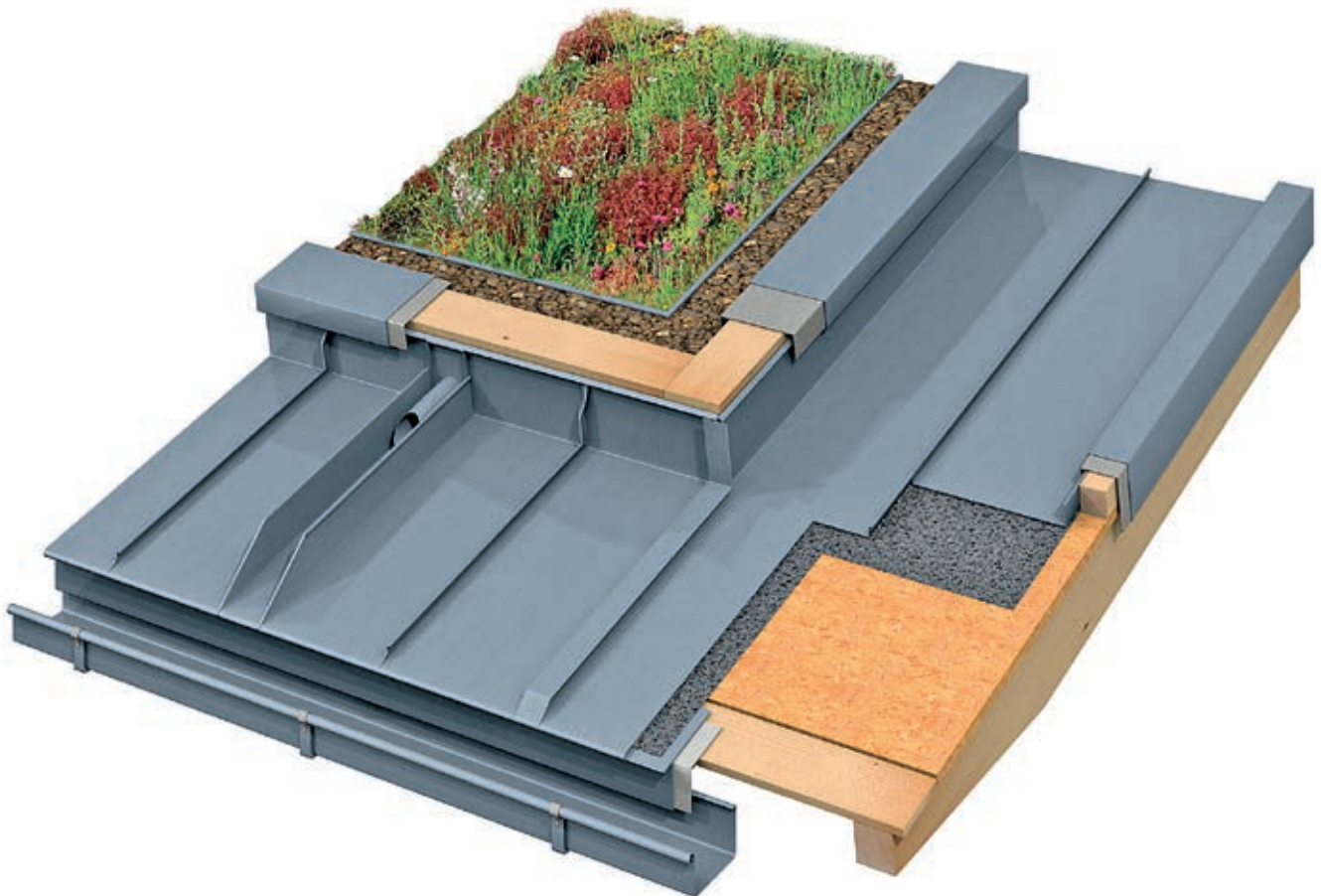


Fig. 49: Eaves side and lateral connection to green roof system – Suggestion with controlled rainwater drainage

