2016

Workbook
for Architects and Planners

Version from: 4 November 2015

Subject to changes and errors.

Workbook for Architects and Planners 2016

This handbook is a guide for architects and planners as well as for professionals involved in construction work such as builders and structural carpenters. The handbook explains the strengths of KIELSTEG elements and how they should be used. It is very important to us to make sure you have professional support at all stages of your projects and we want to give you the best possible service in the form of this technical handbook and our consulting.

Kielsteg is the proud holder of:

Schweighofer Preis 2013
Innovationspreis für die europäische Forst- und Holzwirtschaft

Inventum 2014
The prize of the Austrian Patent Office for the best patent of the year 2013

materialPREIS 2015
First prize in the category ‘wood and wood materials’, awarded by the materials agency raumPROBE.

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General

Foreword

KIELSTEG is a system of flat wooden structural elements intended for use as load-bearing roofs and structural floors. By placing the wood exactly where it contributes the most to static performance, KIELSTEG elements can be used economically for spans of 5 m and upwards. Our technology is not in competition with established glued wood products such as glulam beams but expands the spectrum of possibilities of building in wood.

Consulting, support and design

KIELSTEG comes backed up by our expert advice and service. We are committed to giving you all the support you need. Our experienced experts in structural engineering will help you with all aspects of statics and design, building physics and fire protection. We will help you develop building concepts using KIELSTEG and also with the dimensioning of the KIELSTEG elements.

- Individual project consulting on the KIELSTEG elements, their applications and dimensioning
- Consulting and evaluation in terms of statics, building physics and fire protection
- Consulting on other materials to use with KIELSTEG: including structural, sealing and fastening systems
- Product-specific support for compiling bills of quantities
- Design and construction planning on state-of-the-art CAD-CAM systems
- Detailed planning
- Coordination of trades and site supervision

Certificates

The DIBt (Deutsches Institut für Bautechnik) is the German approval body for construction products and types of construction. The national technical approval (allgemeine bauaufsichtliche Zulassung) regulates the manufacturing and use of KIELSTEG elements.

PEFC

PEFC, the Program for the Endorsement of Forest Certification Schemes, is a certification and labelling program for products derived from ecologically, economically and socially sustainable forestry. When customers buy products with the PEFC label, they can be sure that their purchase supports the use of wood produced under environmentally friendly conditions.

Product

KIELSTEG elements are lightweight and strong wooden construction elements without cross-lamination, with an internal structure running in one direction. They use strips of timber to form top and bottom flanges, which are connected by curved webs of plywood or OSB. The characteristic curve of the webs, which resembles the keel of a boat, gives the KIELSTEG its name.

KIELSTEG elements are usually used in buildings with large clear spans, to create roofs or structural floors. The ability to bridge large spans maximizes the flexibility of how the enclosed space is used. This meets the important architectural demand to be able to rearrange interior layouts throughout the lifetime of a building.

Use:	Structural floors and roofs
Internal structure:	Repeating cellular structure with upper and lower flanges of spruce timber connected by webs of plywood or OSBt aus
Wood:	Spruce
Surface:	Industrial quality/Visible quality (one side); planed and untreated
Dimensions:	Width: 1,200 mm Laid width: 1,165 mm
Thickness:	228 mm to 800 mm
Length:	5.00 m to 35.00 m
Fire resistance class:	Fire retarding REI 30 is the standard fire resistance class for all KIELSTEG Highly fire retardant/REI 60 is possible from KSE 280 upwards
Long edges:	Edges are rebated to overlap/join neighbouring KIELSTEG elements
Service class:	Service classes 1 and 2
Bonding:	MUF glue of emissions class E1
Moisture content:	On delivery: 12±3%
Dimensional changes:	(humidity-dependet) Longitudinal: 0.01% per 1% change in wood moisture content
Lateral:	0.25% per 1% change in wood moisture content
Thickness:	insignificant

Our Raw Materials

KIELSTEG is a lightweight, strong wooden composite system which efficiently combines natural timber and processed wood. In this way it involves value creation out of different forms of wood. The system achieves its unique characteristics by concentrating the wood mass exactly where its strength is needed.

Spruce

For the zones of the element under compression and tension, finger-jointed spruce timber of the strength class C24 is used.

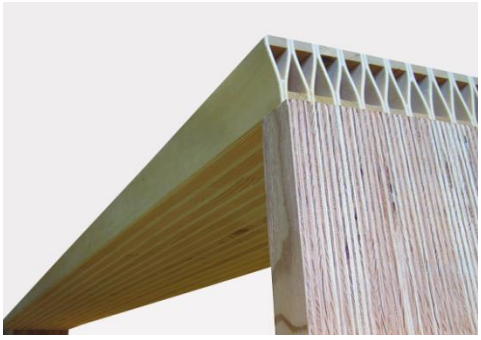
Plywood

Webs of 3-ply, 4 mm spruce and pine plywood form the interior cellular structure of the elements of thicknesses 228 mm to 380 mm.

OSB

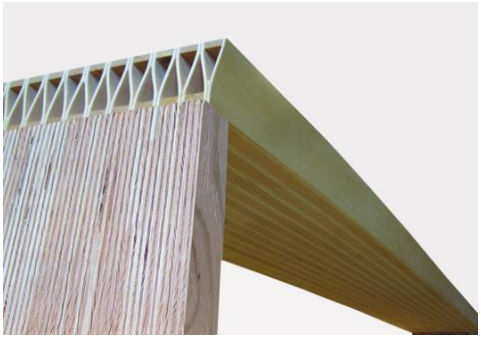
OSB3 sheets of thicknesses 8 mm, 10 mm and 12 mm form the interior cellular structure of the elements of thicknesses 485 mm to 800 mm.

USPs



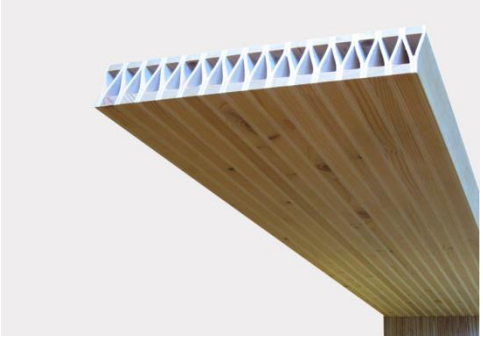
Wide spans for roofs and structural floors

Creation of low-profile load-bearing structures spanning spaces up to 27 metres as single-span beam structure and up to 35 metres as continuous beam structure.



Cambered single-span elements

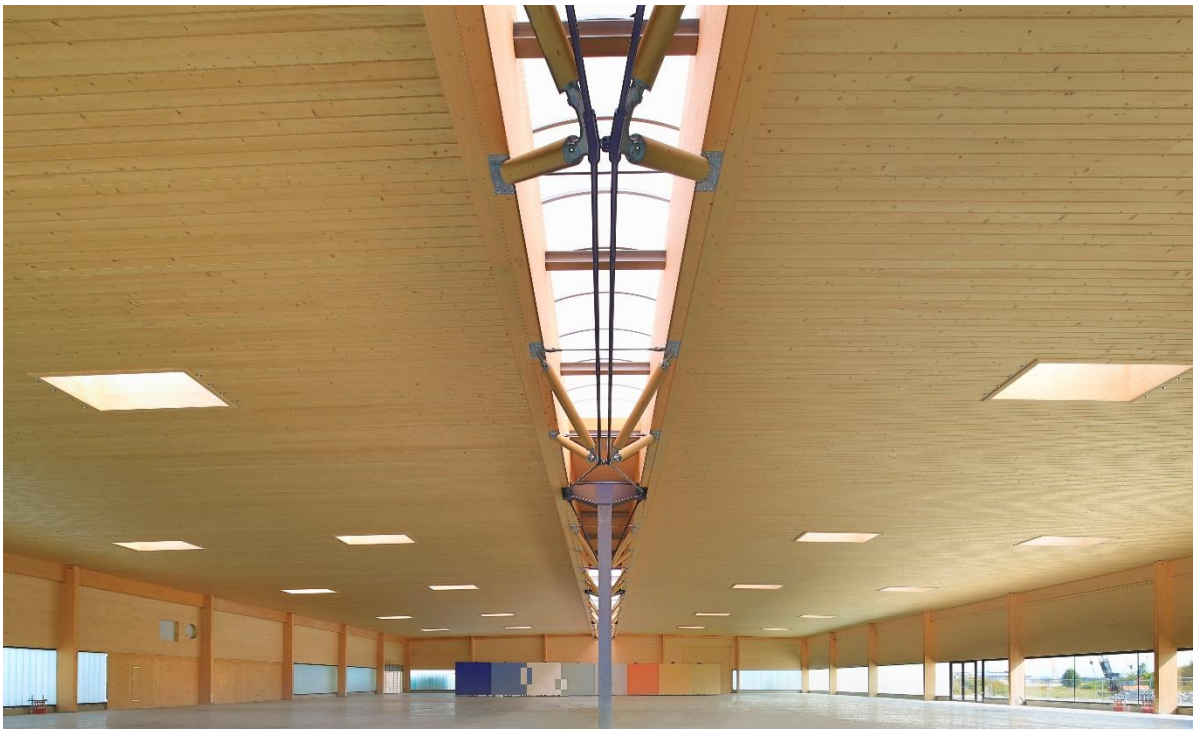
KIELSTEG elements can be made optionally cambered upwards along their length, with corresponding effects on the serviceability limit state.



Cantilevered projections

Projecting roofs are frequently demanded for industrial and commercial buildings. KIELSTEG can be used to make cantilevered projecting roofs up to ten metres deep.

Benefit



… economically efficient structural floors and roofs from 5 to 27 metres clear span

… the wide clear spans ensure flexible use of the building

… aesthetically attractive underside makes suspended ceilings unnecessary

… fire resistance class up to REI 60 without additional constructive measures

… high degree of prefabrication, therefore quick construction

… cantilevered projecting roofs up to 10 metres

… environmentally friendly, sustainable, carbon-negative building method

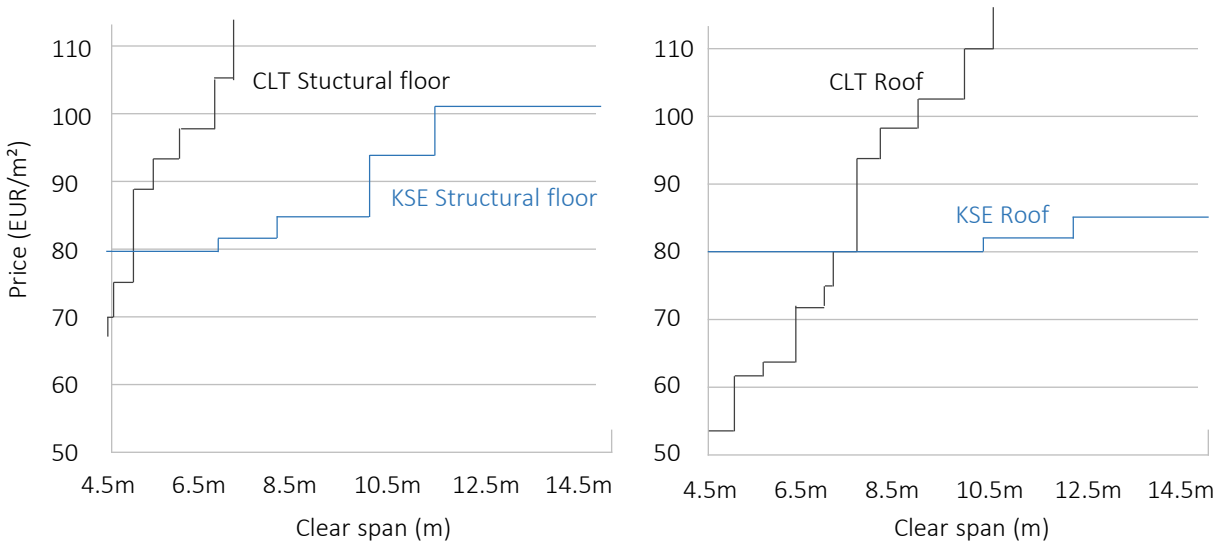
… a personal contribution towards the use of natural resources and responsibility for the coming generations

Cost-effectiveness

KIELSTEG elements are not primarily intended as competition for existing wooden construction materials; their real strength is that as lightweight elements they create structural options that did not exist before. They can be used economically at clear span widths of 5-6 metres upwards, which is exactly the range where the solid wood elements begin to be less economical. This means that KIELSTEG enlarges the market for wooden construction elements.

Cost-effectiveness of KIELSTEG/KSE compared to crosslam/CLT:

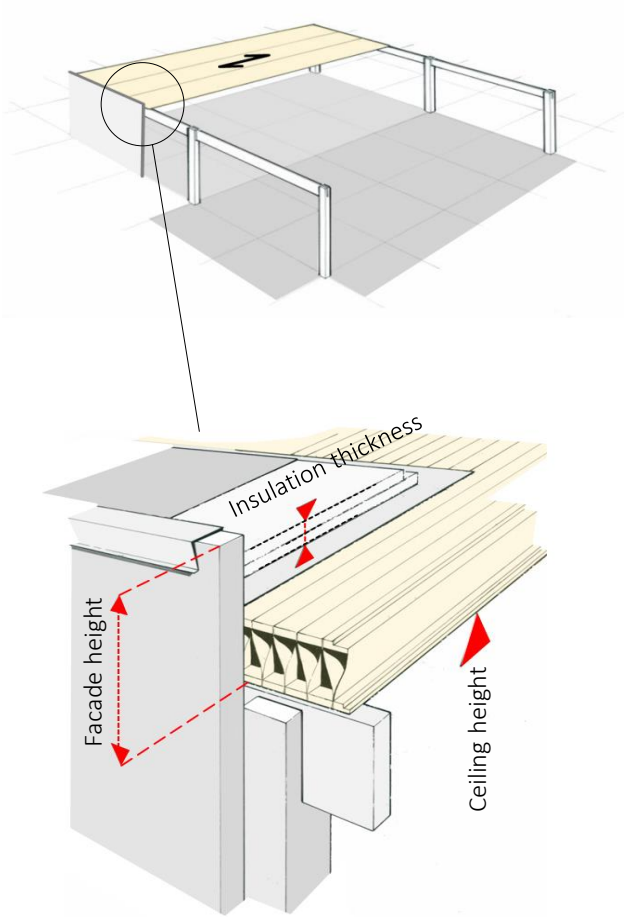
The following table shows the cost of KIELSTEG and crosslam as a function of clear span width. The costs are ex-works prices. This underlines the economic aspect of using KIELSTEG.



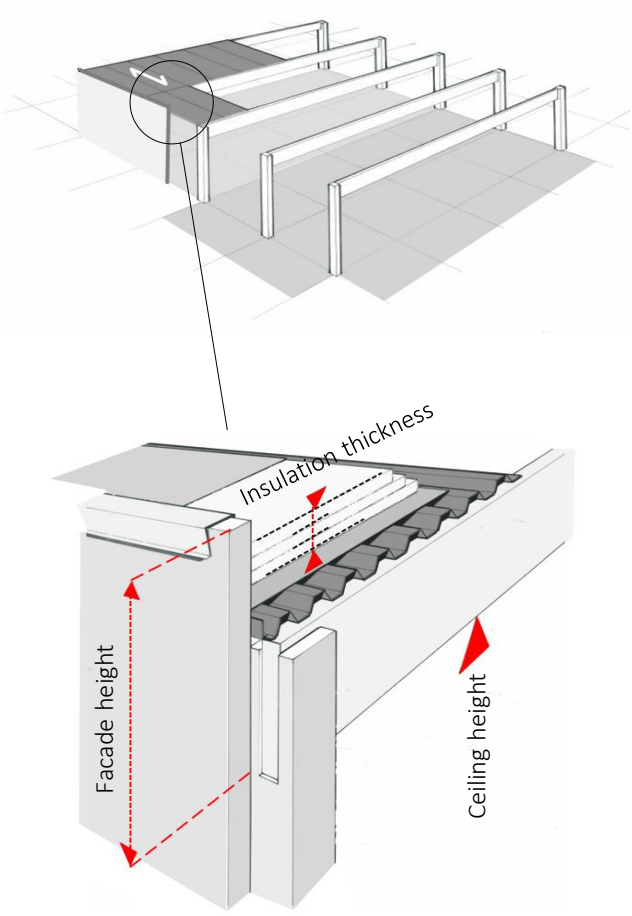
Applications

The cellular structure of KIELSTEG elements gives them outstanding load-bearing performance. This characteristic is key to new design concepts for large sheds and halls for industrial, commercial and other uses. Buildings of this type often use structural posts or frames at intervals of 5–6 metres. However, with KIELSTEG elements, clear spans of up to 27 metres can be achieved. This enables large savings on the supporting structure and wind bracing. Halls and sheds with a support-free width of 20 metres are a quite common request. Using KIELSTEG for the roof of such a building is a highly economical solution, with the added possibility of creating cantilevered projections of up to 10 metres, depending on the individual loading situation and other requirements. As a rule of thumb, KIELSTEG roofs should be used for clear spans of at least 12 metres. In this size range the performance of KIELSTEG as a load-bearing, space-spanning and stiffening element is at its best, and is likely to offer a clear advantage over alternative systems in terms of price-to-performance ratio.

KIELSTEG shed design with posts at 12 m intervals and no transverse beams.



Typical shed design with frames at 5–6 m intervals and load-bearing transverse beams.



Production

So far, KIELSTEG elements have been manufactured only in Austria by Kulmer Holz-Leimbau GmbH. All the different sizes and types of KIELSTEG elements are produced on one highly flexible production line. Against the background of the usual standards in production of glued wood products, it stands out as unique. It can turn out KIELSTEG elements in thicknesses of 228 mm to 800 mm, in lengths up to 35 metres – all of them either flat or with a camber along their length. The line meets the highest standards in all process steps such as finger-jointing, planing, joining and pressing. Production is monitored externally by the Materials Testing Institute at the University of Stuttgart.

sorting- finger jointing

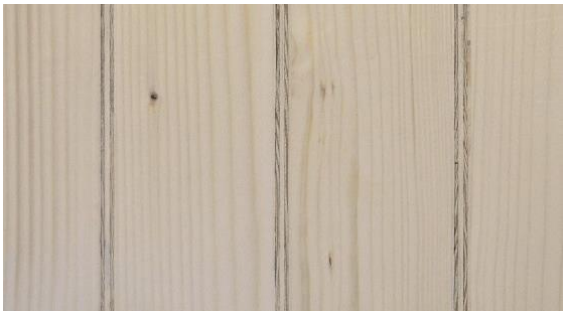
Joining- gluing- pressing

Planing- profiling

The production process begins with the quality sorting and finger-jointing of the pine strips that will form the flanges, which have to bear compression and tension in the finished element. The assembly machine is the heart of the process. It assembles the parts with a maximum tolerance of 3mm to a 35-m long KIELSTEG element. Then comes the innovative planing and routing machine. It planes and rebates all element dimensions – from 228 to 800 mm, flat and cambered – in one step.

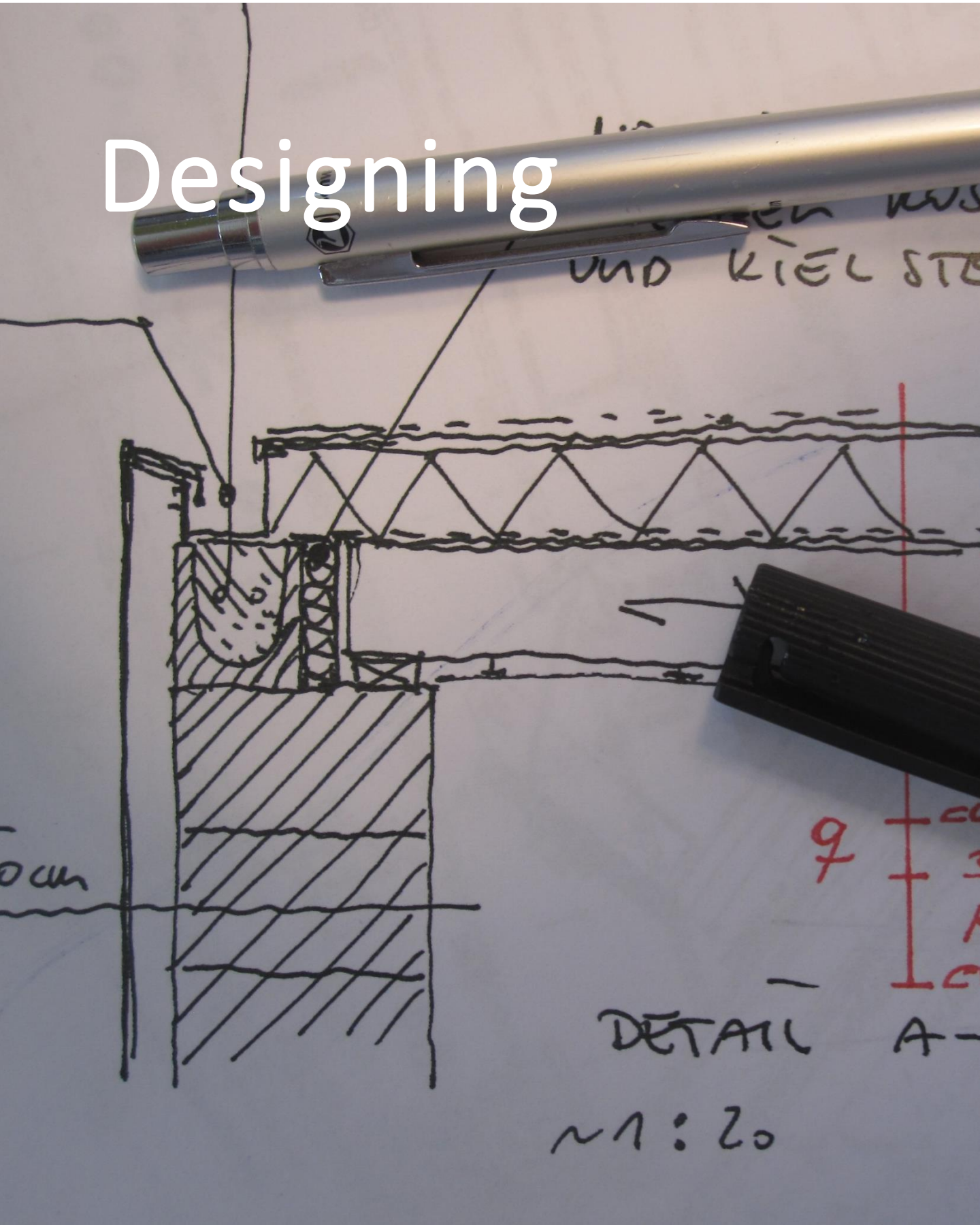
Surface

Wood is a natural, organic and hygroscopic raw material. These properties lead to the movements of wooden parts that we refer to as shrinkage and swelling. KIELSTEG elements are manufactured with a wood moisture content of 12±3%. This moisture content can change during the life cycle of the elements, because the moisture content varies depending on the service class of the building. These changes can cause cracks in the surface of the wood, and the width of the lateral joints between elements can change. On the surface, KIELSTEG shows a highly characteristic pattern that can be used as an aesthetic feature. Depending on their thickness, KIELSTEG elements are made with either plywood or OSB webs. Plywood is used for thicknesses from 228 mm to 380 mm; OSB is used for thicknesses from 485 mm to 800 mm. The visible pattern on the surface depends quite strongly on the web material used. The surface of the KIELSTEG elements is planed and untreated. Whether used as a roof or a structural floor, cladding of the underside is not necessary for either fire-protection or aesthetic reasons. The elements are manufactured in surface quality Grade 1 (industry quality) and Grade 2 (visible quality). The surface quality is defined in terms of ÖNORM B2215 Table A4.



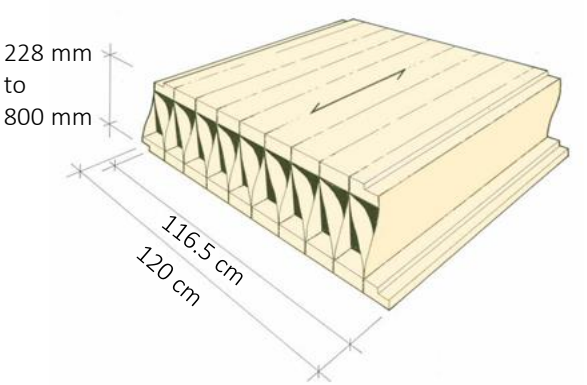
Characteristic	Grade 1 (Industrial quality)	Grade 2 (Visible quality)
Planing quality	Rough patches acceptable	Rough patches not acceptable
	Scalloping acceptable	Scalloping up to 10 mm length, 1 mm depth acceptable
Knots	Sound knots acceptable Knot holes acceptable	Sound knots acceptable Knot holes greater than 20 mm diameter must be filled
Resin pockets	Acceptable	Acceptable up to 5 x 50 mm, must be filled if larger
Pith	Acceptable	Acceptable
Discoloration	Blue stain acceptable	Discoloration by blue stain and red streaks acceptable on up to 5% of the surface area
	Red streaks acceptable	
Insect damage	Acceptable as specified in ÖNORM DIN 4074-1	Not acceptable
Webs	Edge of webs may be offset below surface	Offset of web edges is acceptable up to a total length of 0.5 m per 5 m² of surface area
Cracks	Drying cracks acceptable up to a depth of 1/3 of the flange thickness.	

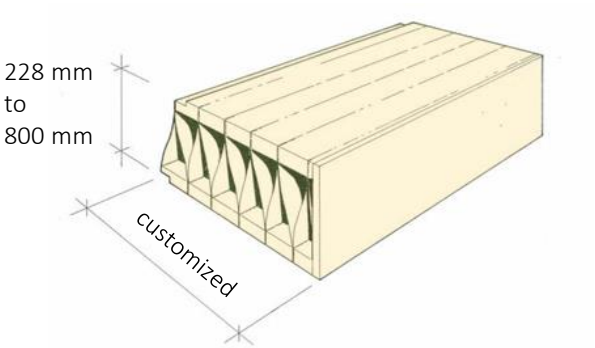
Designing



Planning criteria

Here we describe how to do the dimensional calculations for laying KIELSTEG elements. The heights of the elements range from 228 to 800 mm and should be chosen according to the structural/loading requirements. The loading tables in the section on statics can be used to estimate the suitable sizes. The KIELSTEG elements have a linear structure and are therefore meant to be installed with their long axis spanning the enclosed space. The width of all KIELSTEG elements is 120 cm. Because of the overlapping joints between neighbouring elements, the laid unit width of the elements is actually 116.5 cm plus a joint. The first and last elements in a KIELSTEG assembly do not fit into the regular grid (seen next page). For example, the last element is custom-made exactly to the width needed to complete the roof or floor. This is how KIELSTEG is made to fit the individual dimensions of any project.