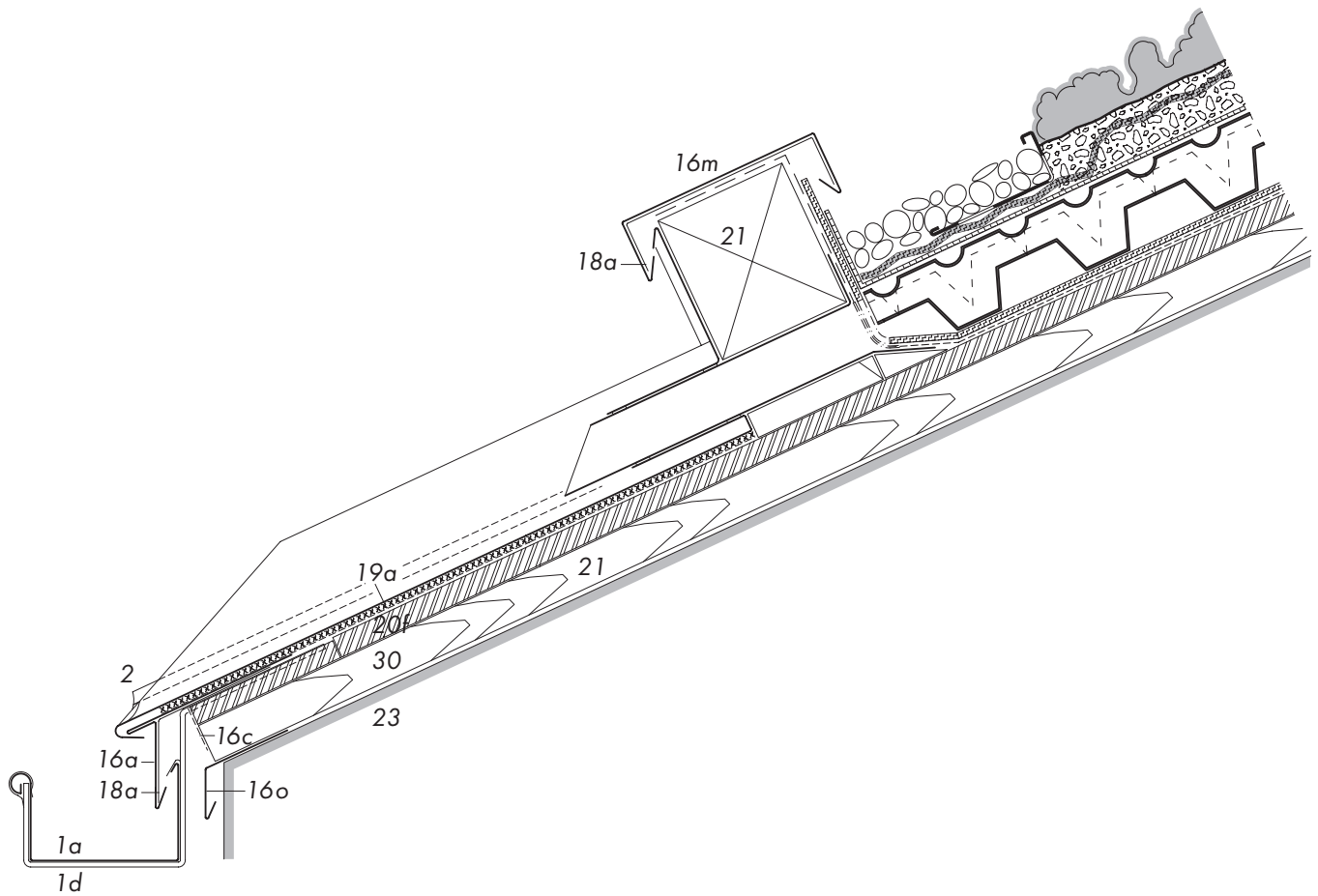


Fig. 50: Detail of eaves – Eaves side connection to a green roof

- | | |
|---------------------------------------|--|
| 1 RHEINZINK-Roof Drainage | 19 Separating Layer |
| a Gutter, box-shaped | a Structured underlay VAPOZINC |
| d Gutter bracket, clad with RHEINZINK | 20 Substructure |
| 2 RHEINZINK-Double Standing Seam | f OSB/veneer plywood sheathing, thickness min. 22 mm |
| 16 RHEINZINK-Building Profile | 21 Batten/Squared Timber |
| a Eaves flashing | 23 Supporting Structure |
| c Perforated strip | 30 Ventilated Air Space |
| m Wall coping | |
| o Eaves profile | |
| 18 Support Profile | |