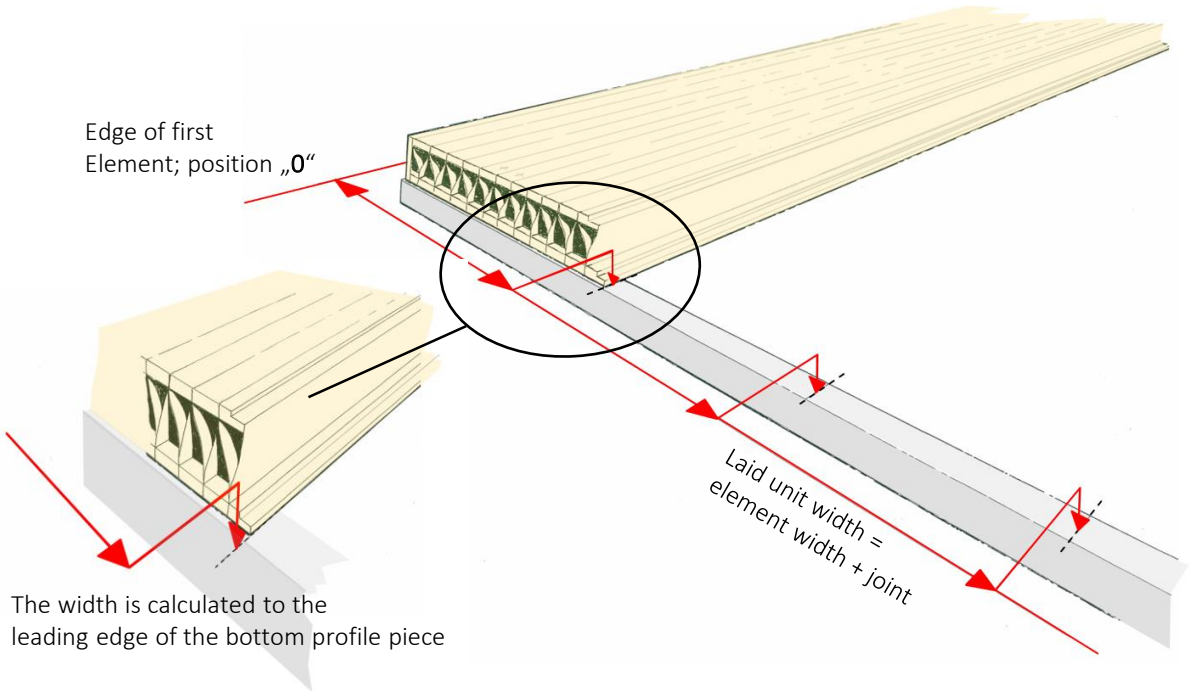
Due to the natural shrinkage and swelling of wood, the KIELSTEG elements are subject to known dimensional changes across their width, depending on the climatic conditions that the elements are exposed to. However, the dimensional changes of KIELSTEG elements are well-characterized and predictable. KIELSTEG elements are delivered with a wood moisture content of 12±3%. In use, variations of the moisture content of up to ±6% are possible, which can cause changes of up to 1.5% in the width of the elements.

Moisture content at equilibrium		Joint width to use
<=12%, heated living space, service class 1	9% ± 3%	5 mm
<=20%, service class 2	17% ± 3%	10 mm
Dimensional change per 1% change of moisture content		
Element length	0.01%	
Element width	0.25%	
Element height	negligible	

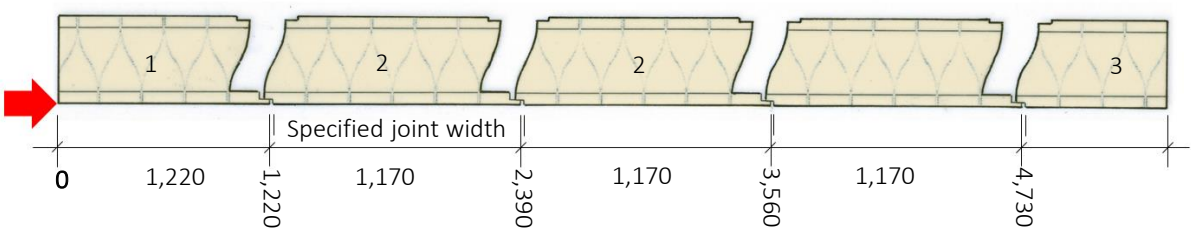
Design steps

The element positions are calculated from the perpendicular outside edge "**0**" of the first KIELSTEG element. The width is calculated to the leading edge of the bottom profile piece of each element. The laid unit width is equal to the element width of 1165 mm plus the specified joint width of 5 or 10 mm.

The example in the lower part of the diagram shows 5 mm joints, so that the laid unit width is 1170 mm. The first element has a width of 1220 mm. After that, the repeating unit width of 1165 mm plus the joint is used. The last element is manufactured in a customized width to match the designed dimensions of the whole floor or roof.



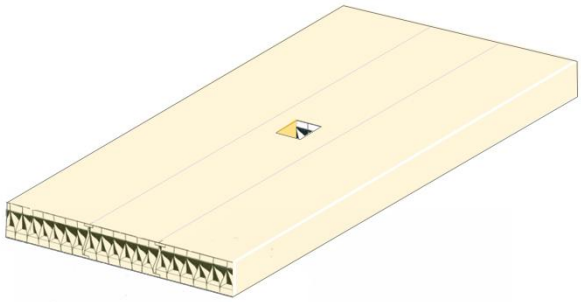
1. First element: 1,220 mm
2. Standard element: 1,165 mm + joint
3. Last element: (customized)



Designing support for openings

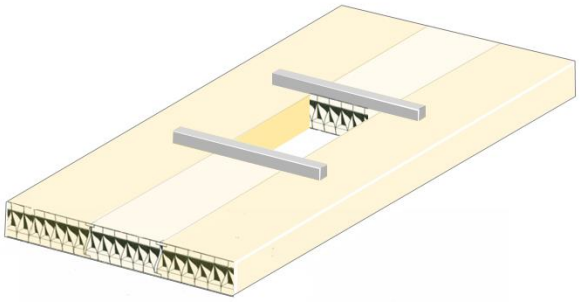
Openings and penetrations for stairs, skylights and other purposes should be specifically designed. Openings of up to 25x25 cm can be made without reinforcing the element, as long as the remaining cross-section of the element is adequate for the applied load. The required fire resistance class is achieved by suitable covering and cladding of the opening.

Penetration, maximum size 25 x 25 cm

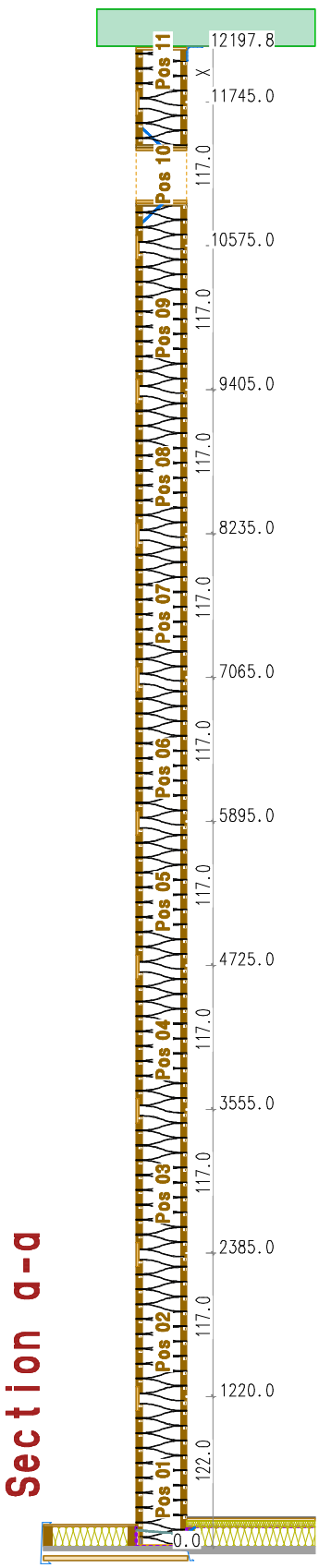


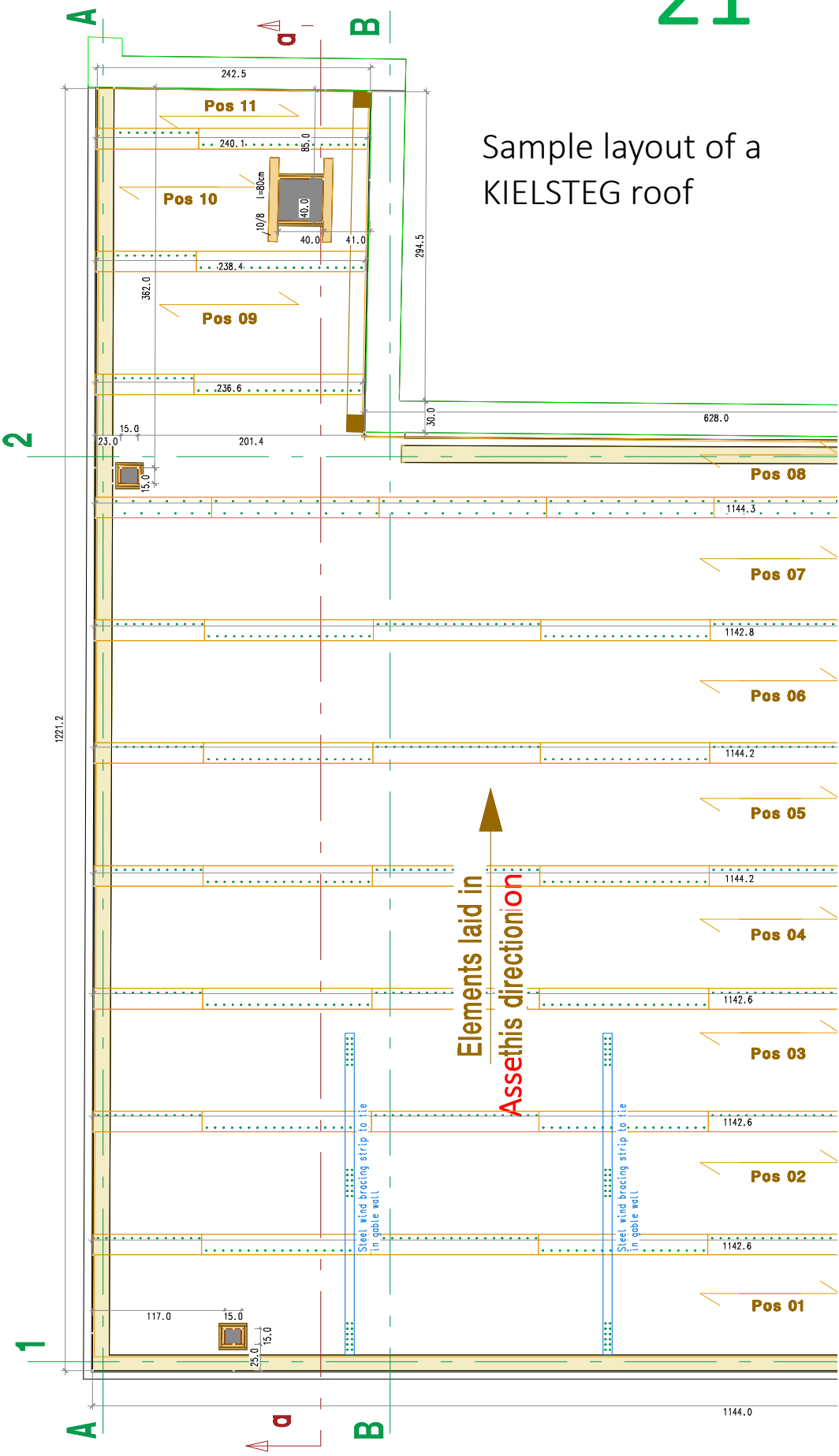
To maintain the strength of the KIELSTEG assembly around larger openings, the elements are reinforced with wooden beams as required. Several examples of possible reinforcement solutions are shown in the section “Details”. The following illustration shows one way of reinforcing the elements around a skylight.

Opening with reinforcement

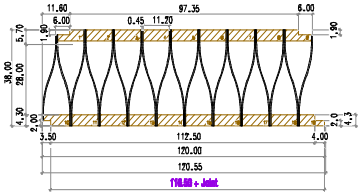


Sample layout of a KIELSTEG roof

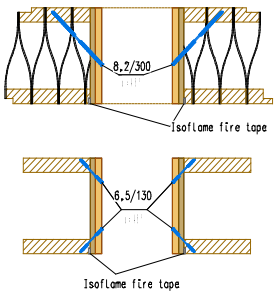




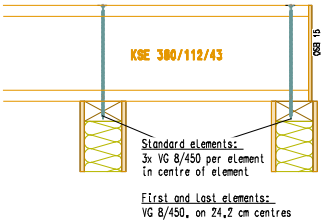
KSE 380/112/43 Industrial quality

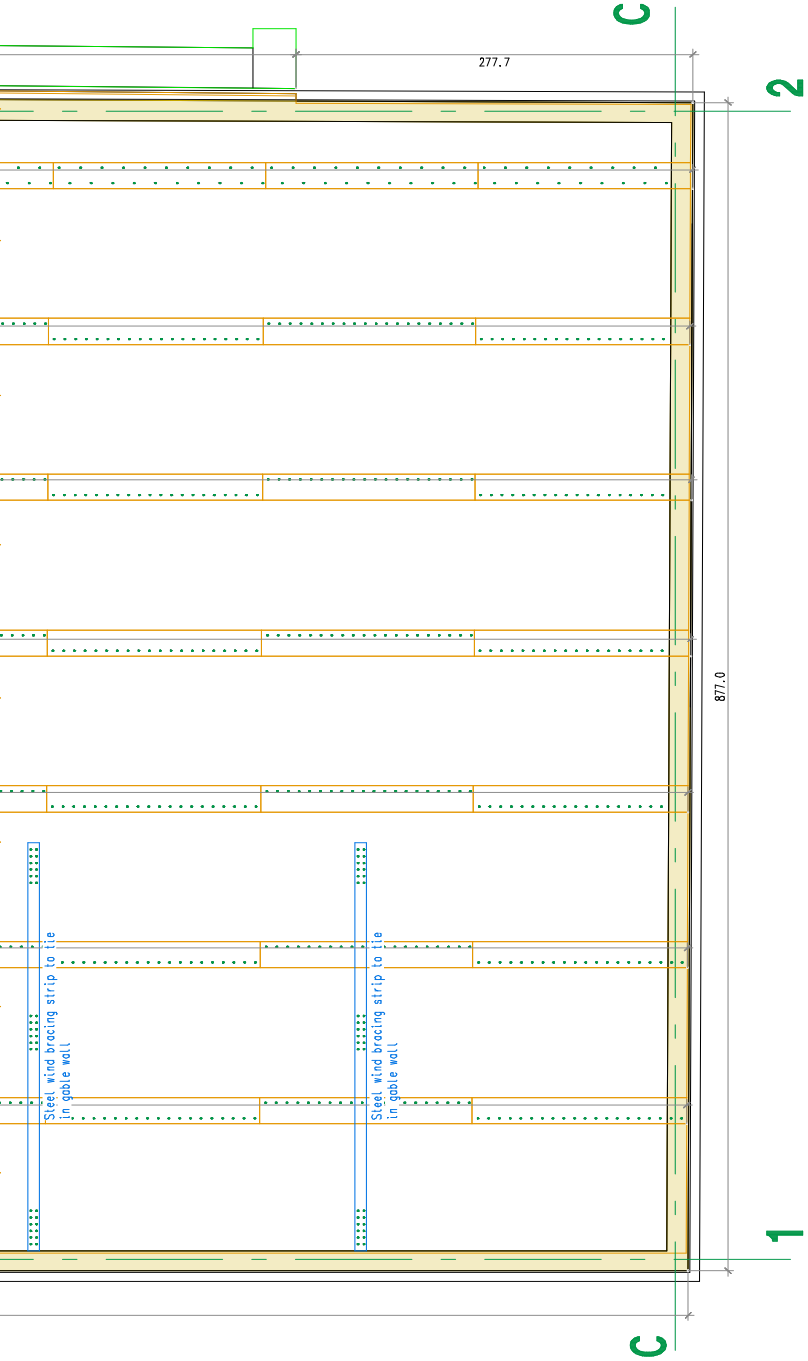


Screw fastenings - small penetrations

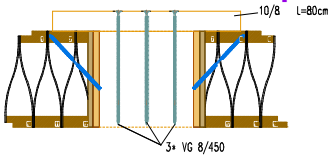


Supports, axis B-B and axis C-C

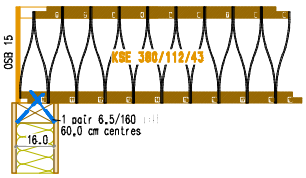




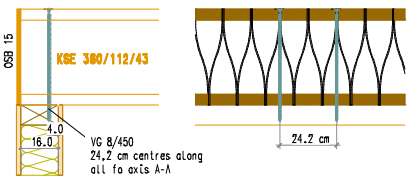
Reinforcement of 40 cm opening



Standard support, axis 1-1 and axis 2-2



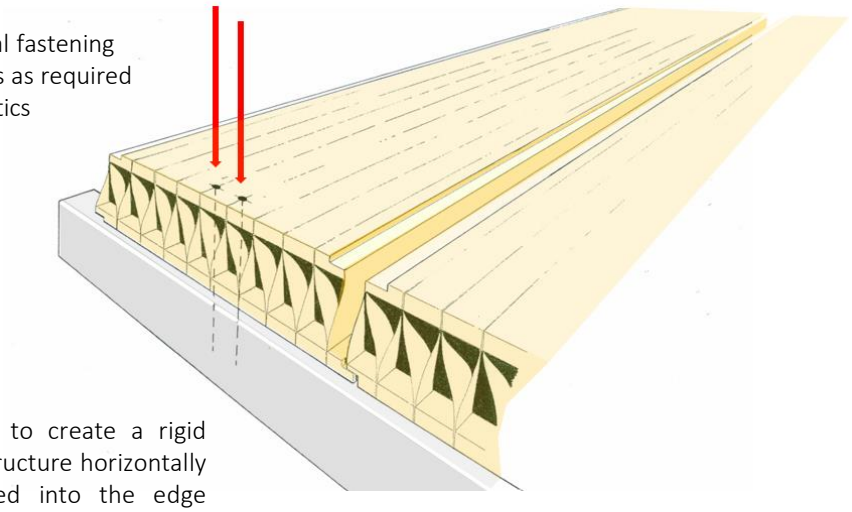
Support, axis A-A



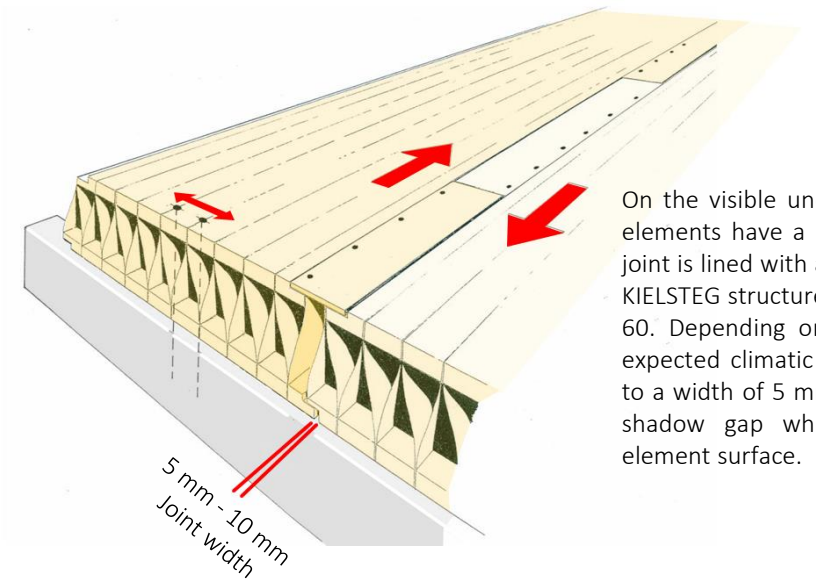
Fastening principles

Fastening to the substructure

The KIELSTEG is fastened to the substructure using an arrangement of screws that allows for humidity-dependent dimensional changes without building up strain in the material. The screws fixing the elements to the supporting pads are concentrated around the centre line of the element. This allows for lateral movement of each element from the central fastening to both sides.



KIELSTEG elements are linked to create a rigid diaphragm that stabilizes the structure horizontally by using joint boards screwed into the edge profiles of the elements. Short lengths of these boards are screwed alternately to one, then the other of each pair of neighbouring elements. This creates an effective mesh linkage while leaving room for movement across the element width.

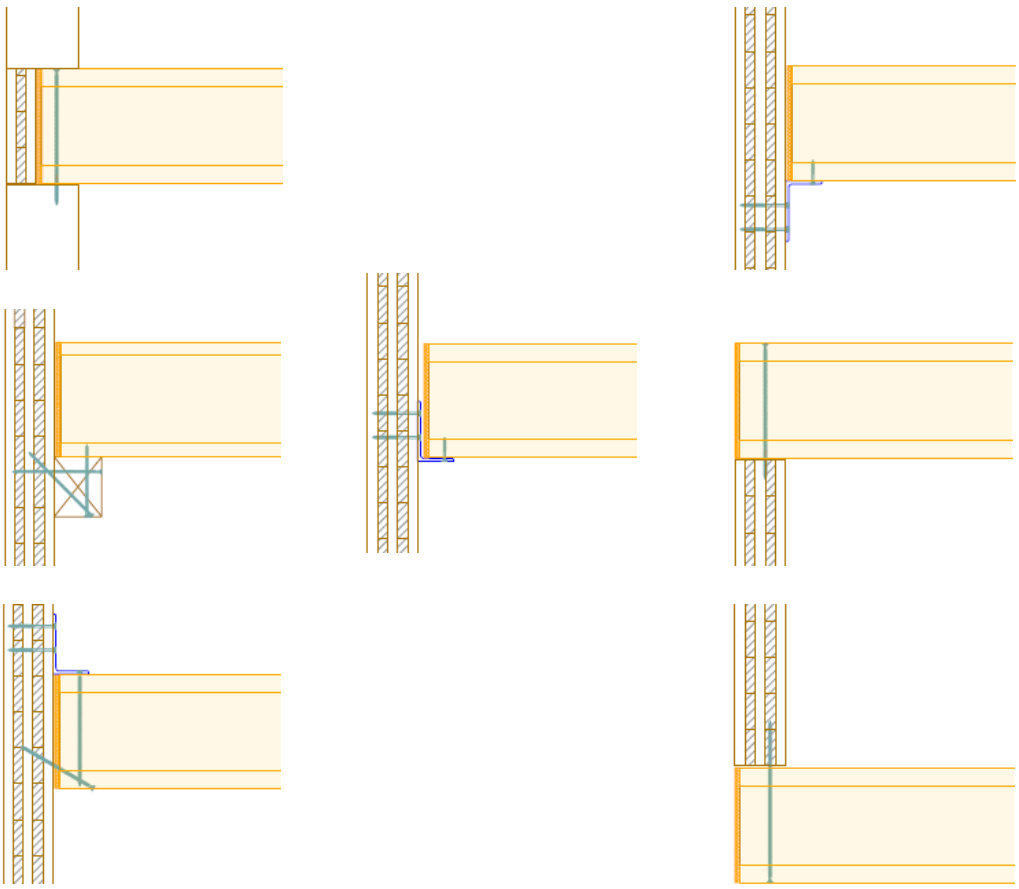


On the visible underside, the edges of the KIELSTEG elements have a profile which overlaps directly. This joint is lined with a fire retardant tape which gives the KIELSTEG structure a fire resistance rating of up to REI 60. Depending on the use of the building and the expected climatic conditions, this joint should be set to a width of 5 mm – 10 mm. The joint forms a slight shadow gap which adds visual structure to the element surface.

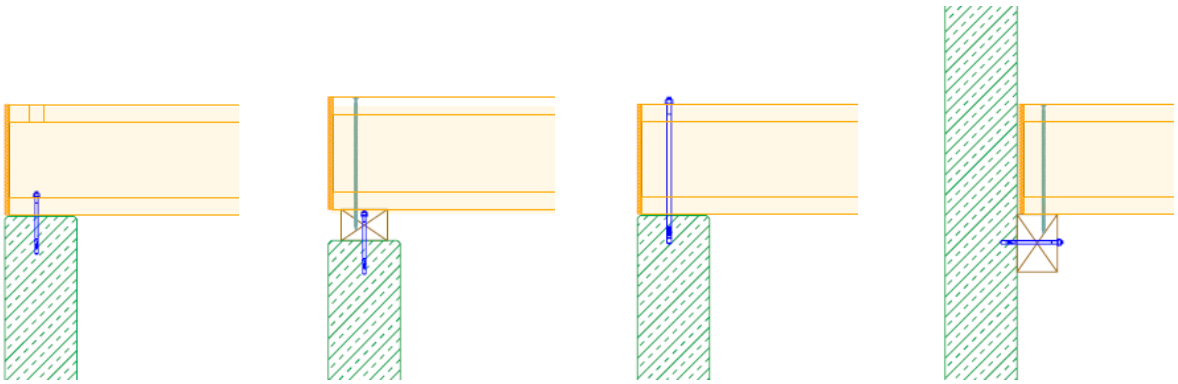
Pad configurations

The elements are usually laid on a linear support that crosses the whole width of the element, and usually they are screwed to the support through the whole thickness of the element. If the ends of the KIELSTEG elements are inserted into the wall, then wooden pads are added to bear the load of the structure above the KIELSTEG floor. Structural calculations must be done for the specific support and/or pad arrangement being used. The following diagrams illustrate a variety of options for connecting KIELSTEG elements to the substructure:

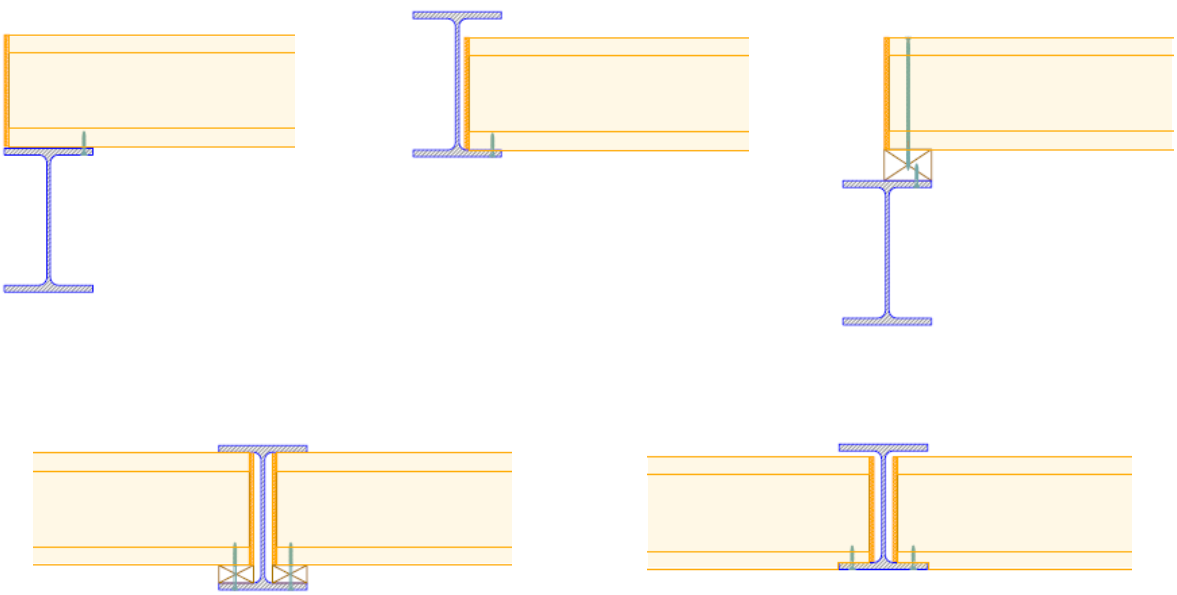
Fastening to wood:



Fastening to concrete:



Fastening to steel:



Cross sections

General information on KIELSTEG Types KSE 228, 280, and 380 with plywood webs

The plywood used in these products is from sustainable forestry.

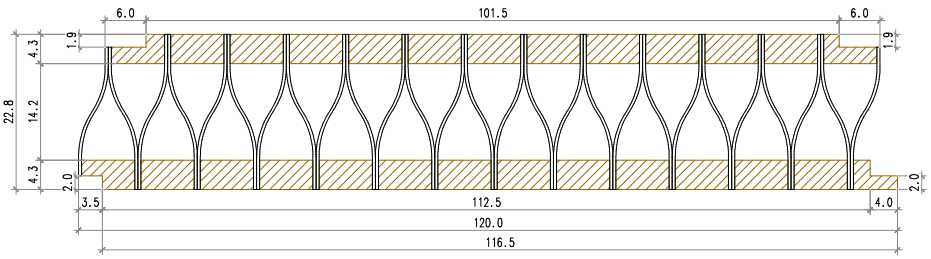
PEFC™
PEFC/06-44-01

Element sahpe:	straight or cambered along the element length
Element width:	120.0 cm (this width counts for price calculation)
Laid unit width:	116.5 cm + joint
Dimensional change:	0.25 % per 1 % change in wood moisture content
Surface:	Industrial quality; planed and untreated Visible quality (one side); planed and untreated
Wood type:	Spruce
Web material:	Spruce/pine plywood, thickness 4.5 mm

KSE 228

Fire resistance class: REI30

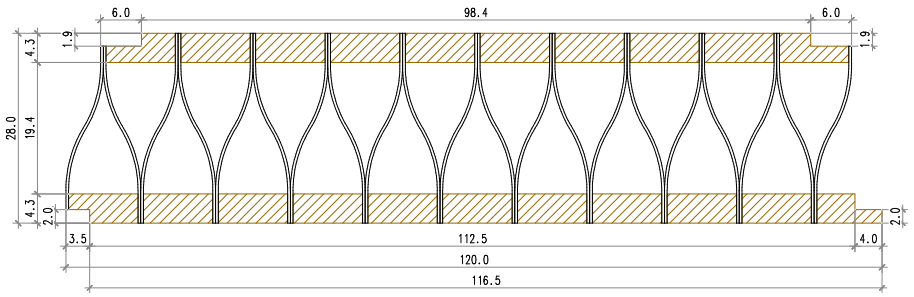
Element weight: 48.4 Kg/m²



KSE 280

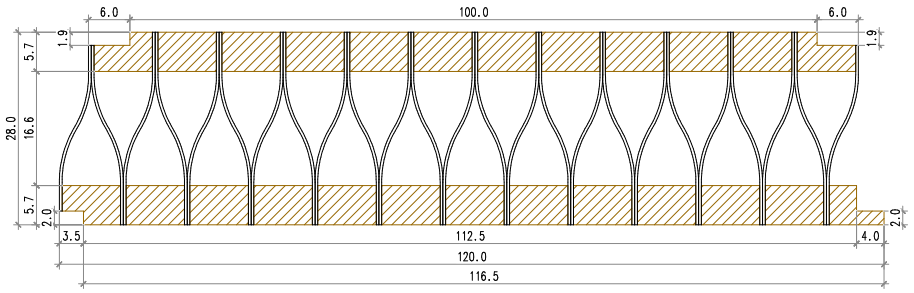
Fire resistance class: REI30

Element weight: 48.7 Kg/m²



Fire resistance class: REI60

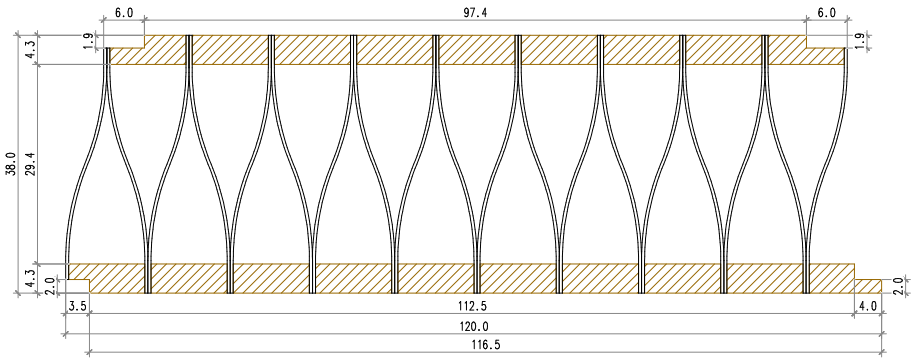
Element weight: 61.5 Kg/m²



KSE 380

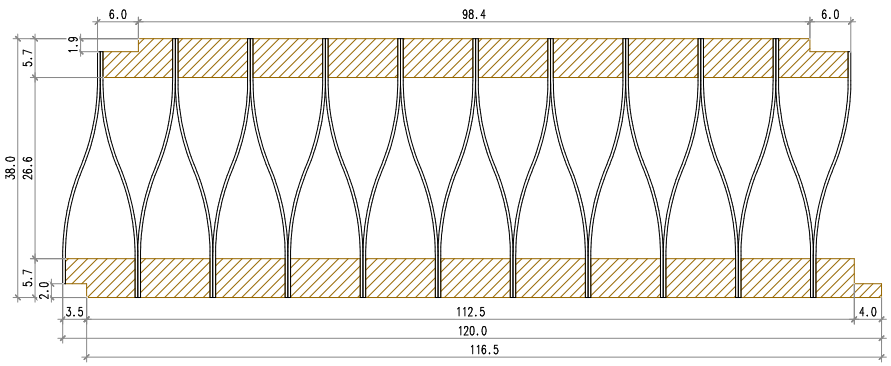
Fire resistance class: REI30

Element weight: 52.6 Kg/m²



Fire resistance class: REI60

Element weight: 65.0 Kg/m²



General information on KIELSTEG Types KSE 485, 560, 610, 730, and 800 with OSB3 webs

The OSB3 used in these products is from sustainable forestry.

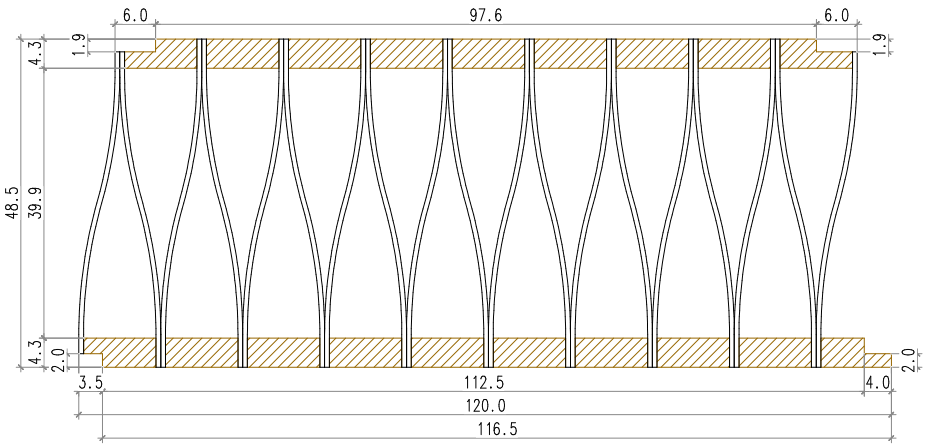
PEFC™
PEFC/06-44-01

Element sahpe:	straight or cambered along the element length
Element width:	120.0 cm (this width counts for price calculation)
Laid unit width:	116.5 cm + joint
Dimensional change:	0.25 % per 1 % change in wood moisture content
Surface:	Industrial quality; planed and untreated Visible quality (one side); planed and untreated
Wood type:	Spruce
Web material:	OSB3, thickness 8.0, 10.0, and 12.0 mm

KSE 485

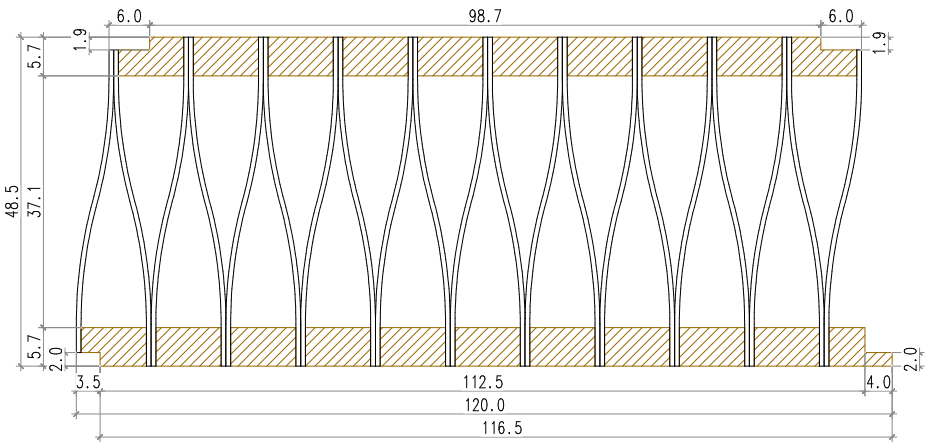
Fire resistance class: REI30

Element weight: 72.4 Kg/m²



Fire resistance class: REI60

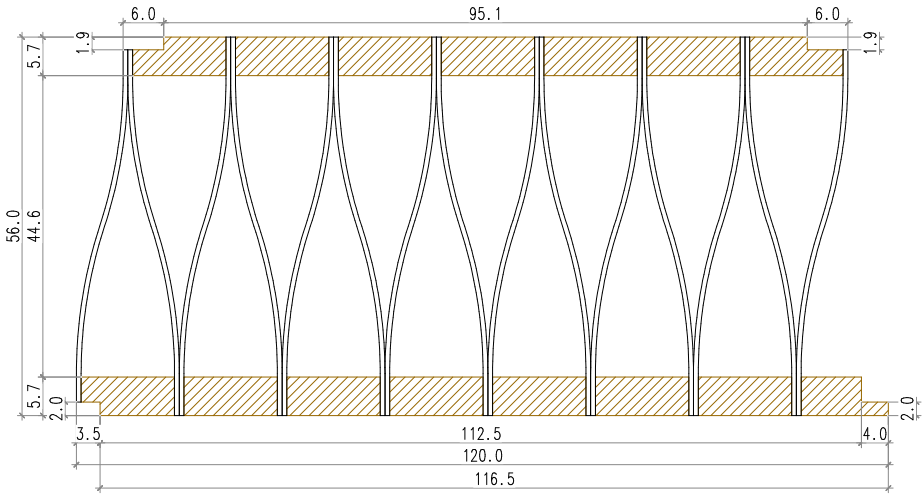
Element weight: 86.1 Kg/m²



KSE 560

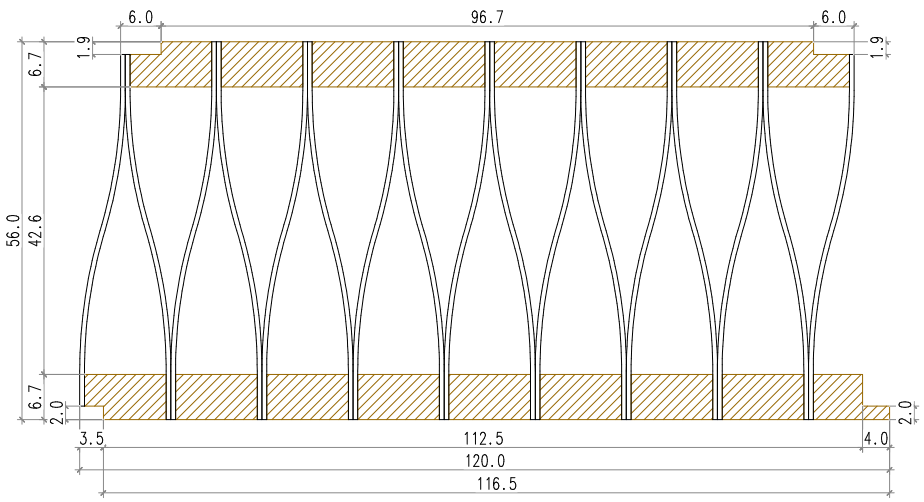
Fire resistance class: REI30

Element weight: 80.7 Kg/m²



Fire resistance class: REI60

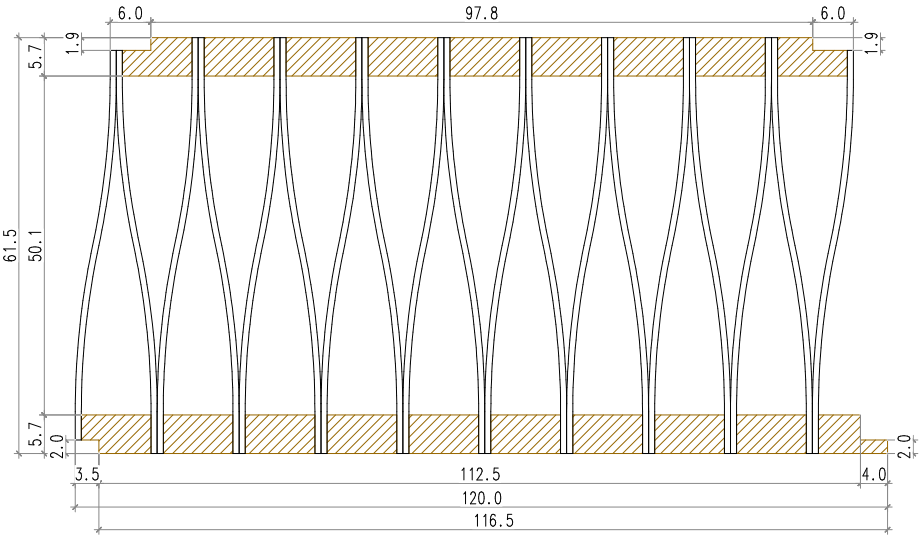
Element weight: 92.2 Kg/m²



KSE 610

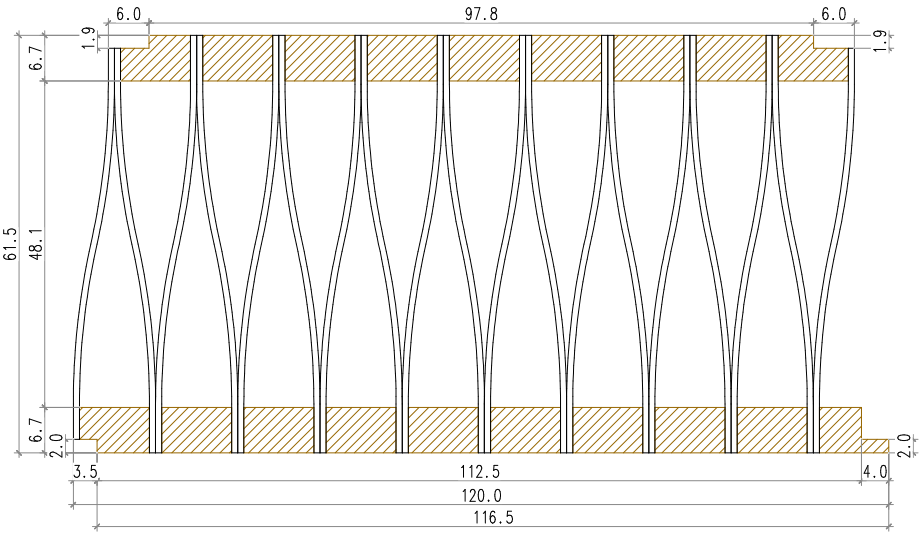
Fire resistance class : REI30

Element weight: 104.6 Kg/m²



Fire resistance class: REI60

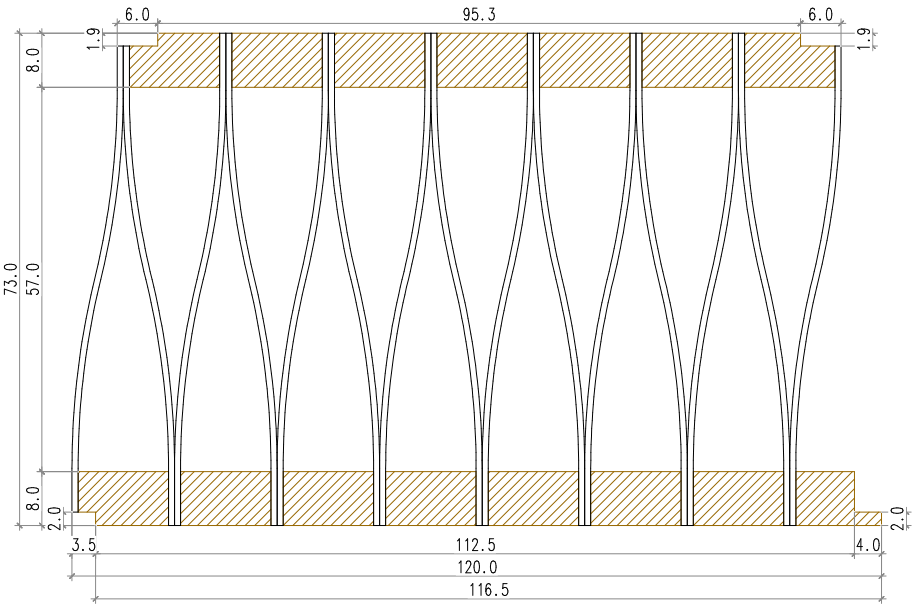
Element weight: 109.7 Kg/m²



KSE 730

Fire resistance class: REI30

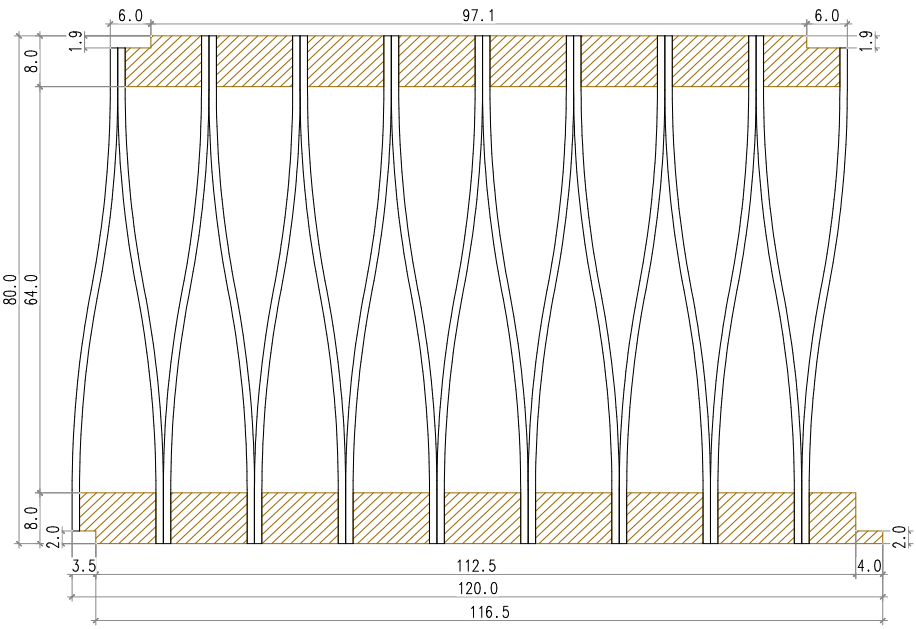
Element weight: 120.1 Kg/m²



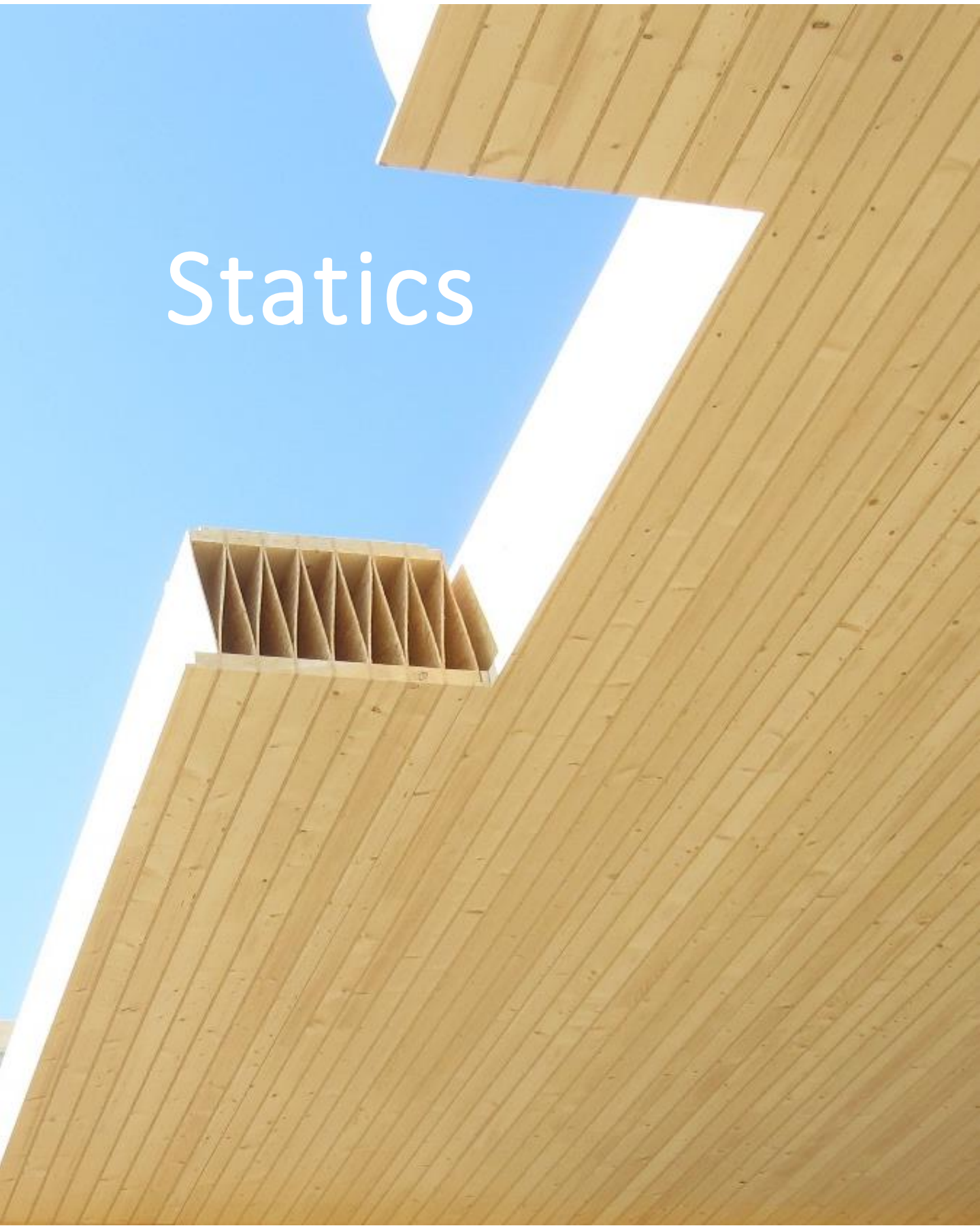
KSE 800

Fire resistance class: REI60

Element weight: 146.5 Kg/m²

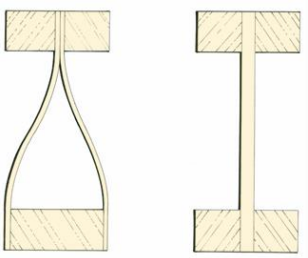


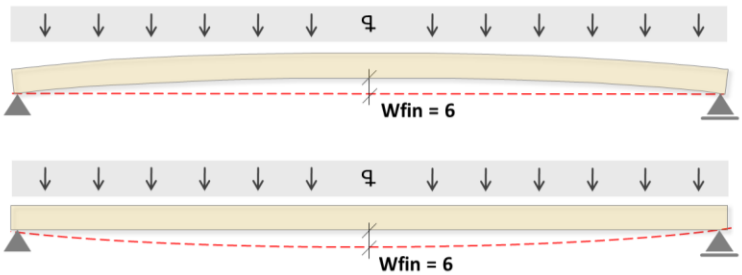
Statics



Statics

Thanks to their special internal structure, KIELSTEG elements are highly suitable for use as simple beams to span wide spaces. The flange zones of finger-jointed solid wood of strength class C24 enable the elements to support large bending forces along their length. The relatively thin webs of three-ply plywood or OSB transmit shear forces between the two layers of flanges and allow a simple scaling of the element thickness for different loads and spans while retaining the optimal distribution of material within the element. The ideal uses of KIELSTEG elements are as flat roofs and structural floors with evenly distributed loading. The calculations on the bending loading are done along the lines of EN 1995-1-1, Section 9 (Thin-Webbed Beams). The diagram below shows the typical KIELSTEG cross-section compared to the equivalent I-beam which is used as the mathematical model for statics calculations. The validity of the model has been demonstrated by extensive load testing of KIELSTEG elements. However, for calculating the performance of KIELSTEG elements under lateral forces, the model based on an I-beam is not adequate without adaptation. The effects of the curved web form and the thinness of the webs on the shear strength of the elements and on the stability of the webs at the support points can be approximated mainly by using a reduced value for the shear strength of the web in the I-beam model. The detailed calculation model is documented in the national technical approval from the DIBT (Deutsches Institut für Bautechnik).