| a Galvanised steel | |

COPINGS, DESIGN AND APPLICATION

GREEN ROOFS

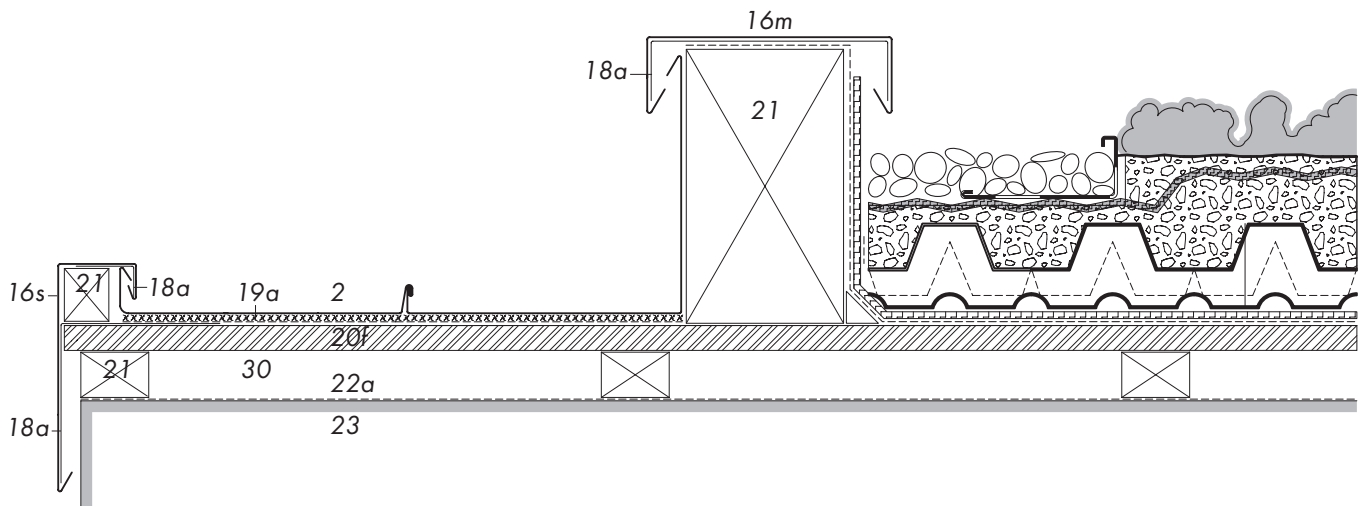


Fig. 49: Detail of verge – Lateral connection to a green roof

- | | |
|----------------------------------|---------------------------------|
| 2 RHEINZINK-Double Standing Seam | 20 Substructure |
| 16 RHEINZINK-Building Profile | f OSB/veneer plywood sheathing, |
| m Wall coping | thickness min. 22 mm |
| s Verge flashing | 21 Batten/Squared Timber |
| 18 Support Profile | 22 Functional Layer |
| a Galvanised steel | a Underlay covering |
| 19 Separating Layer | 23 Supporting Structure |
| a Structured underlay VAPOZINC | 30 Ventilated Air Space |

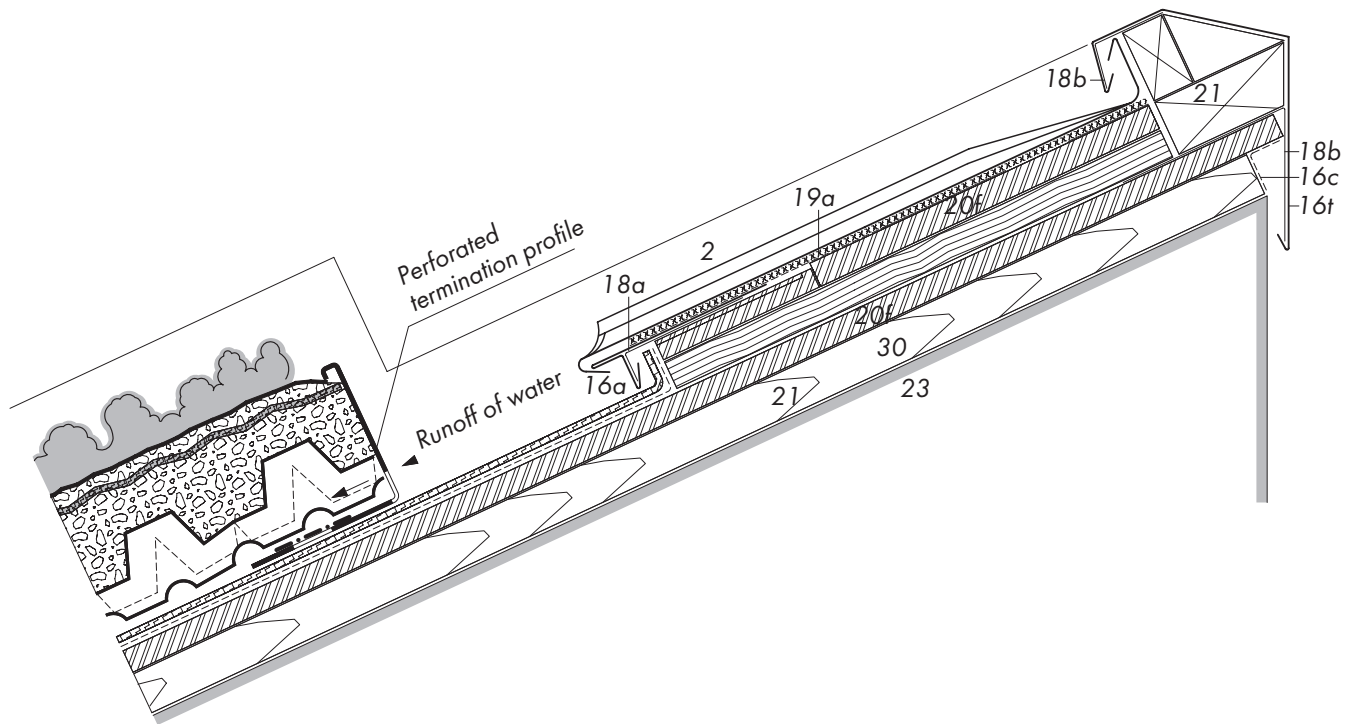


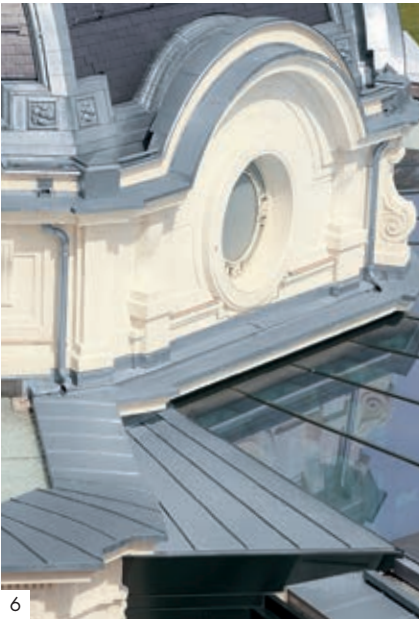
Fig. 51: Detail of ridge – Ridge side connection to a green roof