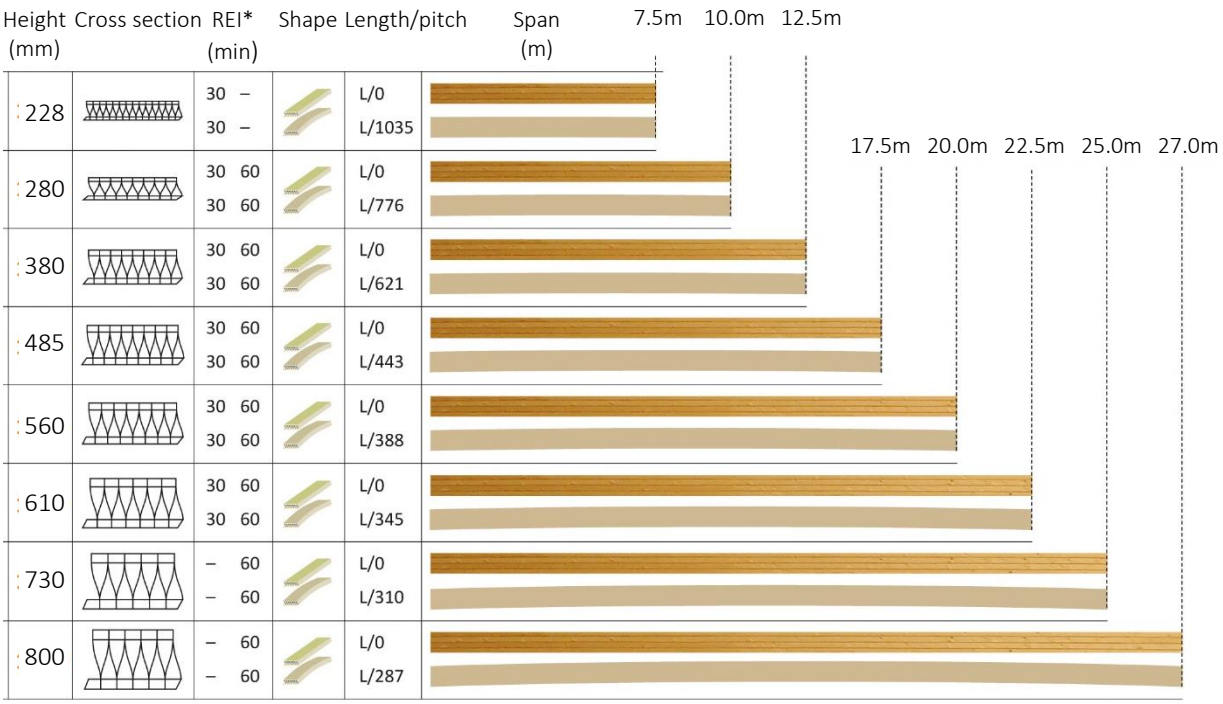


Camber

KIELSTEG elements can be produced flat or with a camber of radius 970 m along their length. The cambered elements satisfy the requirements on the serviceability limit state for structural floor and roof constructions with large clear spans.

Product overview

The following diagram gives an overview of the static performance of KIELSTEG elements.



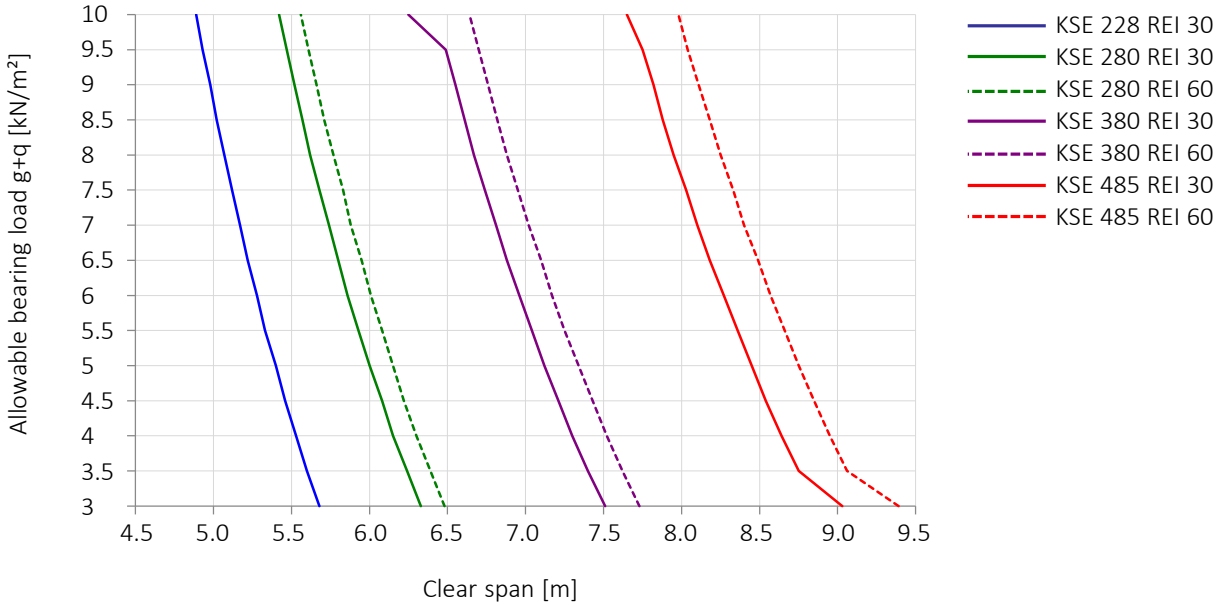
*REI= Fire resistance class. The elements are made optionally with a camber radius of R=970 m

Load diagrams

The main applications of KIELSTEG elements are as structural floors and flat or low-slope roofs with wide spans in the service classes 1 and 2 (Nutzungsklassen as defined in DIN 1052). Service class 1 describes the climatic conditions inside buildings that are closed on all sides and heated; service class 2 describes roofed, but open structures. KIELSTEG is not approved for use in situations fully exposed to the weather (service class 3). The following load diagrams show the combinations of clear span and uniform gravity load that meet several different serviceability requirements. In the case of structural floors with wide spans, it is usually the vibrational criteria that limit the feasible clear span. For roofs, different deformation limits may make sense depending on the usage scenario. The figures shown represent the allowable load in addition to the weight of the KIELSTEG elements themselves (i.e. the dead weight does not need to be subtracted). The stability of the element ends on the supporting structure must be validated separately. The diagrams are intended for making preliminary estimates and are not a substitute for structural calculations by professional structural engineers.

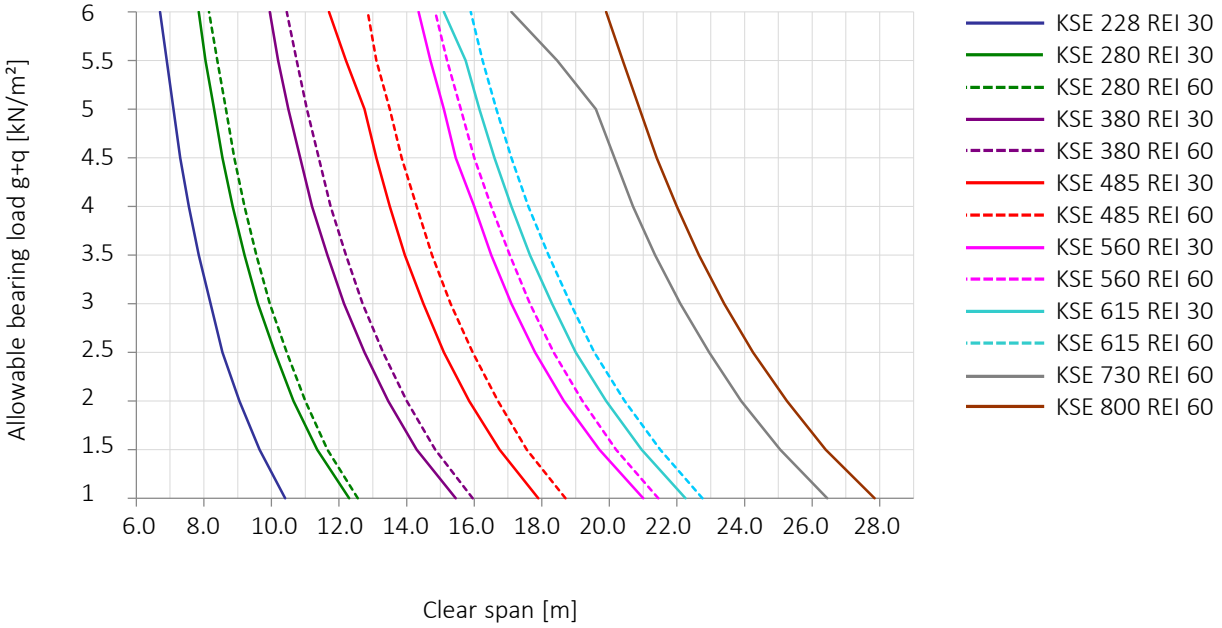
Structural floors

Single-span beam under uniform gravity load, vibrational criteria as per DIN 1052 (Deformation under quasi-permanent loads **w = 6 mm**)



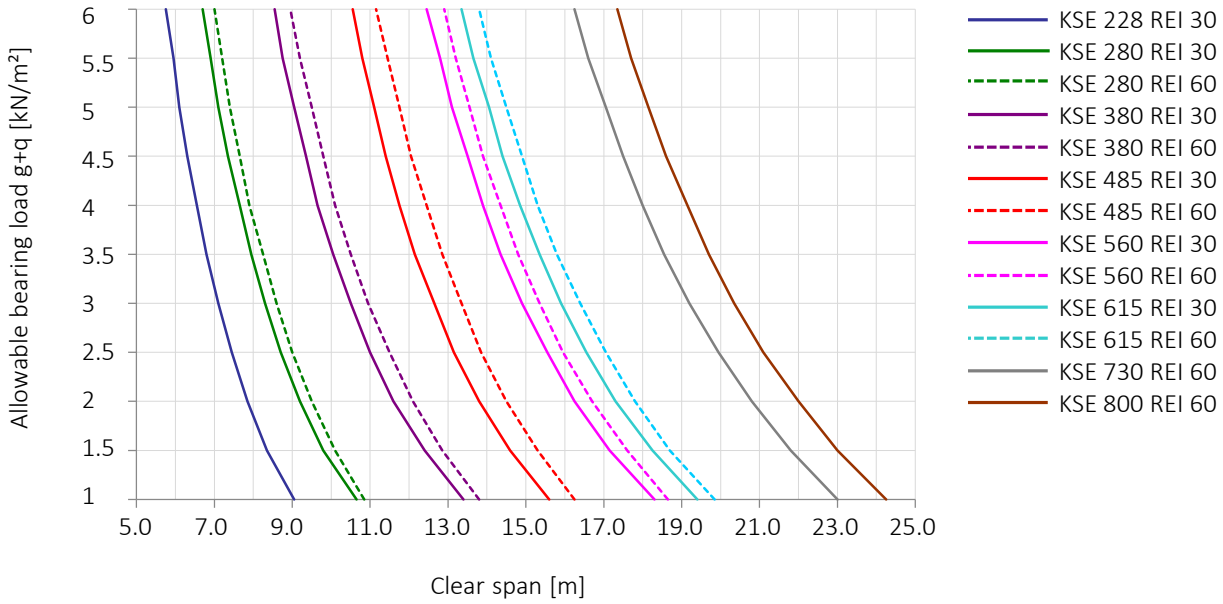
Roof structures

Single-span beam under uniform gravity load, total deformation $W_{g,fin} + W_{q,fin}$ = **w = l/200**



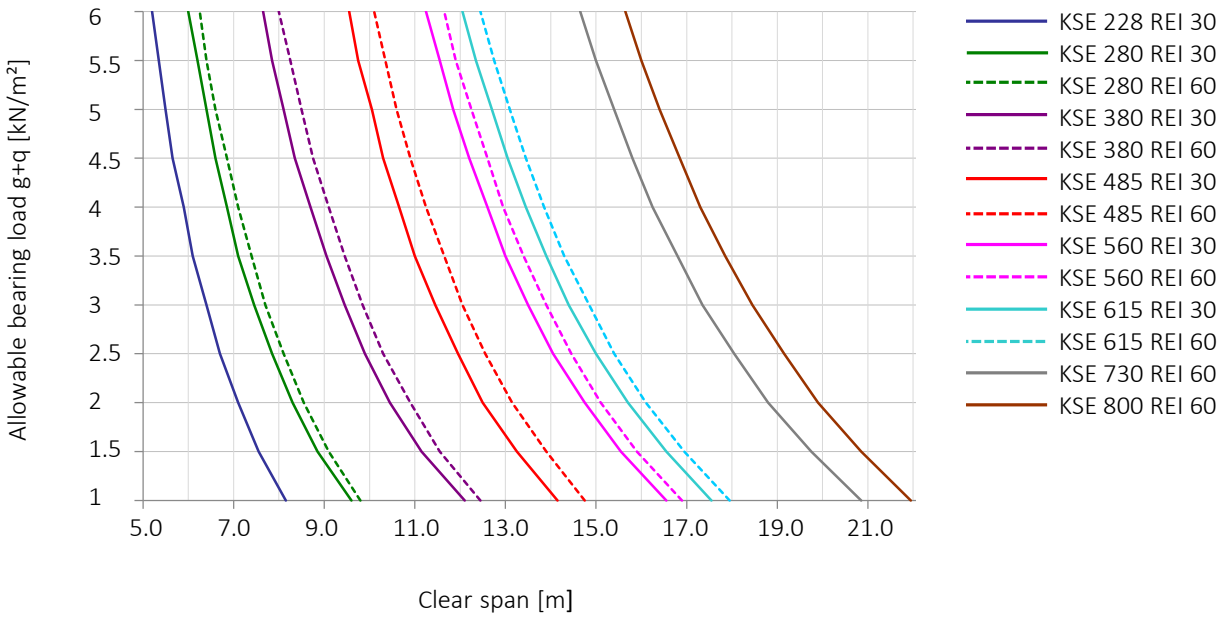
Roof structures

Single-span beam under uniform gravity load, total deformation $W_{g,fin} + W_{q,fin}$ = **w = l/300**



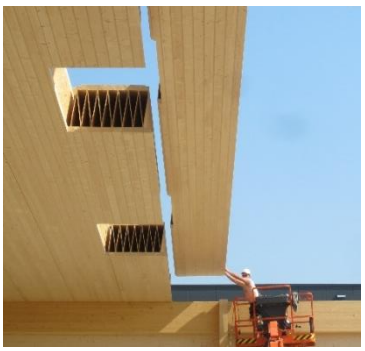
Roof structures

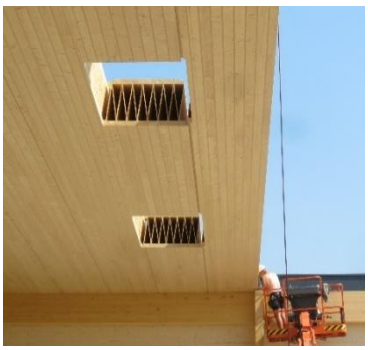
Single-span beam under uniform gravity load, total deformation $W_{g,fin} + W_{q,fin}$ = **w = l/400**



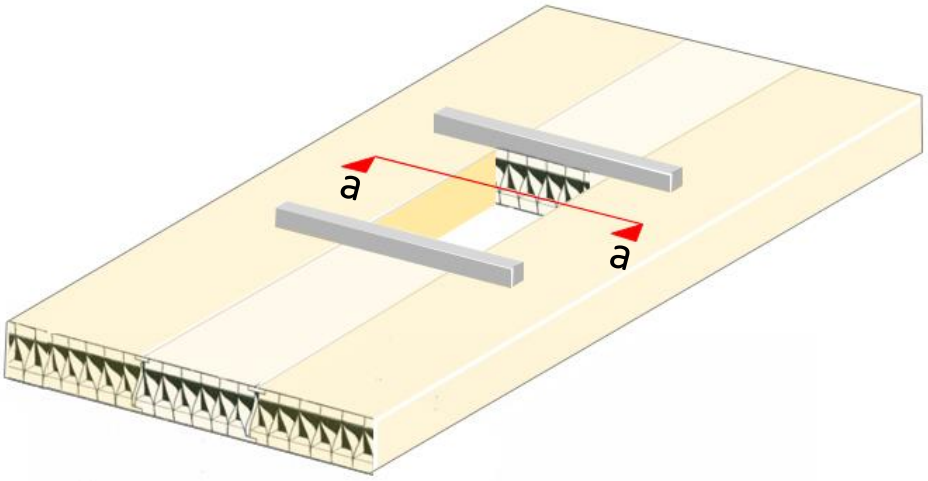
Support for openings

Openings can be supported in a number of ways depending on the structural and aesthetic needs. Generally, the width of an opening should not exceed 120 cm. There is no limit to the length of the opening. The following diagrams show the options for providing support.



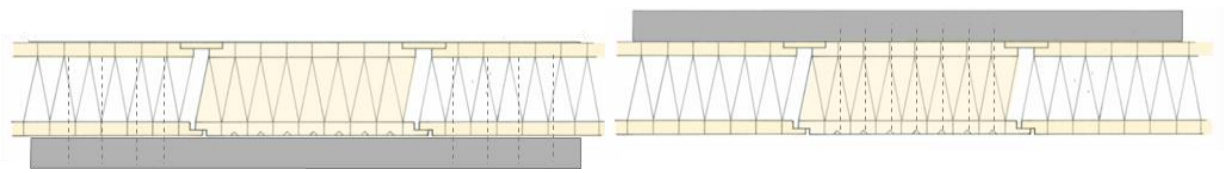


Type 1: In this variant, the load on the affected KIELSTEG element is transferred to the neighbouring elements using wooden beams. These can be positioned on top of the KIELSTEG elements or underneath them, as required.



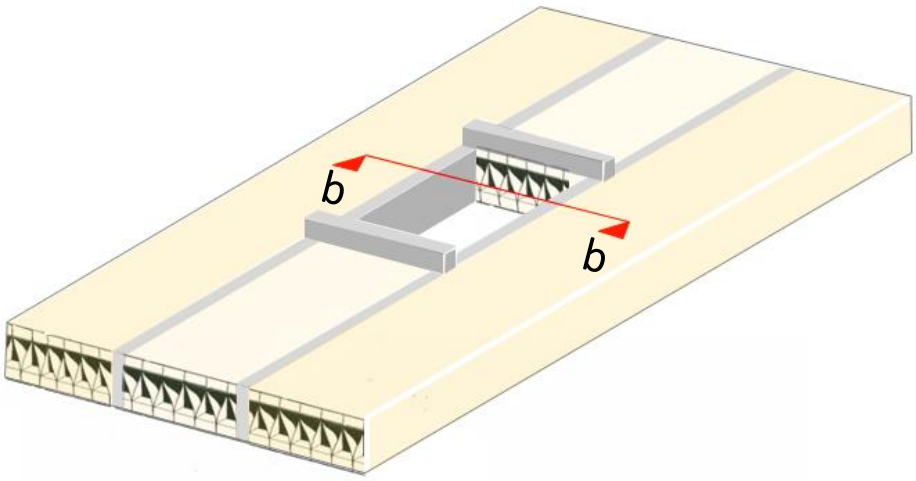
Variant: beams below the elements

a-a

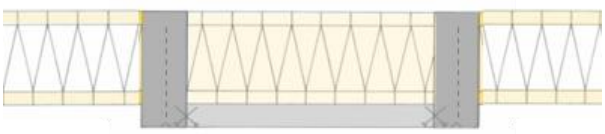


Variant: beams above the elements

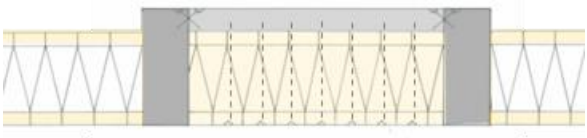
Type 2: In this version, the load on the KIELSTEG element interrupted by the opening is transferred to additional glulam beams. These can be linked to the ends of the opening either above or below the KIELSTEG element.



Variant: supports below the elements



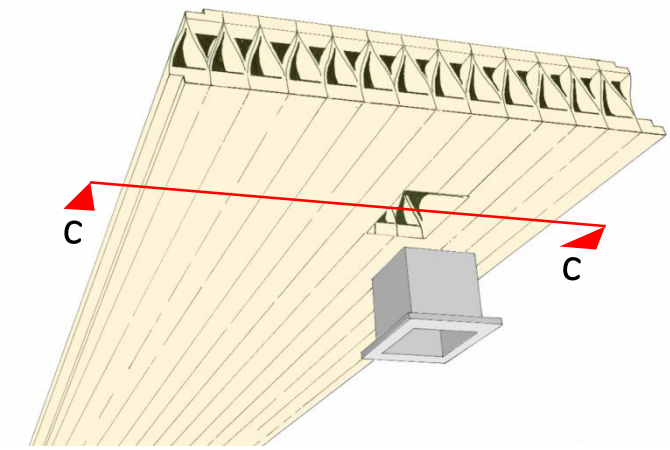
b-b



Variant: supports above the elements

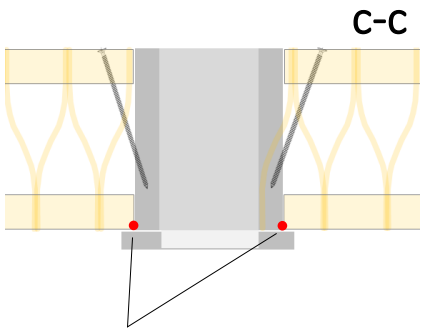
Small penetrations

Smaller penetrations of up to 25×25 cm, for example for piping or ducting, are allowable on condition that they do not compromise the global load-bearing ability of the KIELSTEG element (i.e. the remaining cross-section retains bending and shear strength). The penetration should be reinforced using simple construction measures so that the integrity of the KIELSTEG element as a space-enclosing partition for fire-protection purposes is preserved.

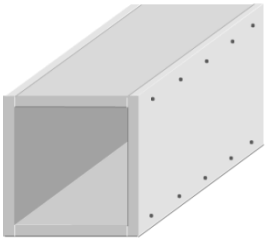


Section

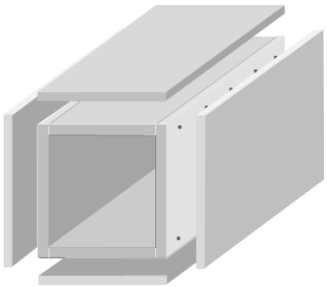
For example, the penetration can be lined with a prefabricated lining of OSB, plasterboard or 3-layer boards



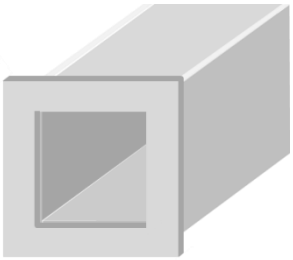
Lining of penetrations



Single-layer lining



Double-or multi-layer lining

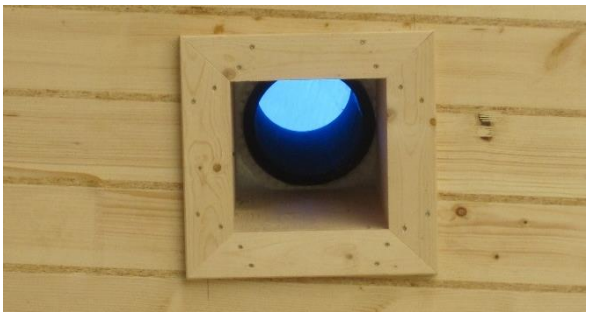


Always seal off lining with an cover frame

The penetration lining/covering should be made in a way that meets the requirements for the visual appearance and the specified fire resistance class REI 30 or REI 60.
Depending on the aesthetic and fire protection requirements, the penetration can be lined with one or more layers of various materials.

The end of the lining at the visible side of the KIELSTEG element should be finished off with an overlapping frame. This frame should be combined with a combination with a fire joint tape to ensure the integrity of the KIELSTEG element as a fire partition.

The frame also covers the cut edges of the opening, which ensures a visually acceptable result even if, for example, the opening was cut with a chainsaw.



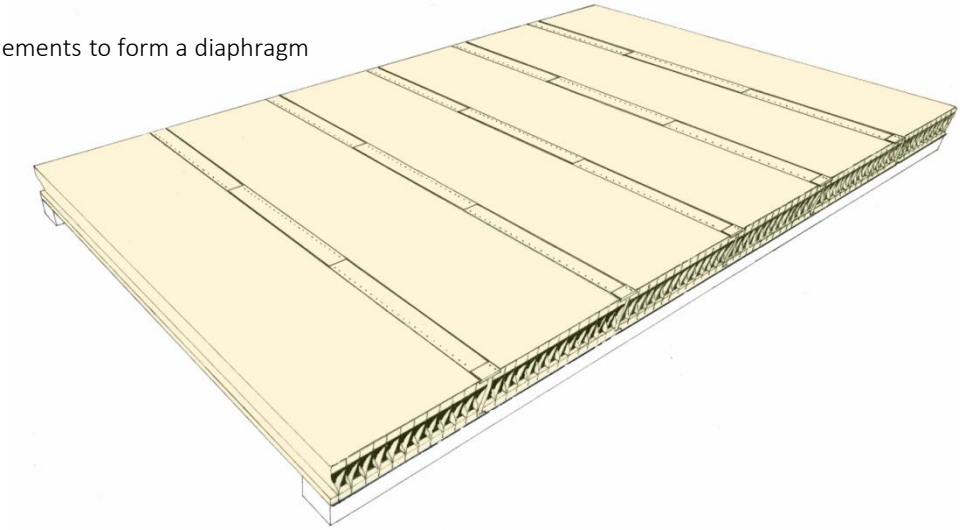
Bracing-general principles

Horizontal bracing of buildings is usually achieved either by trusses (horizontally positioned frameworks) or by creating stiff diaphragms. These bracing elements have two functions: firstly, they stabilize the elements that bear vertical loads, such as posts and inclined frame members, and secondly they enable the structure to react to wind loads, by transferring these effectively to the necessary vertical bracing elements – such as wall assemblies, wall diaphragms, frames and posts . In braced-frame systems, the loads are transferred from the elements that are exposed to the load (e.g. gable posts) via tension/compression members into the framework. The further distribution of the forces within the framework occurs essentially in accordance with truss theory. In structures that are braced by diaphragms, it may not be so easy to visualize the interplay of forces. In this section we will describe how structural floors and roofs built with KIELSTEG elements function as diaphragms and how this contributes to bracing the building.

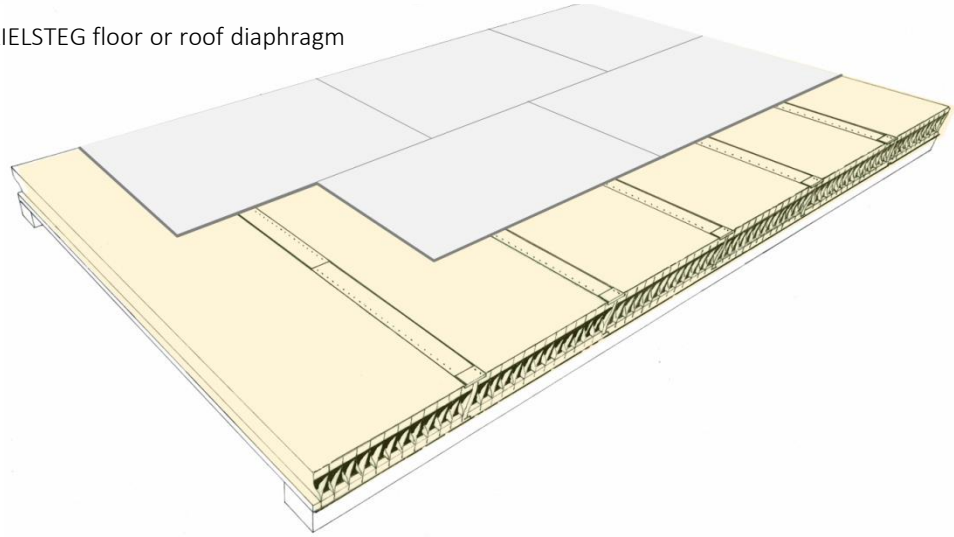
Scheibenwirkung von KIELSTEG Bauelementen

A layer of KIELSTEG elements forming a floor or roof can effectively be made to function as a stiff diaphragm by linking the elements to each other using joint boards. Each of these boards is screwed to the top of one KIELSTEG element and overlaps the neighbouring element, resting in the rebated top edge. Alternating lengths of the boards are screwed to one or the other of the two elements. This creates a mesh joint that can accommodate some lateral movement due to shrinkage and swelling. If the roof or floor diaphragm is subject to higher loads, a layer of OSB can be fastened to the top surface to add stiffness. On the underside (visible side) of the KIELSTEG elements, the neighbouring elements overlap directly through the profiles routed into their edges. A strip of fire tape is laid in the joint, which gives the ceiling a fire resistance level of up to REI 60. The width of the movement joint on the visible side should be set in the range 5 mm–10 mm depending on the expected use of the building and its internal climate. The joint is visible as a slight shadow gap and contributes to the characteristic striped pattern of the ceiling.

Linking KIELSTEG elements to form a diaphragm using joint boards

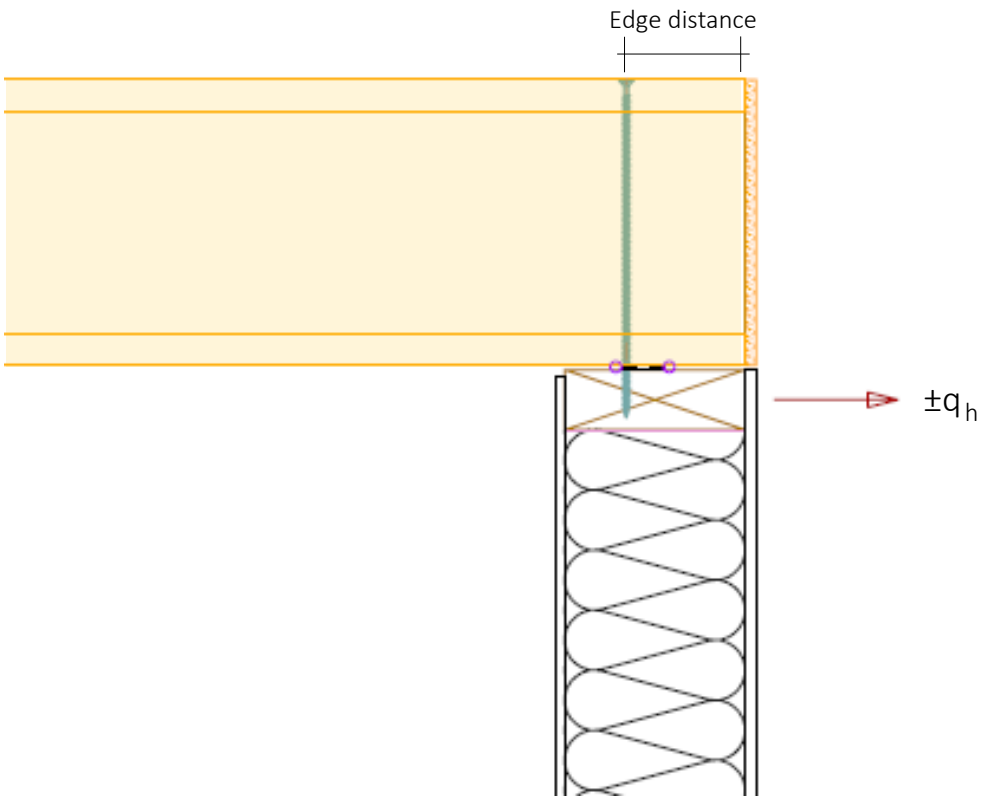


Reinforcement of a KIELSTEG floor or roof diaphragm using OSB sheets



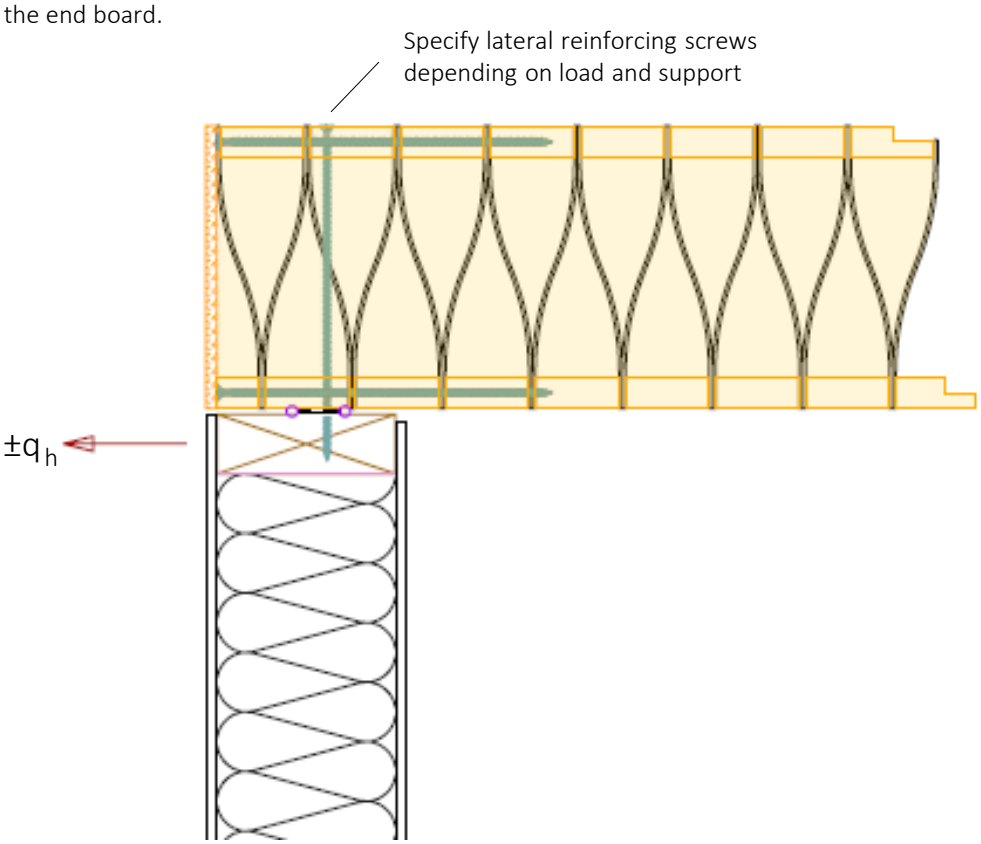
Local entry of horizontal load into the KIELSTEG Assembly at the ends of the elements

A critical factor is to ensure a sufficient distance of the fasteners from the edges of the KIELSTEG element. In particular, when the wall is subjected to wind suction loads, the screws must be far enough away from the end that they do not begin to tear out the end grain.



Local entry of horizontal load into the KIELSTEG assembly across the width of the elements

When KIELSTEG elements are fastened to the substructure along their sides, lateral stresses must be taken into consideration. If necessary, lateral reinforcements must be added in view of the fact that these stresses act across the grain of the flanges. The edges of the first and last elements can be reinforced by adding fully threaded screws through the flanges, as shown in the diagram. This can be done in either the top or bottom flanges or in both. It is not allowed to tie the element to the substructure with screws into the webs or into the end board.

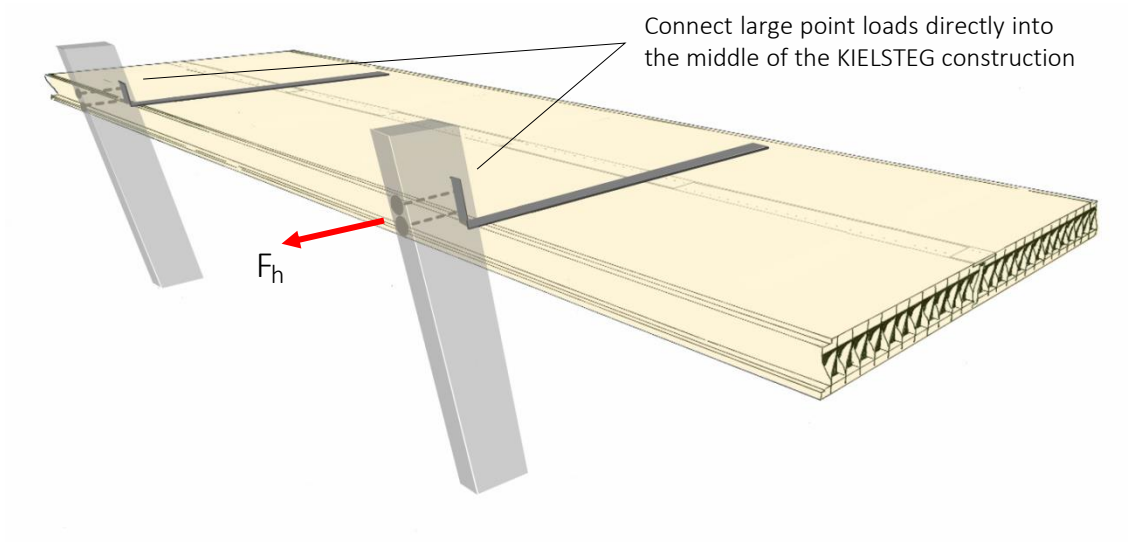


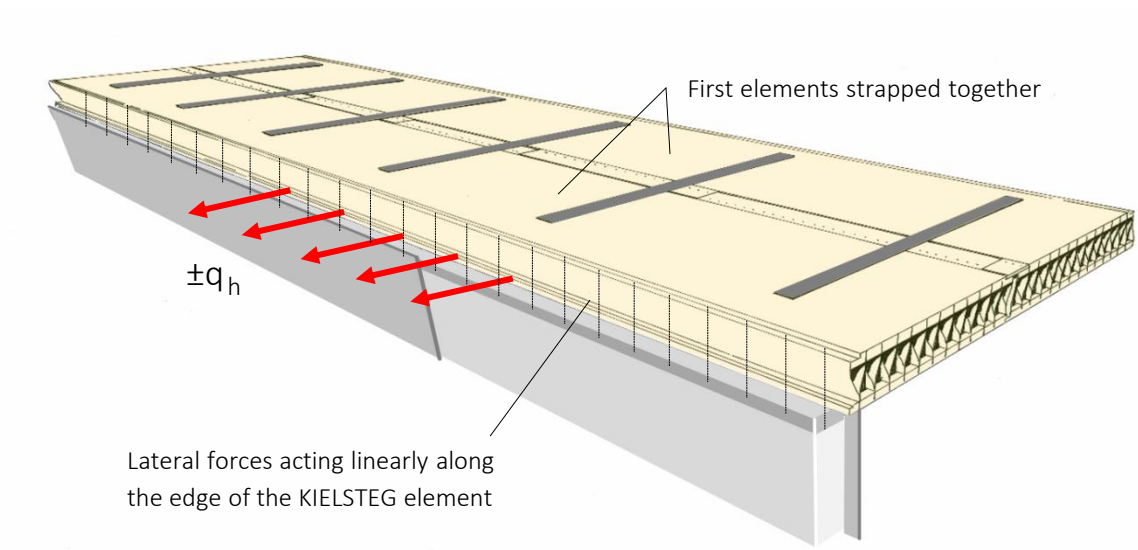
Load transfer into the interior of the diaphragm along the length of the elements

Horizontal forces acting on the ends of the elements are distributed very efficiently because of the high compression and tension strengths of the longitudinal flange timbers. Where ends of KIELSTEG elements butt up against each other, for example on middle beams, they should be tightly connected across the joint.

Load transfer into the roof across the width of the elements

The fact that the joints between the KIELSTEG elements are not made absolutely tight in the lateral direction means that horizontal forces applied laterally to the edge element are not distributed into the middle of the diaphragm without extra measures. For this reason, the first three or four KIELSTEG elements from the edge, depending on the loading, should be strapped together across their width. This can be done with steel wind bracing strips, lengths of timber or sheet wood (plywood or OSB).





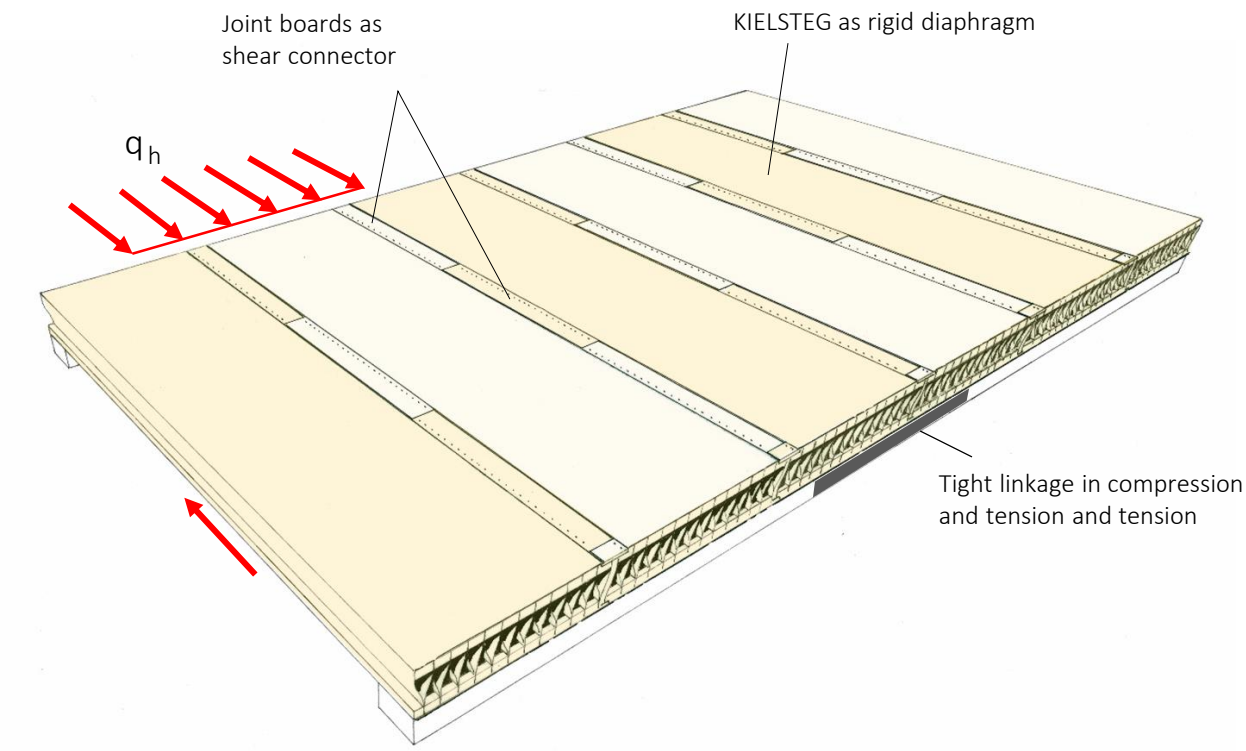
Interior diaphragm forces due to loads along the length of the elements

In order for the roof or floor to function as a rigid diaphragm, the following parts are necessary:

KIELSTEG elements: The elements take up the applied forces at the edges of the floor/roof and distribute them along their length. On the other hand, the elements also distribute shear forces like the diagonal elements in a braced frame.

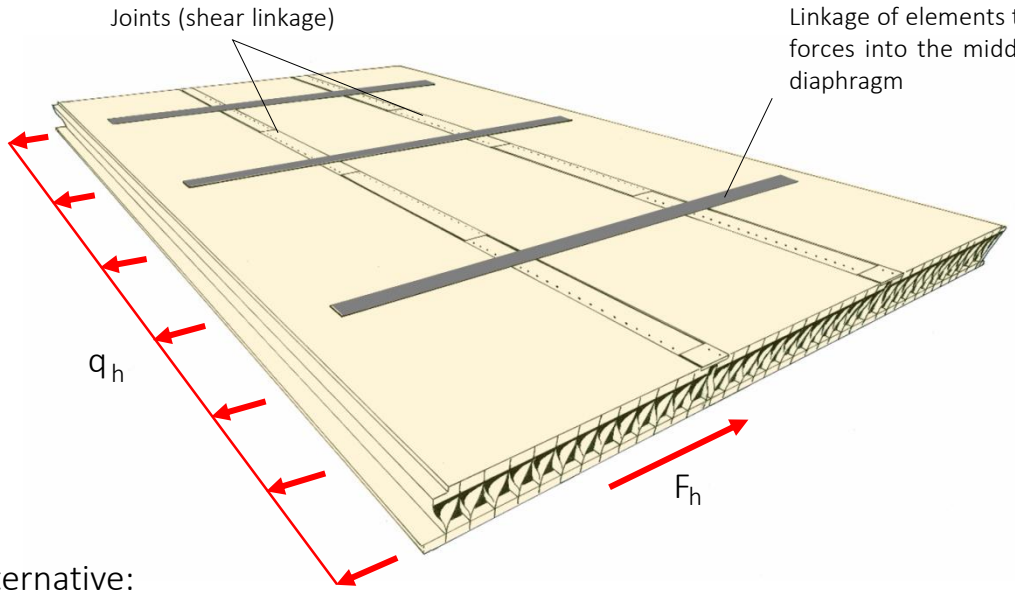
Joint boards: The joint boards are essential for transferring the shear forces from one element to the next. The boards are made of 19 mm three-ply material which is usually attached to the KIELSTEG element by dowel-type fasteners. Allowing stress-free shrinkage and swelling of the elements, short lengths of joint boards are nailed alternately to the two neighbouring elements. To form a mesh linkage between the elements, the joint boards must butt up against each other tightly at their ends. The shear forces on the joints are largest around the perimeter of the diaphragm and decline towards the middle. When calculating the spacing of the fasteners, it must be taken into account that only half the length of each element is available, because of the alternating nailing pattern.

Full-length chords: Every rigid diaphragm structure must have full-length elements that fulfil the function of the top and bottom chords in a truss. This role is usually played by the top boards (in framework walls) or glulam beams which form the supports for the KIELSTEG elements. These chords must be tightly connected in both tension and compression along their whole length. The forces are transferred through the KIELSTEG assembly, thanks to its shear stiffness, and via the fastenings into the supporting beams. The forces in the beams increase from the ends towards the middle.

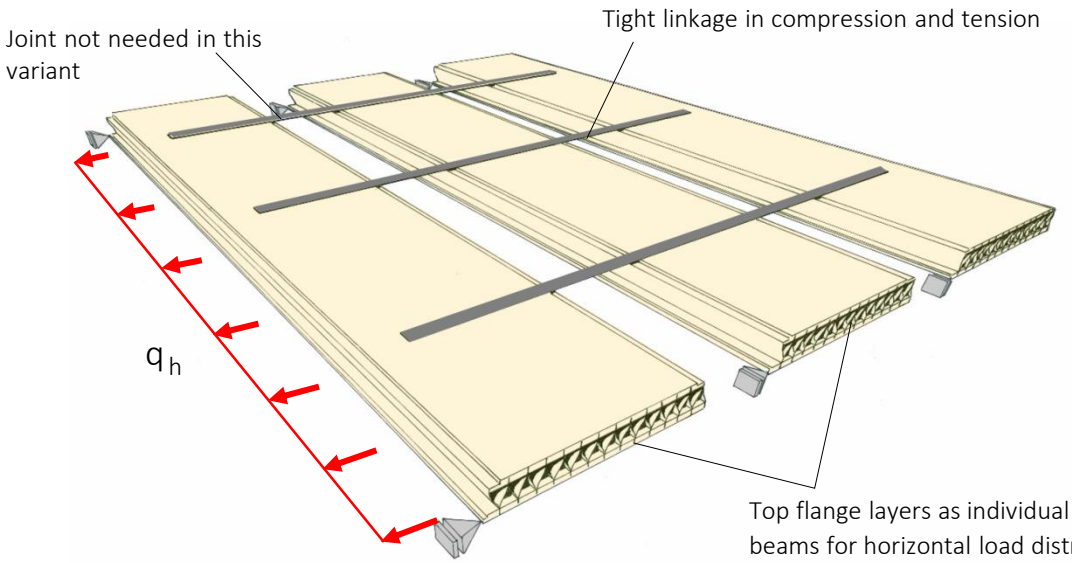


Interior diaphragm forces due to loads across the width of the elements

As already mentioned in the previous point, if there are significant loads applied across the width of the KIELSTG elements, several elements need to be strapped together in order to transmit these forces into the middle of the diaphragm. The joints formed by the joint boards between the KIELSTEG elements, which are necessary to transfer shear forces along the length of the KIELSTEG elements, also create a significant shear linkage across their width. The elements at the edge that are strapped together can still be loaded as a rigid diaphragm. Alternatively, the effects of lateral forces on the KIELSTEG elements can be analysed by treating the elements as individual bending beams, lying flat, instead of using diaphragm theory. The bending forces should be calculated only for the top flange layer, and the bending forces from vertical loads should be superimposed on them.

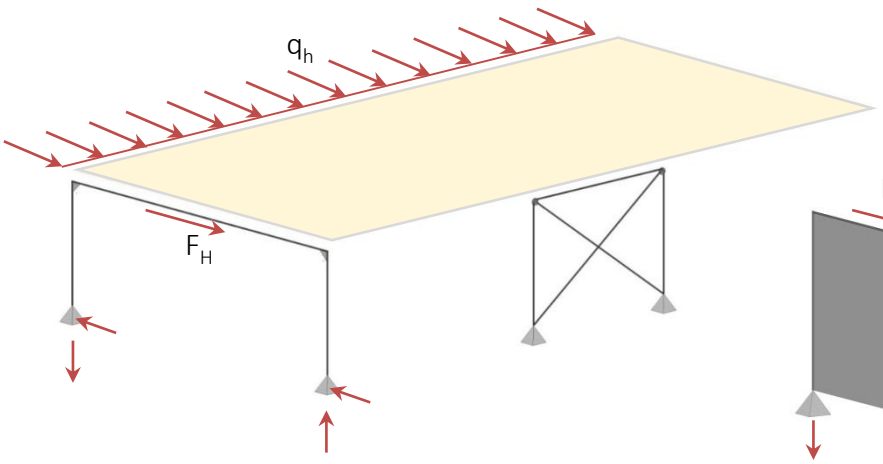


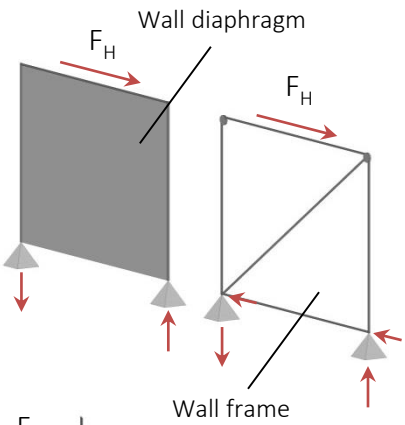
Alternative:

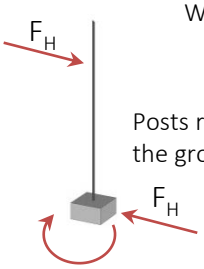


Diaphragm supports

The roof and floor diaphragms and roof assemblies need support structures that can transfer the horizontal forces out of the roof/floor plane into the foundation. The supports can be created in the form of wall assemblies, rigid wall elements, frames or post rigidly anchored in the ground. The transmission of forces from the roof diaphragm into the supporting structure usually occurs linearly along a supporting beam through screws. The type and number of screws used needs to be determined individually for each project.



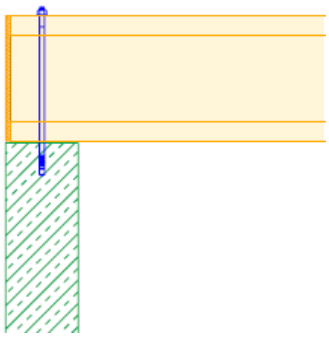


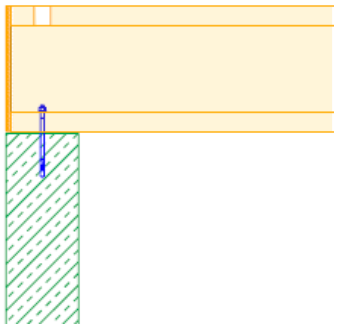


Screw fastening

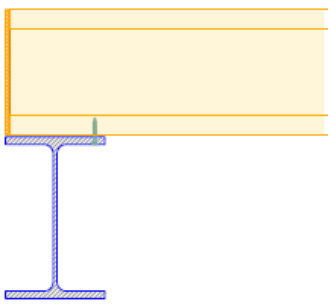
KIELSTEG elements in floors and roofs can be screwed to the supporting structures in many different ways. The main options are shown in the following diagrams.

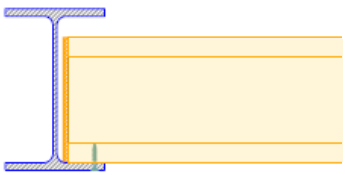
Laid on concrete:





Laid on steel:





In the common configuration in which the KIELSTEG elements are laid directly on wood, they should be fastened to the support with fully threaded screws, as far as possible without stress, with the screws close to the centre line of the KIELSTEG element. The screws are started at the top in the middle of the web material, so that they pass through the middle of the bottom flange (see Fig. A). The number of screws depends on the loading and needs to be calculated on a project-by-project basis. The values for the load-bearing capacity of the screws can be found in the following table. However, a minimum of two screws at each end of each element should always be used.