- | | |
|-----------------------------------|---------------------------------|
| 2 RHEINZINK-Double Standing Seam | 19 Separating Layer |
| 16 RHEINZINK-Building Profile | a Structured underlay VAPOZINC |
| a Eaves flashing | 20 Substructure |
| c Perforated strip | f OSB/veneer plywood sheathing, |
| t Ridge flashing, mono pitch roof | thickness min. 22 mm |
| 18 Support Profile | 21 Batten/Squared Timber |
| a Galvanised steel | 23 Supporting Structure |
| b Aluminium | 30 Ventilated Air Space |

COPINGS, DESIGN AND APPLICATION

REFERENCE PROJECTS





COPINGS, DESIGN AND APPLICATION

ILLUSTRATIONS

Cover (projekt left):

Two private Residences, Seeheim-Jugenheim, Germany

Architect: Planungsbüro Hapke GmbH, Herten, Germany

RHEINZINK-work done by: Schreck Klempnerei GmbH, Mespelbrunn, Germany

Cover (project top right):

Commercial/residential building, Bremen, Germany

Architect: Dipl. Ing. Arch. H. Kapels, Zetel, Germany

RHEINZINK-work done by: H. Egden, Friedeburg-Wiesede, Germany

Cover (project centre right):

Natural Living in De Weel, Zijdewind, The Netherlands

Architect: Breddels architecten bna, Heerhugowaard, The Netherlands

RHEINZINK-work done by: Ridder Metalen Dak- en Wandsystemen, Zwaag, The Netherlands

Cover (project bottom right):

Szabó Ervin Library, Budapest, Hungary

Architect: MATESZ, Budapest, Hungary

RHEINZINK-work done by: NARVA Kft., Budapest, Hungary

1. The Salzburg State Theater, Salzburg, Austria

Architect: Scheicher ZT GmbH Architekten, Adnet, Austria

RHEINZINK-work done by: Ing. Hans Öschlberger Bedachung, Seekirchen am Wallersee, Austria

2. Parkhotel Hagenbeck, Hamburg, Germany

Architect: Pbr Planungsbüro Rohling AG, Osnabrück, Germany

RHEINZINK-work done by: Athens GmbH & Co. KG, Hövelhof, Germany

3. Natural Living in De Weel, Zijdewind, The Netherlands

Architect: Breddels architecten bna, Heerhugowaard, The Netherlands

RHEINZINK-work done by: Ridder Metalen Dak- en Wandsystemen, Zwaag, The Netherlands

4. Private Residence, Dolenjska, Slovenia

Architect: Mars inženiring d.o.o., Ljubljana, Slovenia

RHEINZINK-work done by: M-STREHE d.o.o., Ljubljana, Slovenia

5. Kempinski Palace Portorož, Portorož, Slovenia

Architect: API d.o.o., KONSTAT BIRO d.o.o., ELEA IC d.o.o., BIRO ES d.o.o.,

LANDSCAPE d.o.o., BIROR d.o.o., Ljubljana, Slovenia

RHEINZINK-work done by: DIMNIKI d.o.o., Ljubljana-Bizovik, Slovenia

6. Hotel Beau Rivage Palace, Lausanne, Switzerland

Architect: Richter - Dahl Rocha & Associés architectes SA, Lausanne, Switzerland

RHEINZINK-work done by: ARGE RICHARD Pierre SA, Lausanne et Graf J.-Ch. et PH. SA, Montpreveyres, Switzerland

Jean-Michel Meyroux, Sugiez, Switzerland (Ornaments)

7. Two private Residences, Seeheim-Jugenheim, Germany

Architect: Planungsbüro Hapke GmbH, Herten, Germany

RHEINZINK-work done by: Schreck Klempnerei GmbH, Mespelbrunn, Germany

8. Hotel Corte Valier, Lazise, Italy

Architect: Stefano Feriotti, Verona, Italy

RHEINZINK-work done by: P-Dach, Egna, Italy



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