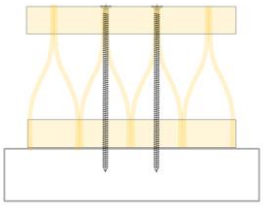
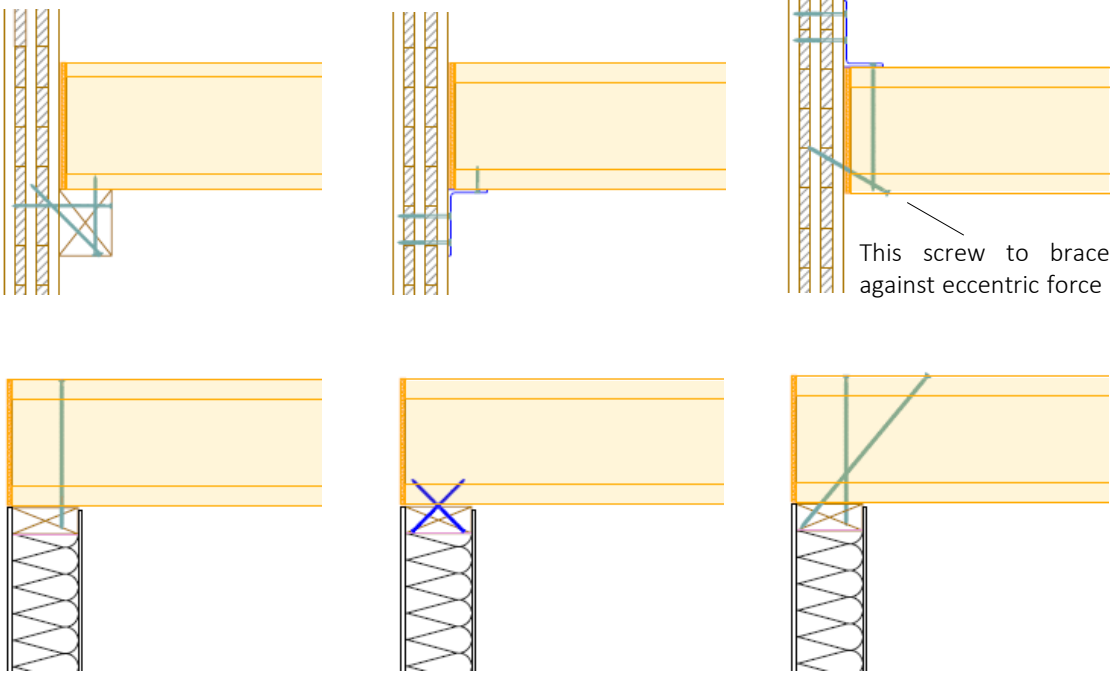


Fig. A

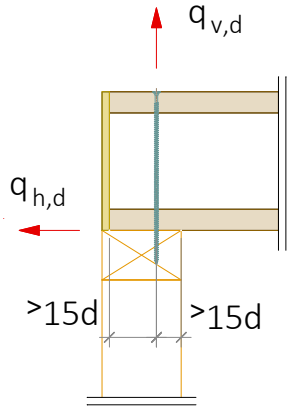
Laid on wood:



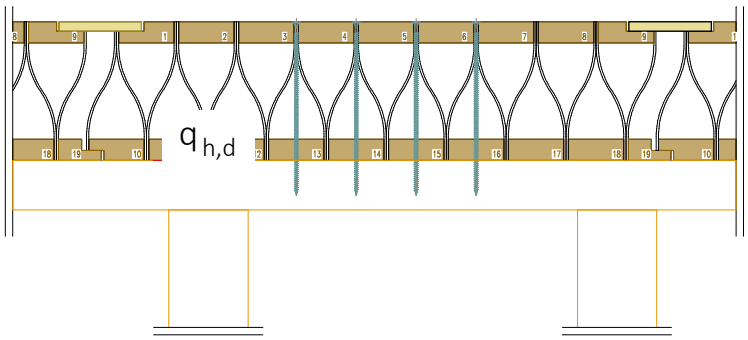
Standard screw fastening to wooden supports

At least two screws must be used at each end of each element. Screws with cylindrical heads are preferable to screws with countersunk heads because of the lower tendency to split the wood. The use of partly threaded screws is not allowed. The screws must always be positioned so that at the contact point between the KIELSTEG element and the support, the screw passes though solid flange timber and not through the end of the web material. Only one screw may be used per pair of webs, i.e. per bottom flange. The screws should be positioned in the middle of the KIELSTEG element.

Parameter	
P_k[kg/m³]	350
K_{mod} [-]	0.9
$\gamma_{M,Holz}$ [-]	1.3
$\gamma_{M,Stahl}$ [-]	1.1



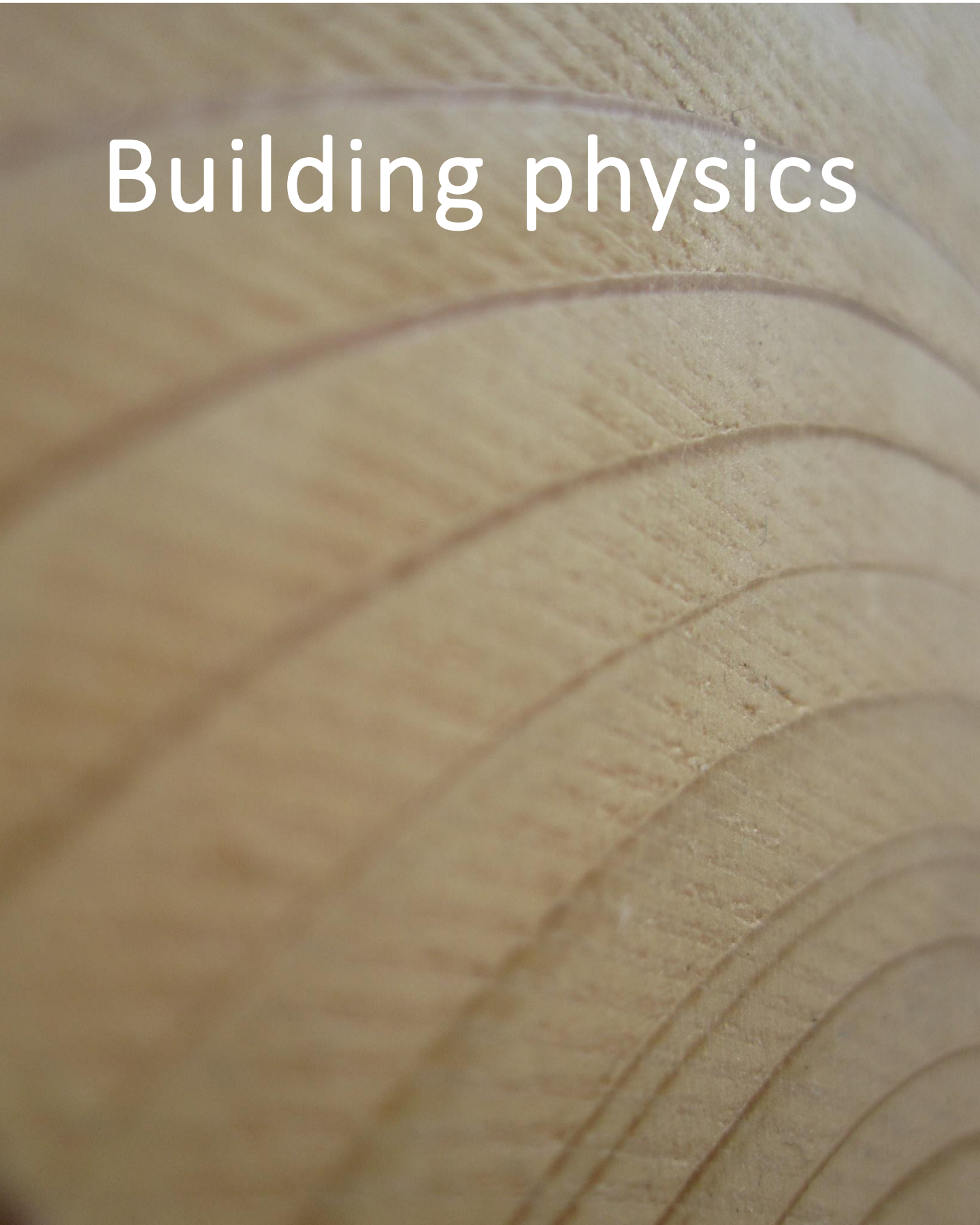
The screws should be positioned close to the centre line of the KIELSTEG element.



Data for screw fastening

Minimum support length a1, t+a2,t [mm]	180	180	180	180	180	200	200	200	200	200	200	260	260
Minimum offset from side of wood Support a2,t=5*t [mm]	45	45	45	45	45	50	50	50	50	50	50	65	65
Minimum offset from end of wood (flange) a1,t=15*d [mm]	135	135	135	135	135	150	150	150	150	150	150	195	195
Minimum screw penetration [mm]	56.1	56.1	56.1	56.1	56.1	58.9	58.9	58.9	58.9	58.9	58.9	79.9	79.9
Minimum thickness of flange wood [mm]	42.5	42.5	42.5	42.5	42.5	44.2	44.2	44.2	44.2	44.2	44.2	58.7	58.7
Max. shear load on screw R_d [N]	2757	2757	2757	2757	2757	3147	3147	3147	3147	3147	3147	5227	5227
Max. pull-out load on screw $R_{a,xd}$ [N]	4946	4809	4809	4809	4809	4376	4834	4580	4580	4325	4325	14112	8820
Minimum screw penetration of support wood [mm]	72	70	70	70	70	95	95	90	90	85	85	170	100
Screw length [mm]	300	350	350	450	450	580	580	650	650	700	700	900	900
Screw diameter [mm]	9	9	9	9	9	10	10	10	10	10	10	13	13
Recommended screw type	SFS WR-T 9	SFS WR-T 9	SFS WR-T 9	SFS WR-T 9	SFS WR-T 9	Assy Plus VG 10	Assy Plus VG 10	Assy Plus VG 10	Assy Plus VG 10	Assy Plus VG 10	Assy Plus VG 10	SFS WR-T 13	SFS WR-T 13
Thickness of flange [mm]	43	43	57	43	57	43	57	57	67	57	67	80	80
Fire resistance [min]	REI 30	REI 30	REI 60	REI 30	REI 60	REI 30	REI 60	REI 30	REI 60	REI 30	REI 60	REI 60	REI 60
Total height [mm]	228	280	280	380	380	485	485	560	560	610	610	730	800
	KSE	KSE	KSE	KSE	KSE	KSE	KSE	KSE	KSE	KSE	KSE	KSE	KSE

Building physics

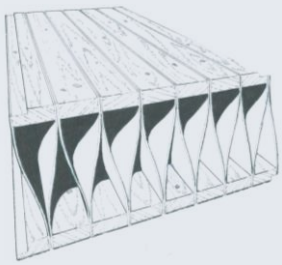


Wood

Shrinkage and swelling

KIELSTEG elements are not cross-laminated, and the timber in them is all laid in one direction. This means that KIELSTEG elements are subject to a certain amount of dimensional change, which is strongest in the lateral direction. KIELSTEG elements are delivered with a wood moisture content of 12±3%. Depending on the service class, in use the wood moisture content can vary between 7 and 20%. Dimensional change of KIELSTEG elements per 1% change of wood moisture content:

Length: 0.01%
Width: 0.25%
Thickness: negligible



CO2

Ecology

Wood is one of the few renewable mass materials available worldwide that has useful strength. In terms of the criteria binding of CO_2 and minimization of CO_2 emissions, wood is generally recognized as the material with the best sustainability. Use of wood in construction makes an important contribution. Lightweight systems such as KIELSTEG use as much as 50% less material as solid products. Therefore KIELSTEG should be seen as part of the discussion about how we should use wood in future. We need to work out a balance between current regional needs and the global trends for the coming decades. To put it simply, we need to find the optimum between maximizing the use of material in order to bind CO_2 and minimizing the use of material to make more efficient use of resources.

Emissions

Natural wood emits very small amounts of formaldehyde. During the drying process, formaldehyde is formed by the degradation of lignin, hemicellulose and other polysaccharides in the wood. Formaldehyde is also released by certain types of adhesive used to make processed wood products. The rate of formaldehyde emission depends on time and temperature. The 6th executive regulation to the Austrian Chemicals Act (Österreichisches Chemikaliengesetz) lays down limits for different materials. In order to comply with the Formaldehyde Ordinance of 12.2.1990 (Federal Law Gazette for the Republic of Austria), the formaldehyde emissions must not exceed (single sheet value) 3.5 mg formaldehyde per m^2h (gas analysis value) after 4 weeks' storage. KIELSTEG elements do not emit problematic amounts of formaldehyde. The emissions from a sample analysed by Holzforschung Austria (KIELSTEG element with plywood webs KSE 228) remained below the limits at every time point. The sample therefore fulfilled the statutory requirement of the formaldehyde emissions class E1 of ≤ 0.1 ppm.[1]

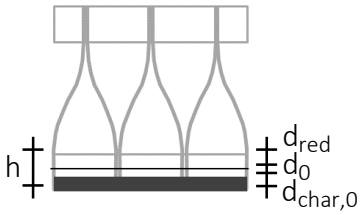
Fire protection

Suitably dimensioned KIELSTEG elements qualify as fire resistance class REI 30 or REI 60 without any additional construction measures such as cladding of the bottom surface. When penetrations through the elements are needed for pipes or other installations, the measures required to protect their integrity as space-enclosing partitions should be considered on a case-by-case basis. Because of the cellular internal structure of the KIELSTEG elements, with the top and bottom flange layers of solid wood, the fire resistance in terms of the fire duration until failure and the remaining load-bearing ability are evaluated only terms of the burning of the flange layer next to the fire source. The design of the joints between the elements, including the use of the fire-protective tape in the joints, has been tested and meets the requirements of the stated fire resistance classes. The internal cavities of the KIELSTEG elements provide significant insulation between the fire-exposed side and the side facing away from the fire. As a result of this effect, it is possible to use lightweight expanded polystyrene insulation on warm roof constructions with KIELSTEG elements.

Fire resistance classes that can be achieved with different KIELSTEG types							
KSE 228	**KSE 280**	**KSE 380**	**KSE 485**	**KSE 560**	**KSE 610**	**KSE 730**	**KSE 800**
REI 30	REI 30	REI 30	REI 30	REI 30	REI 30	REI 30	REI 30
	REI 60	REI 60	REI 60	REI 60	REI 60	REI 60	REI 60

Fire resistance classification

The fire resistance classification of KIELSTEG elements was done in accordance with EN 1363-1 and EN 1365-2 at the Institut für Brandschutztechnik und Sicherheitsforschung in Linz. The calculation for exposure to fire on one side from below is done as specified in ÖNORM EN 1995-1-2.

Fire resistance duration			
h	Flange thickness	43 mm	
		57 mm	
		67 mm	
		80 mm	
d0	Zero strenght layer	7 mm	
dred	Reduced depth		
dchar,0	Char depth		
ß0	Charring rate	0.656 mm/min	
t	Fire duration	REI30, REI60	

$d_{char,0} = \beta_0 \times t$

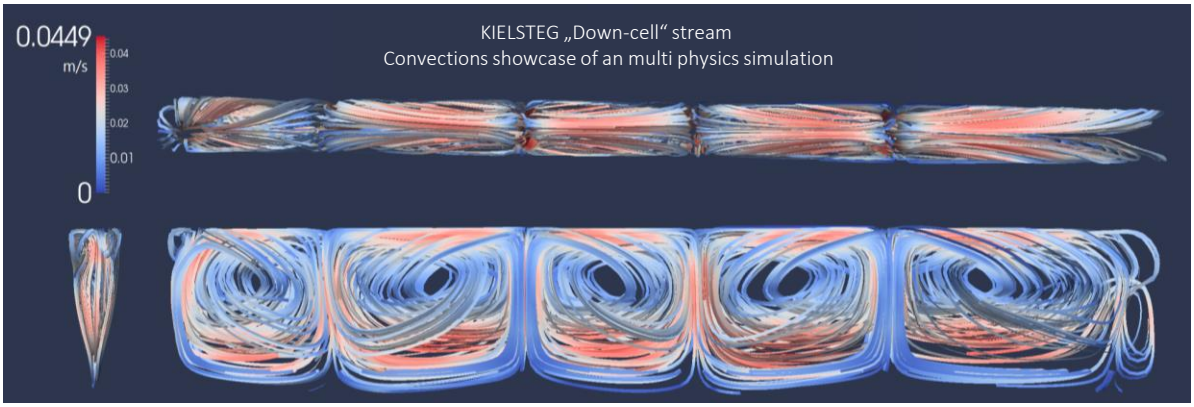
At $\beta_0 = 0.656$ mm/min and t = 30 minutes, $d_{char,0} = 19.7$ mm.

At $\beta_0 = 0.656$ mm/min and t = 60 minutes, $d_{char,0} = 39.4$ mm.

Depending on the fire resistance duration, KIELSTEG elements can be classified into two fire resistance classes as defined in ÖNORM EN 1995-1-2.

Fire resistance duration t in minutes		
Fire retardant	> 30 min	REI 30
Highly fire retardant	> 60 min	REI 60

Thermal insulation

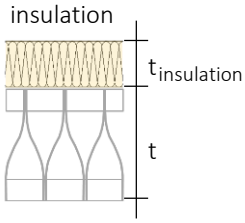


The insulation thicknesses you need to achieve different U-values are shown in the tables below and on the next page. The figures are for warm roof constructions with mineral or lightweight expanded polystyrene (EPS) insulation. Due to the large variety of available materials for the vapour barrier, insulation and outer roofing, it is not possible to cover all of their properties here. It will be necessary to choose a combination of materials that meets the requirements of the individual project for waterproofing and humidity regulation.

Table of U-values (REI 30 elements)

		KSE 228	KSE 280	KSE 380	KSE 485	KSE 560	KSE 610
Kielsteg without insulation		0.898	0.886	0.880	0.875	0.739	0.735
Insulation thickness $t_{insulation}$ (mm) λ 0.040	100	0.274	0.272	0.271	0.270	0.256	0.255
	120	0.241	0.239	0.238	0.238	0.227	0.226
	140	0.215	0.214	0.213	0.212	0.202	0.203
	160	0.194	0.193	0.192	0.192	0.184	0.184
	180	0.177	0.176	0.175	0.175	0.169	0.168
	200	0.162	0.162	0.161	0.161	0.155	0.155
	220	0.150	0.149	0.149	0.148	0.144	0.144
	240	0.139	0.139	0.139	0.138	0.134	0.134

Mineral insulation



		KSE 228	KSE 280	KSE 380	KSE 485	KSE 560	KSE 610
Insulation thickness $t_{insulation}$ (mm) λ 0.033	100	0.239	0.238	0.237	0.236	0.225	0.224
	120	0.209	0.208	0.207	0.206	0.198	0.197
	140	0.185	0.184	0.184	0.183	0.176	0.176
	160	0.166	0.166	0.165	0.165	0.159	0.159
	180	0.151	0.150	0.150	0.150	0.145	0.145
	200	0.138	0.138	0.137	0.137	0.133	0.133
	220	0.128	0.127	0.127	0.126	0.123	0.123
	240	0.118	0.118	0.118	0.117	0.115	0.114

EPS-insulation

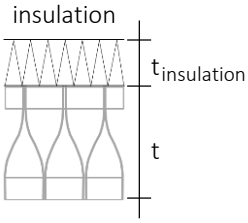
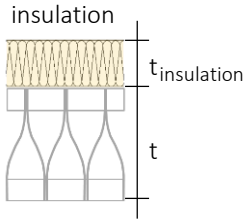


Table of U-values (REI 60 elements)

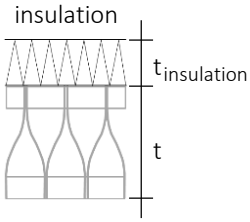
		KSE 280	KSE 380	KSE 485	KSE 560	KSE 610	KSE 730	KSE 800
Kielsteg without insulation		0.734	0.734	0.726	0.658	0.656	0.587	0.588
Insulation thickness $t_{insulation}$ (mm) λ 0.040	100	0.258	0.256	0.255	0.246	0.245	0.235	0.235
	120	0.228	0.227	0.225	0.219	0.218	0.210	0.210
	140	0.205	0.203	0.202	0.197	0.196	0.190	0.190
	160	0.185	0.184	0.184	0.179	0.179	0.173	0.173
	180	0.170	0.169	0.168	0.164	0.164	0.159	0.159
	200	0.156	0.156	0.155	0.152	0.151	0.148	0.148
	220	0.145	0.144	0.144	0.141	0.141	0.137	0.137
	240	0.135	0.134	0.134	0.132	0.131	0.128	0.128

Mineral insulation



		KSE 280	KSE 380	KSE 485	KSE 560	KSE 610	KSE 730	KSE 800
Insulation thickness $t_{insulation}$ (mm) λ 0.033	100	0.226	0.225	0.224	0.217	0.217	0.209	0.209
	120	0.199	0.198	0.197	0.192	0.191	0.185	0.185
	140	0.177	0.176	0.176	0.171	0.171	0.166	0.166
	160	0.160	0.159	0.159	0.155	0.155	0.151	0.151
	180	0.146	0.145	0.145	0.142	0.142	0.138	0.138
	200	0.134	0.133	0.133	0.130	0.130	0.127	0.127
	220	0.124	0.123	0.123	0.121	0.121	0.118	0.118
	240	0.115	0.115	0.114	0.113	0.112	0.110	0.110

EPS-insulation



Material parameters

The following material parameters can be used for a variety of calculations such as the energy pass and rough estimation of the U-value.

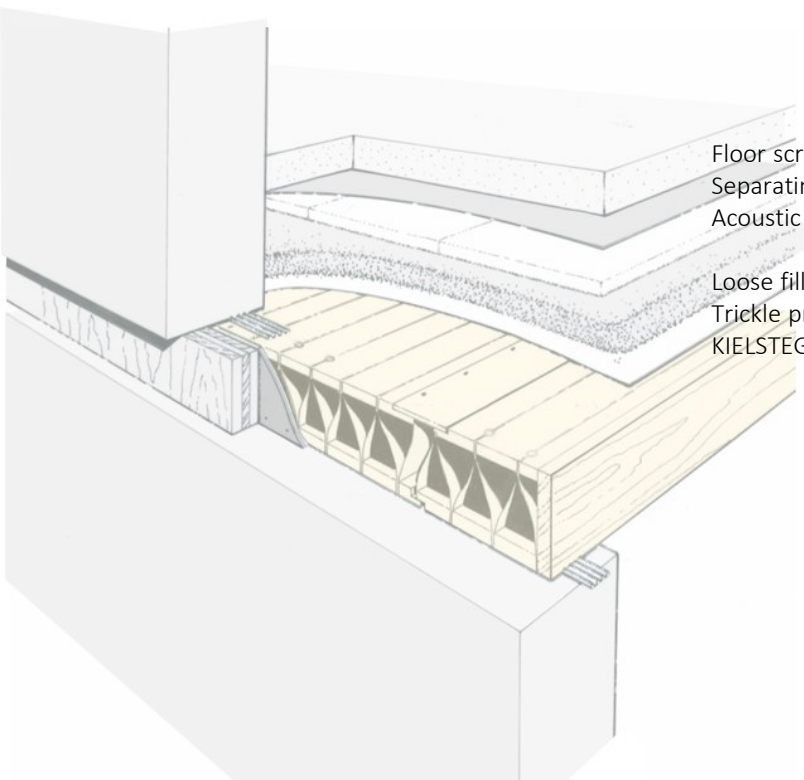
Type	Fire resistance class min	Mass/area of elements kg/m²	Mass of flange wood kg/m²	Effective thermal storage mass kg/m²	Specific heat capacity J/KgK	Thermal conductivity of webs λ(W/mK)	Thermal conductivity of flanges λ(W/mK)	Diffusion resistance of flanges μ	Diffusion resistance of air chambers μ
KSE 228	REI 30	48.4	19.3	27	1600	0.14	0.13	50	0.5
KSE 280	REI 30	48.7	19.3	27	1600	0.14	0.13	50	0.5
	REI 60	61.5	25.6	32					
KSE 380	REI 30	52.6	19.3	27	1600	0.14	0.13	50	0.5
	REI 60	65.0	25.6	32					
KSE 485	REI 30	72.4	19.3	27	1600	0.13	0.13	50	0.5
	REI 60	86.1	25.6	32					
KSE 560	REI 30	80.7	25.6	30	1600	0.13	0.13	50	0.5
	REI 60	92.2	30.1	32					
KSE 610	REI 30	104.6	25.6	30	1600	0.13	0.13	50	0.5
	REI 60	109.7	30.1	32					
KSE 730	REI 60	120.1	36.0	32	1600	0.13	0.13	50	0.5
KSE 800	REI 60	146.5	36.0	36	1600	0.13	0.13	50	0.5

Structural floor

Comfort in the interior of buildings is a function of surface textures, temperatures, colours, light, design, odour, acoustics and noise transmission from other rooms. The quality of a space for living or working can be very easily impaired by unwanted noise. This means that the quality of interior floors/ceilings has a lot to do with their ability to insulate against airborne and impact noise. Acoustic insulation of floors always a matter of achieving the right mass, separating layers and decoupling the margins of the floor from the structure.

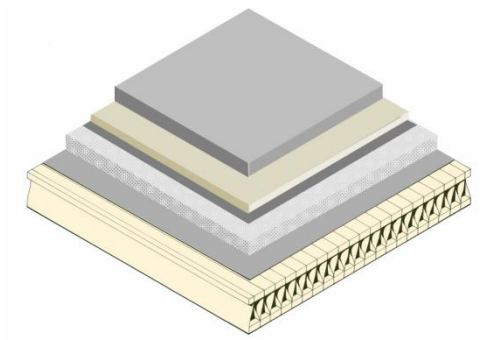
Recommended floor layup

KIELSTEG elements are a very lightweight construction system with high load-bearing capability. As intermediate floors in buildings, they can easily reach applicable acoustics standards for residential and similar use by means of conventional, proven floor layups – using loose fill, acoustic insulation board, screed and soft perimeter seals. As a rule, floors with good attenuation of airborne noise also insulate well against impact noise.



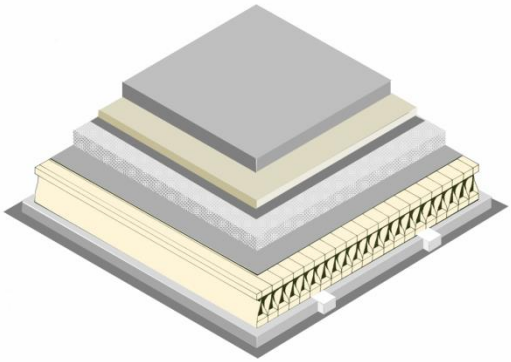
Geschoßdeckenaufbauten

Material	Thickness (cm)	ρ (kg/m²)
Floor screed	6.0	120.0
Separating foil PVC	-	-
Acoustic insulation board TDP 35/30	3.5	2.6
Loose fill	5.0	90.0
Trickle protection	-	-
KSE 228	22.8	48.4



Structure thickness	Structure mass	Load	Fire protection	Airborne sound	Impact sound
t_{total} (cm)	ρ_{total} (kg/m²)	g (kN/m²)	REI (min)	R_w (dB)	L_{nTw} (dB)
37.3	261.0	2.12	30 to 60 depending on KSE type	58.7 dB	47.2 dB

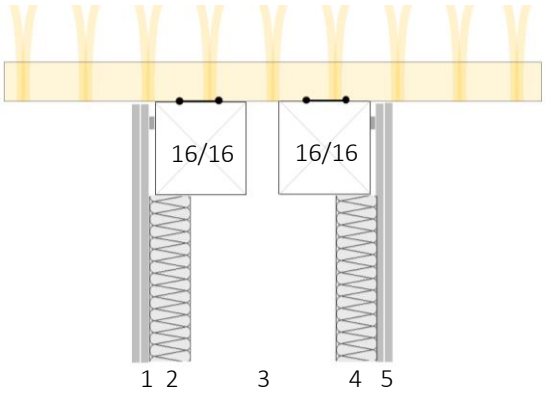
Material	Thickness (cm)	ρ (kg/m²)
Floor screed	6.0	120.0
Separating foil PVC	-	-
Acoustic insulation board TDP 35/30	3.5	2.6
Loose fill	5.0	90.0
Trickle protection	-	-
KSE 228	22.8	48.4
Mineral insulation	7.0	1.3
Gypsum plaster board	1.2	11.2

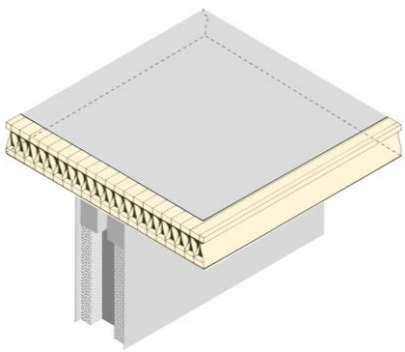


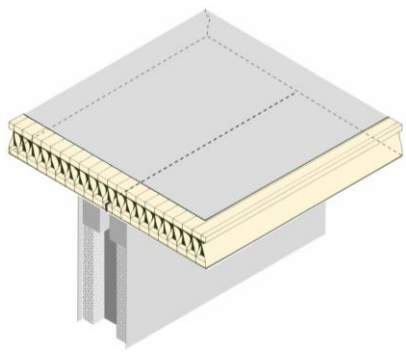
Structure thickness	Structure mass	Load	Fire protection	Airborne sound	Impact sound
t_{total} (cm)	ρ_{total} (kg/m²)	g (kN/m²)	REI (min)	R_w (dB)	L_{nTw} (dB)
45.6	273.5	2.25	30 to 90 depending on KSE type	59.5 dB	43.2 dB

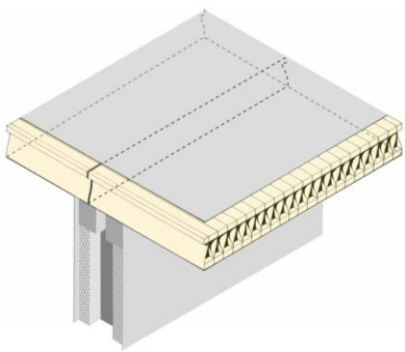
Sound conduction across wall joints

	Material	Thickness (cm)	ρ (kg/m³)
1	Gypsum plaster board fire protection 1.25 cm 2 layers	2.8	25.2
2	CW- stud with mineral insulation	8.0	4.0
3	Air space between the CW-studs	25.0	-
4	CW- stud with mineral insulation	8.0	4.0
5	Gypsum plaster board fire protection 1.25 cm 2 layers	2.8	25.2









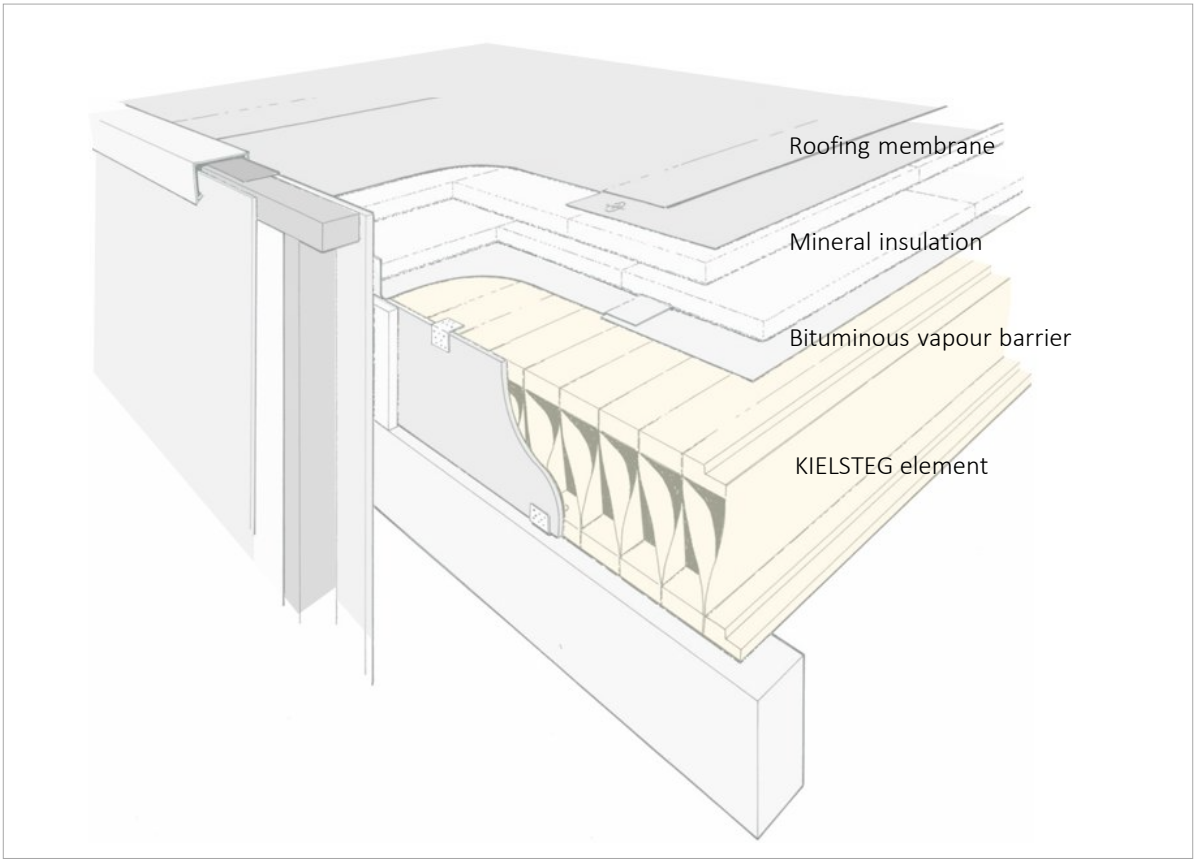
Wall joint along length of KIELSTEG element	Wall joint along length of KIELSTEG element, decoupling cut in bottom flange	Wall joint across width of KIELSTEG element
D_{nT} = 60.0 dB	D_{nT} = 62.0 dB	D_{nT} = 60.0 dB

Roof

Flat roofs have become a fixed part of our built landscape. An optimal application of KIELSTEG elements is for flat or mono-pitched roofs, and in this role they are used in detached family houses, in other residential buildings, and in commercial and industrial buildings. Besides the architectural aspects, the roof construction with gravel or green roof cover also has considerable engineering benefits. The roof is better protected against extreme temperatures and wind suction, and the acoustic insulation is also enhanced.

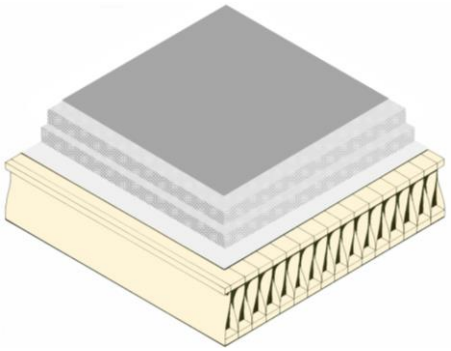
Recommended roof structure

Roof constructions that comply with the design rules for warm roofs with insulation above the structural layer are generally very robust in terms of building physics. These structures can be used without problems for green roofs and the summer drying period is not significantly affected by shade. The separation of the structural layer and the insulation layer is the perfect configuration to achieve robust building physics and long life.



Data for roof constructions

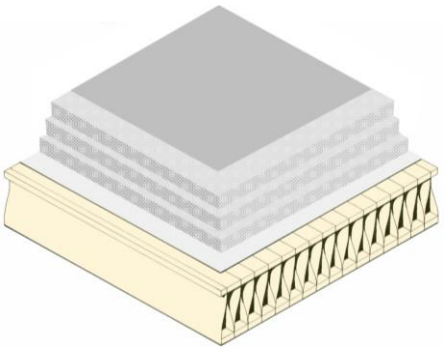
Material	Thickness (cm)	Λ (W/mK)	μ ()	ρ (kg/m²)
Roofing membrane	0.2	0.17	20000	3.6
EPS W-20 insulation	5.0	0.033	70	1.0
EPS W-20 insulation	5.0	0.033	70	1.0
Vapour barrier	0.3	0.17	1500	3.3
KSE 228	22.8	0.223	50	48.4



Structure thickness	Structure mass	Load	Fire protection	Thermal protection	Airborne sound	Impact sound
h_{ges} (cm)	ρ_{ges} (kg/m²)	g (kN/m²)	REI (min)	U-Wert (W/m²K)	R_w (dB)	L_{nTw} (dB)
33.3	57.3	0.09	30 to 60 depending on KSE type	0.24	38.7	-

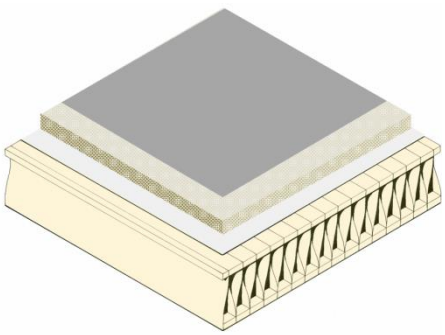
Data for roof constructions

Material	Thickness (cm)	Λ (W/mK)	μ ()	ρ (kg/m³)
Roofing membrane	0.2	0.17	20000	3.6
EPS W-20 insulation	5.0	0.033	70	1.0
EPS W-20 insulation	5.0	0.033	70	1.0
EPS W-20 insulation	5.0	0.033	70	1.0
Vapour barrier	0.3	0.17	1500	3.3
KSE 228	22.8	0.223	50	48.4



Structure thickness	Structure mass	Load	Fire protection	Thermal protection	Airborne sound	Impact sound
h_{ges} (cm)	ρ_{ges} (kg/m²)	g (kN/m²)	REI (min)	U-Wert (W/m²K)	R_w (dB)	L_{nTw} (dB)
38.3	58.3	0.096	30 to 60 depending on KSE type	0.17	37.5	-

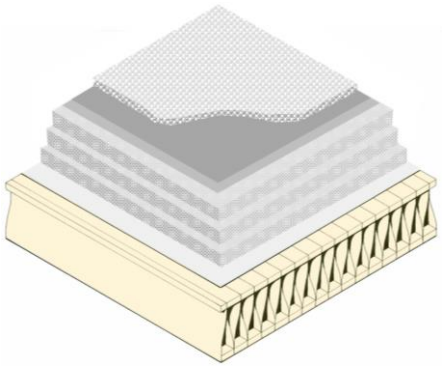
Material	Thickness (cm)	Λ (W/mK)	μ ()	ρ (kg/m³)
Roofing membrane	0.2	0.17	20000	3.6
Mineral insulation	7.0	0.040	1	3.5
Vapour barrier	0.3	0.17	1500	3.3
KSE 228	22.8	0.223	50	48.4



Structure thickness	Structure mass	Load	Fire protection	Thermal protection	Airborne sound	Impact sound
h_{ges} (cm)	ρ_{ges} (kg/m²)	g (kN/m²)	REI (min)	U-Wert (W/m²K)	R_w (dB)	L_{nTw} (dB)
30.3	58.8	0.10	30 to 60 depending on KSE type	0.34	45.7	-

Data for roof constructions

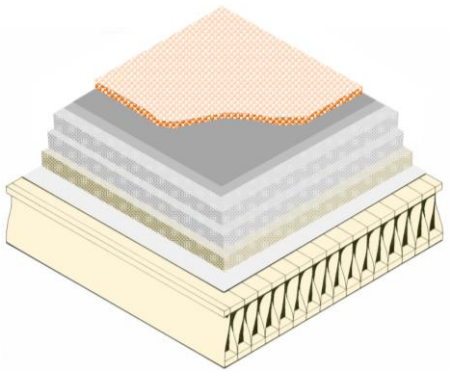
Material	Thickness (cm)	Λ (W/mK)	μ ()	ρ (kg/m³)
Gravel	6.0	0.7	3/3	108.0
Protective membrane	-	-	-	-
Roofing membrane	0.2	0.17	20000	3.6
EPS W-20 insulation	5.0	0.033	70	1.0
EPS W-20 insulation	5.0	0.033	70	1.0
EPS W-20 insulation	5.0	0.033	70	1.0
Vapour barrier	0.3	0.17	1500	3.3
KSE 228	22.8	0.223	50	48.4



Structure thickness	Structure mass	Load	Fire protection	Thermal protection	Airborne sound	Impact sound
h_{ges} (cm)	ρ_{ges} (kg/m²)	g (kN/m²)	REI (min)	U-Wert (W/m²K)	R_w (dB)	L_{nTw} (dB)
44.3	166.3	1.17	30 to 60 depending on KSE type	0.17	42.0	-

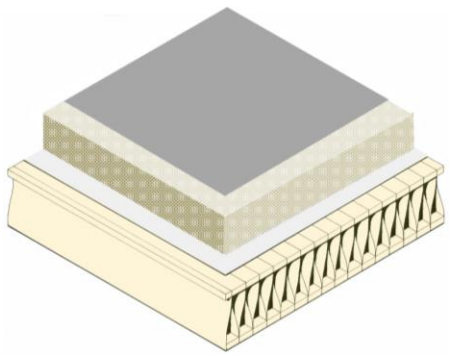
Data for roof constructions

Material	Thickness (cm)	Λ (W/mK)	μ ()	ρ (kg/m²)
Clay grit	10	0.53	5/10	130.0
Protective membrane	-	-	-	-
Roofing membrane	0.2	0.17	20000	3.6
EPS W-20 insulation	5.0	0.033	70	1.0
EPS W-20 insulation	5.0	0.033	70	1.0
Mineral insulation	7.0	0.040	1	3.5
Vapour barrier	0.3	0.17	1500	3.3
KSE 228	22.8	0.223	50	48.4



Structure thickness	Structure mass	Load	Fire protection	Thermal protection	Airborne sound	Impact sound
h_{ges} (cm)	ρ_{ges} (kg/m²)	g (kN/m²)	REI (min)	U-Wert (W/m²K)	R_w (dB)	L_{nTw} (dB)
50.3	190.8	1.42	30 to 60 depending on KSE type	0.16	46.7	-

Material	Thickness (cm)	Λ (W/mK)	μ ()	ρ (kg/m²)
Roofing membrane	0.2	0.17	20000	3.6
Mineral insulation	14.0	0.040	1	7.0
Vapour barrier	0.3	0.17	1500	3.3
KSE 228	22.8	0.223	50	48.4



Structure thickness	Structure mass	Load	Fire protection	Thermal protection	Airborne sound	Impact sound
h_{ges} (cm)	ρ_{ges} (kg/m²	g (kN/m²)	REI (min)	U-Wert (W/m²K)	R_w (dB)	L_{nTw} (dB)
37.3	62.3	1.39	30 to 60 depending on KSE type	0.21	50 dB	-

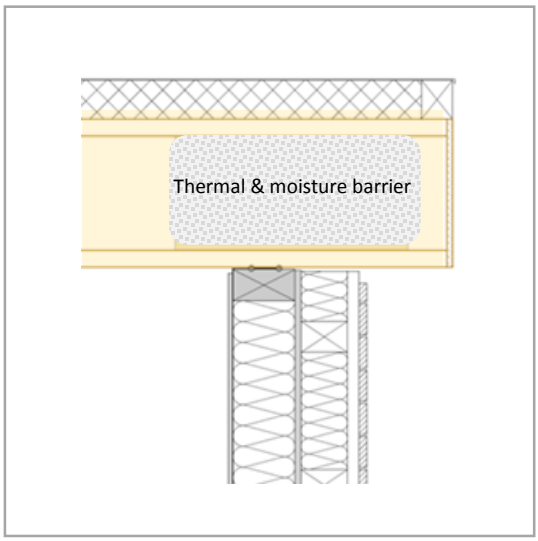
Details

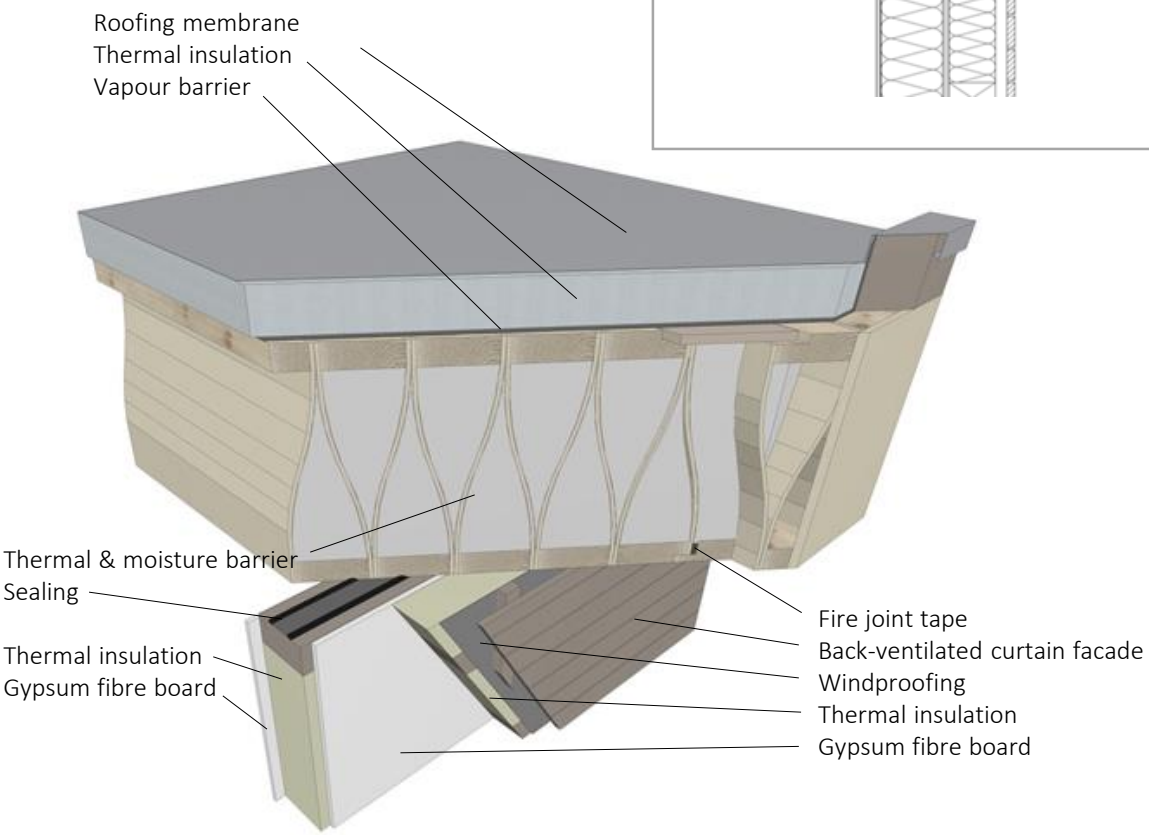
Suggested constructions

On the following pages you will find a selection of suggested construction details to help designing structures with KIELSTEG elements. The fastening parameters such as the number and dimensions of fasteners, their minimum spacing and edge spacing, need to be decided upon in individual cases. In principle, all details must be evaluated structurally and in terms of building physics for each individual case. The details shown here do not claim to be complete and should serve as a starting point for your own design work. We will always be glad to advise you on other constructions and possible solutions.

Construction detail 01

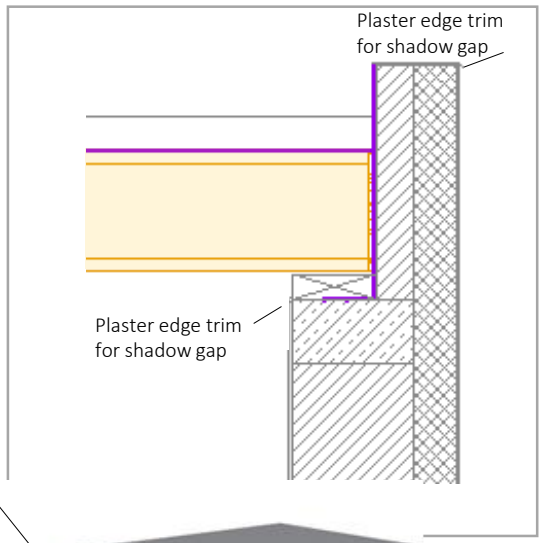
Support: wooden framework wall
Facade: back-ventilated facade

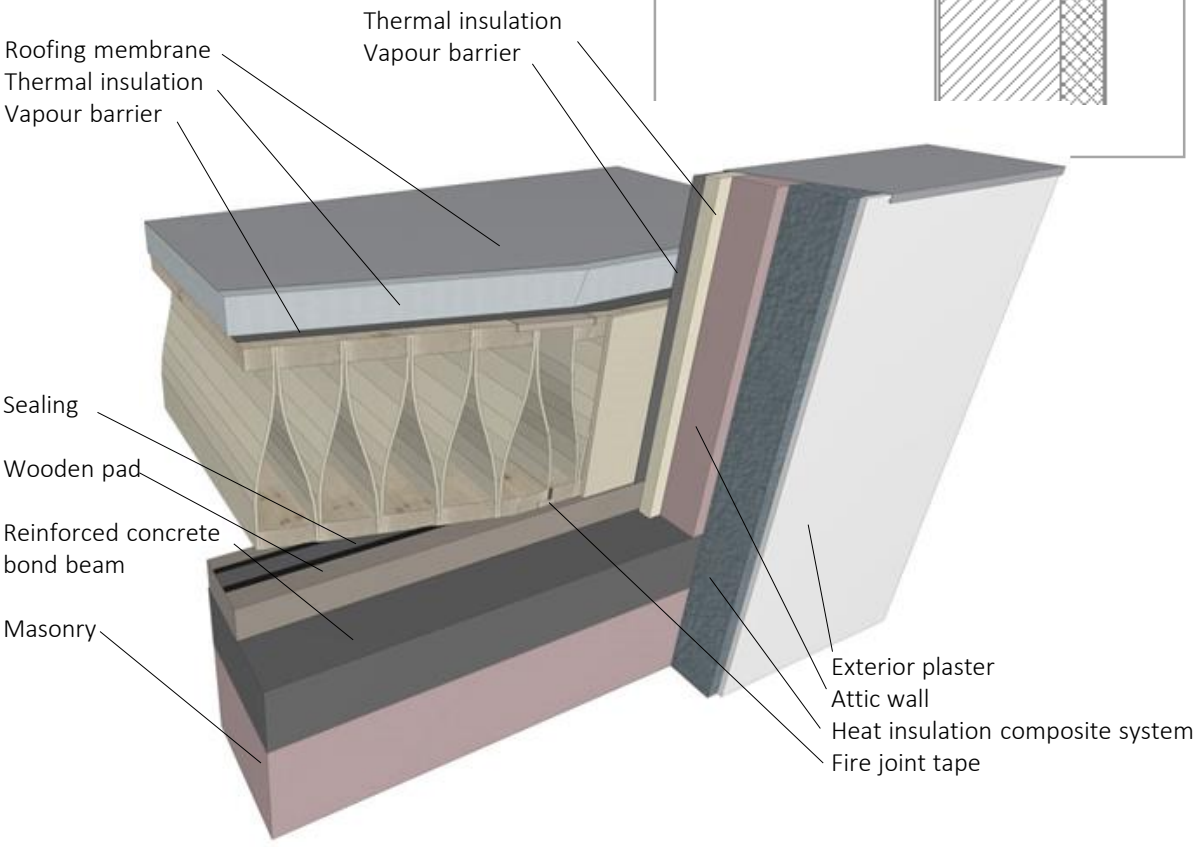




Construction detail 02

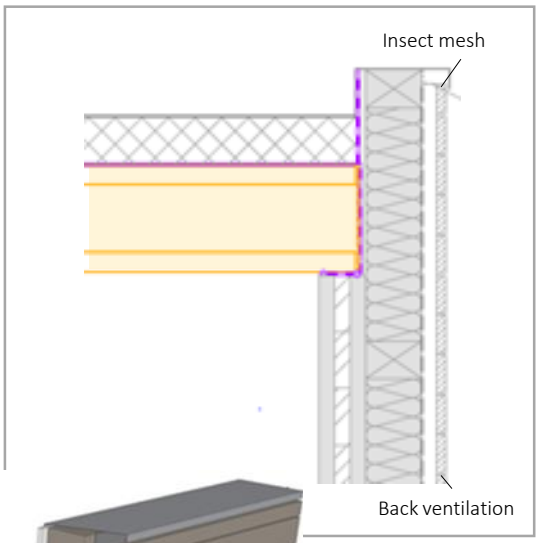
Support: masonry wall
Facade: exterior insulation finishing system

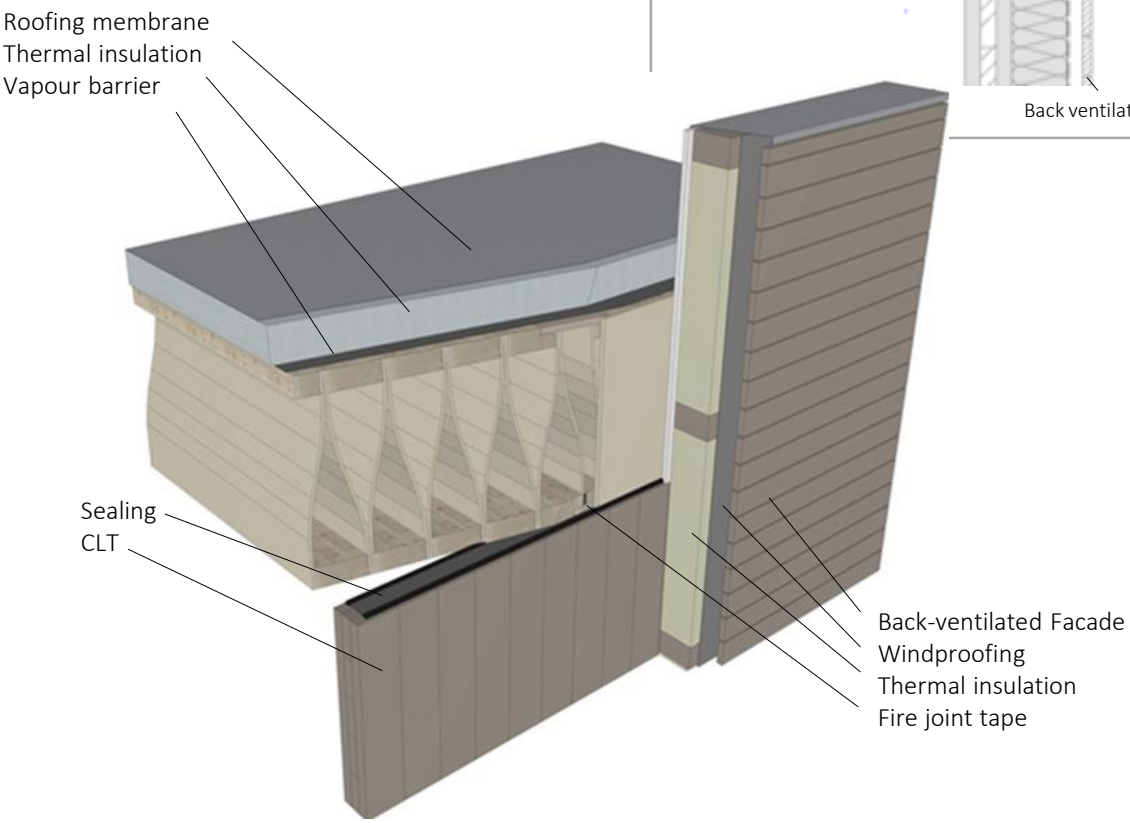


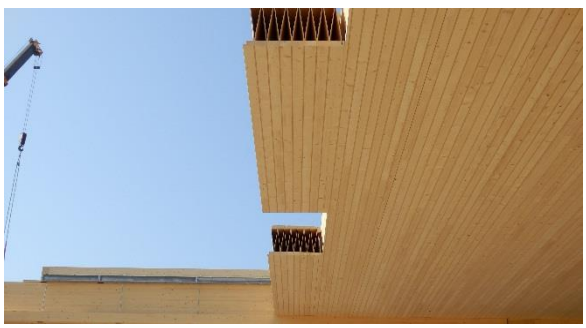


Construction detail 03

Support: crosslaminated timber (CLT)
Facade: back-ventilated facade

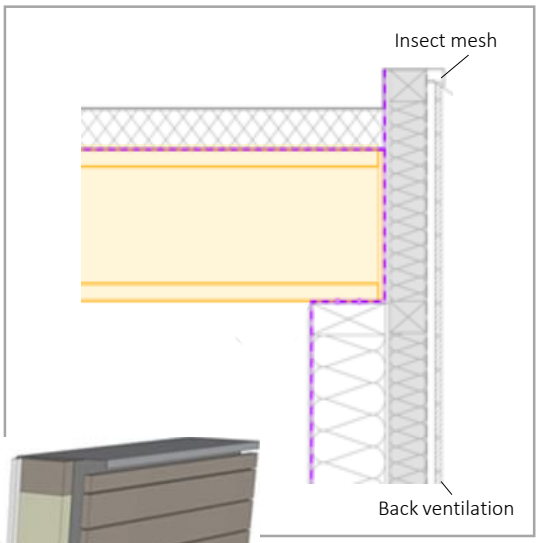


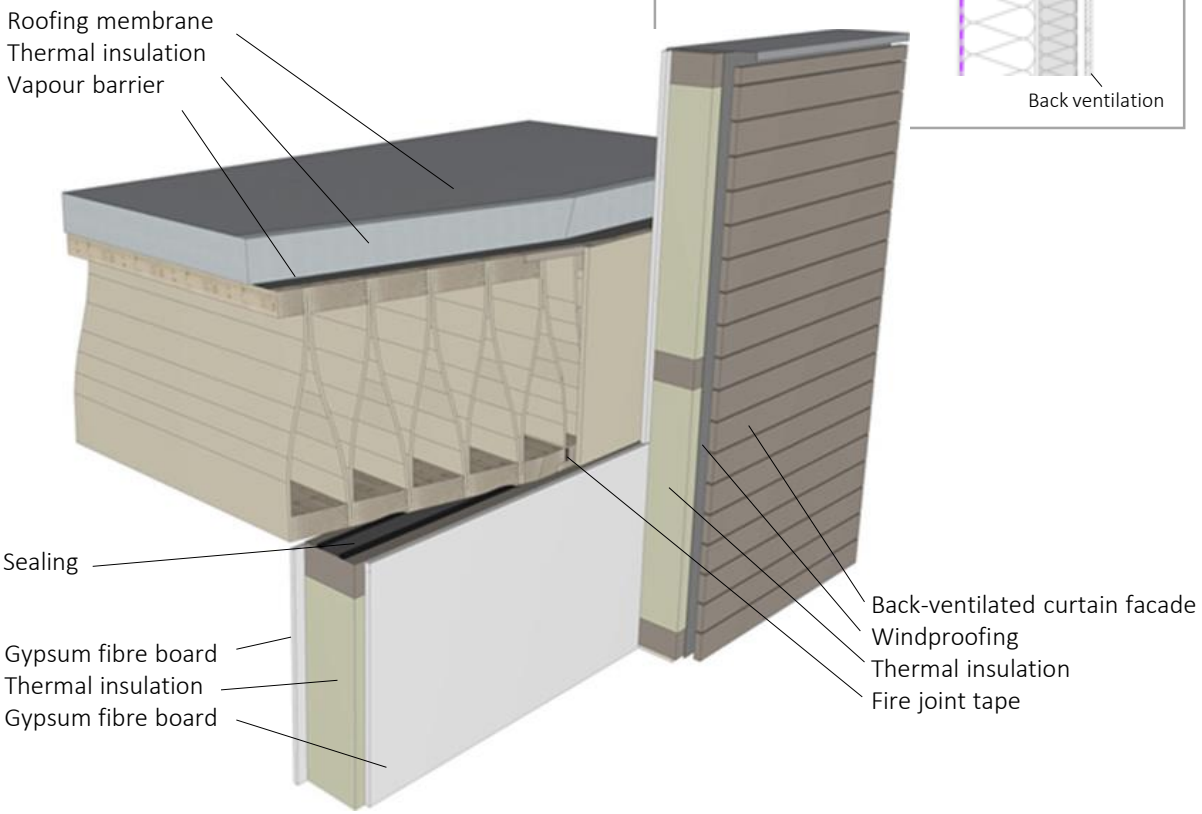




Construktion detail 04

Support: wooden framework wall
Facade: back-ventilated facade





Standard support configurations

On the following pages you will find construction principles for laying KIELSTEG elements on different types of supporting structure. As examples, the diagrams also show the joints between KIELSTEG and a variety of possible facade systems.

1. Wooden framework wall

2. CLT wall

3. Glulam beam

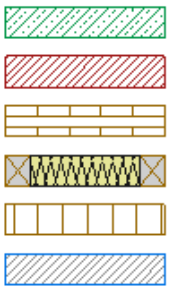
4. Concrete wall

5. Steel beam

Legend to construction details

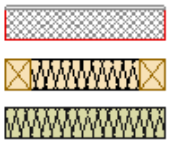
Load-bearing substructure:

- Steel-reinforced concrete
- Masonry
- CLT
- Wooden framework wall
- Glulam
- Steel



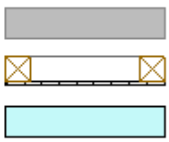
Thermal insulation:

- Exterior insulation finishing system
- Wooden framework wall
- Insulation material



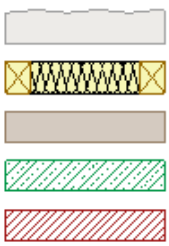
Interior surfacing:

- Plaster
- Interior drywall cladding
- Gypsum plasterbord



Parapet walls:

- PUR sandwich panels
- Wooden framework wall
- Wood bord
- Steel-reinforced concrete
- Masonry

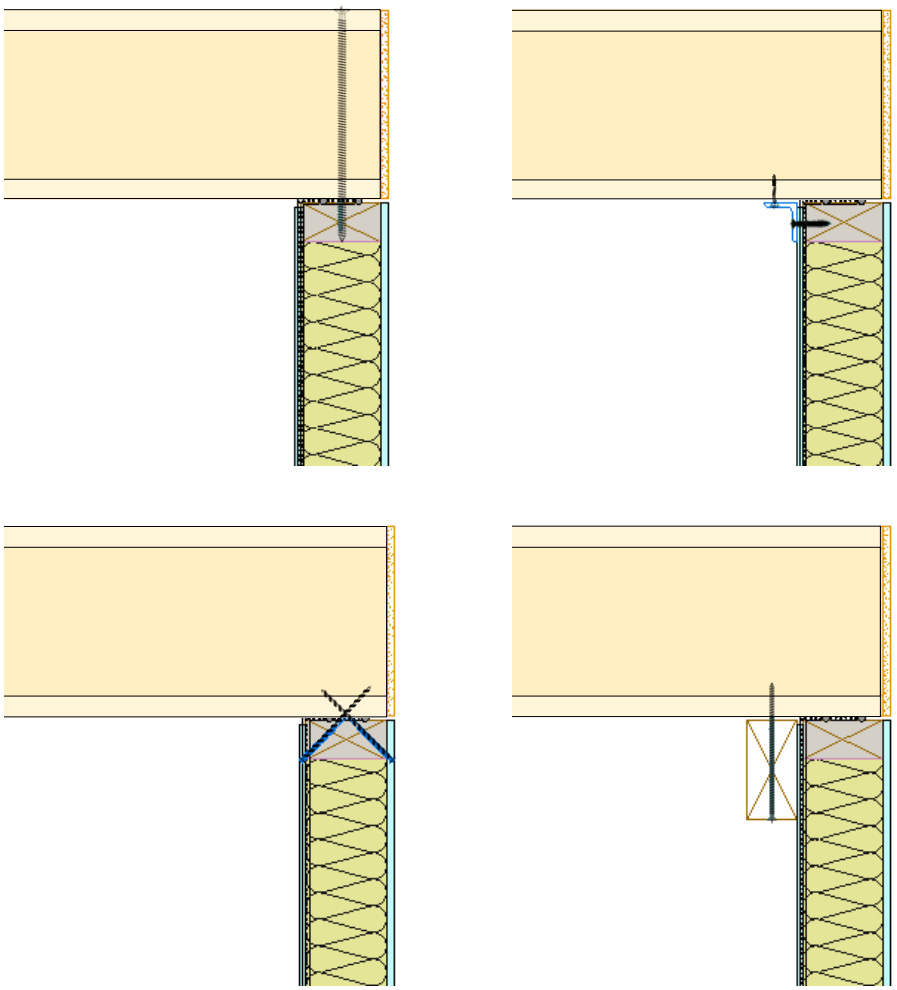


Other:

- Thermal & moisture barrier
- Vapour barrier
- Seal
- OSB
- Windproofing

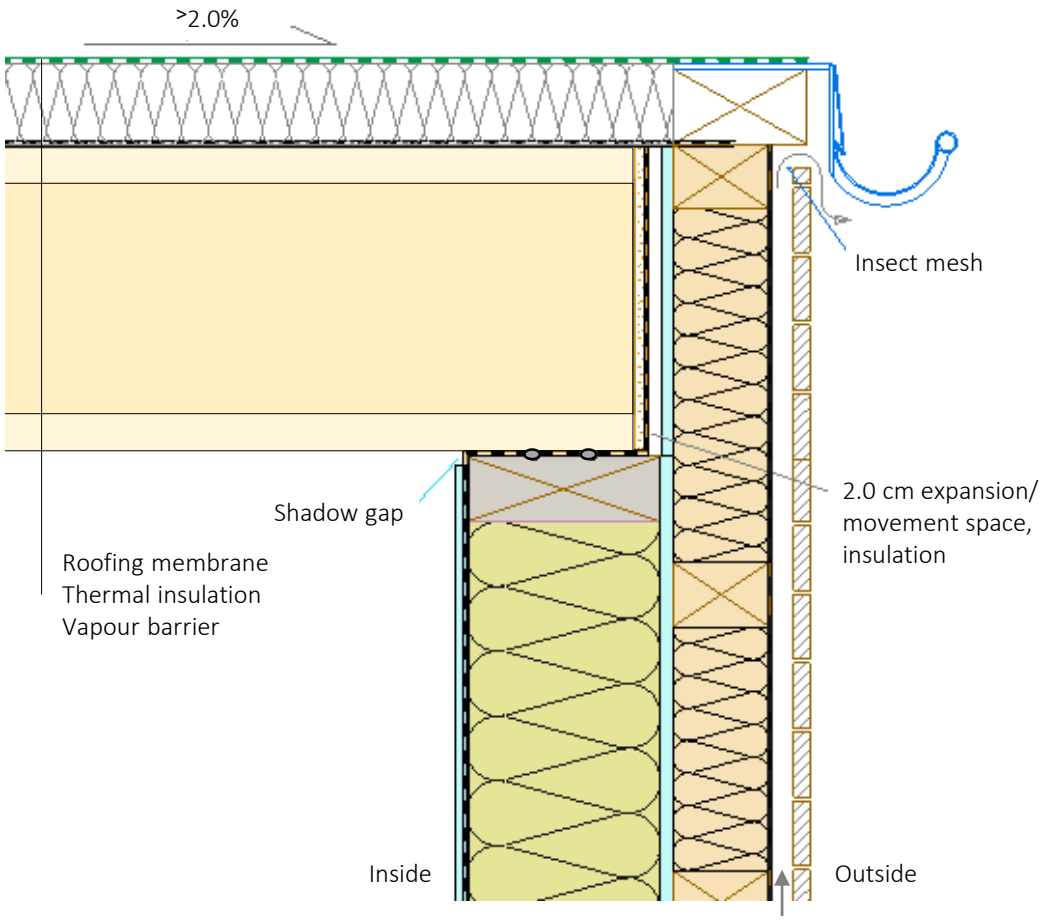
1. KIELSTEG on wooden framework wall

Standard screw fastening configurations



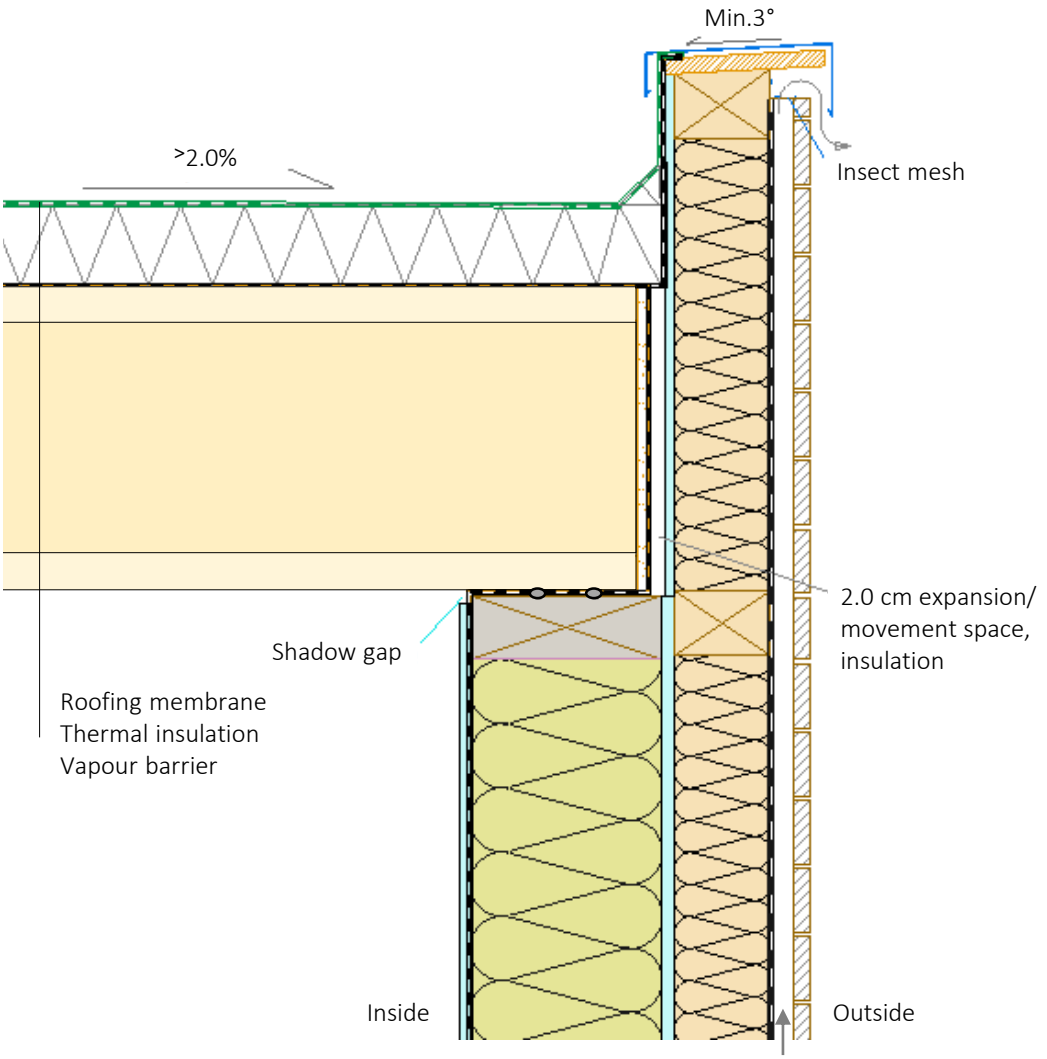
1.1 Wooden framework wall, roof edge with gutter

Facade: back-ventilated curtain facade



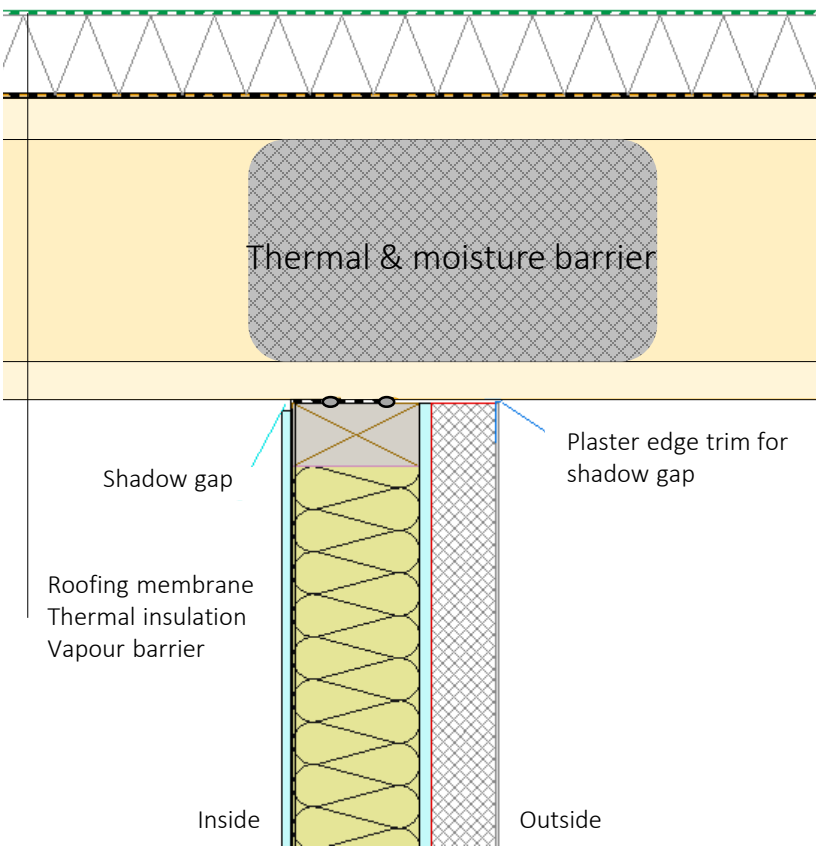
1.2 Wooden framework wall with parapet

Facade: back-ventilated curtain facade



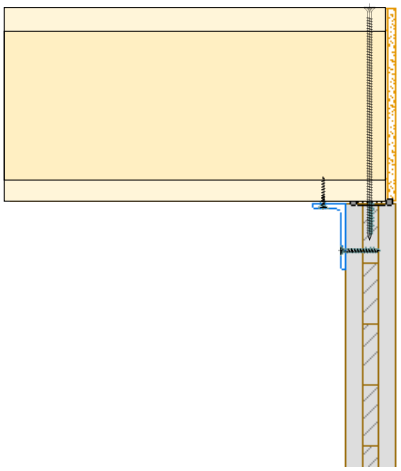
1.3 Wooden framework wall, cantilevered projecting roof

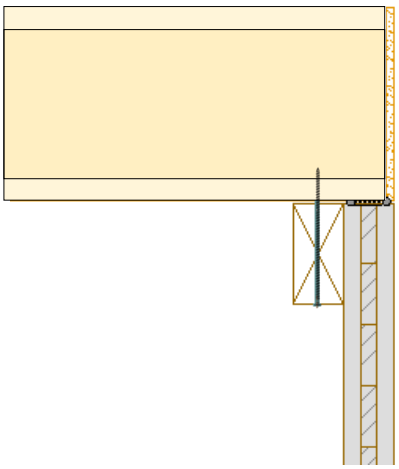
Facade: Exterior insulation finishing system

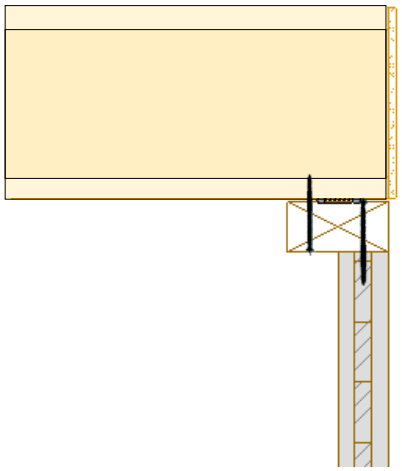


2. KIELSTEG on CLT wall

Standard screw fastening configurations

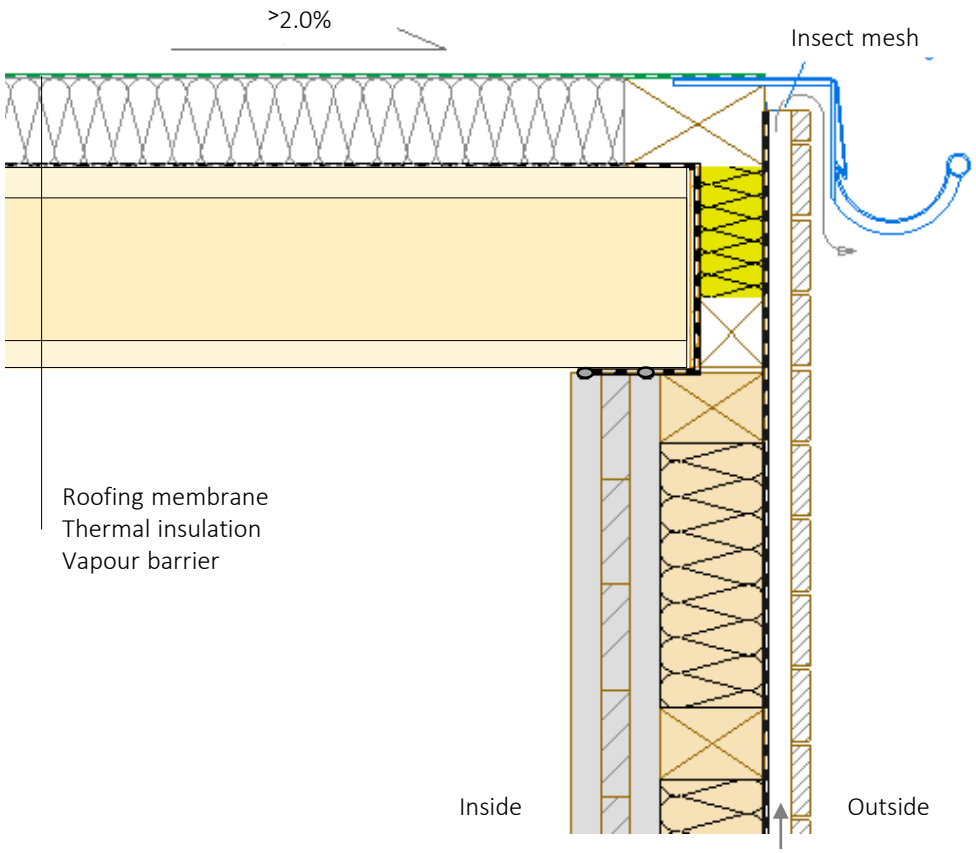






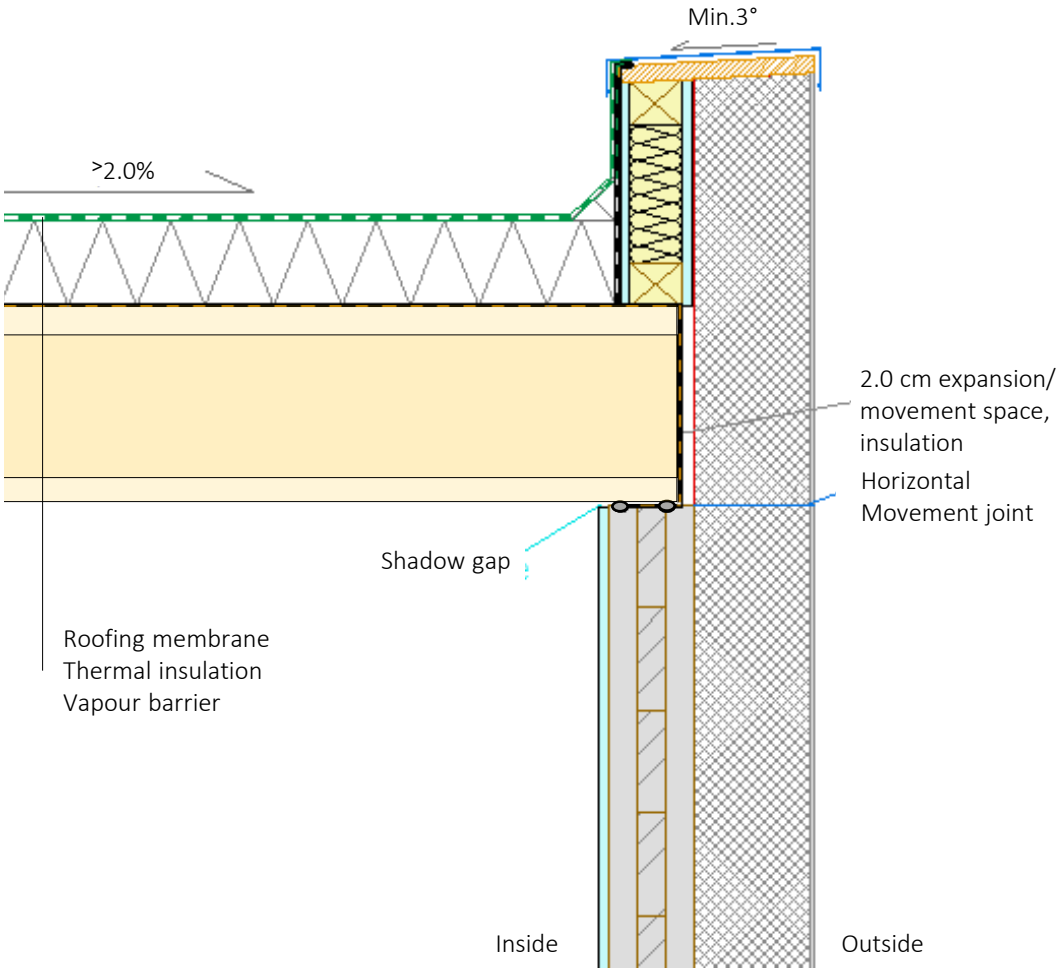
2.1 CLT wall, roof edge with gutter

Facade: back-ventilated curtain facade



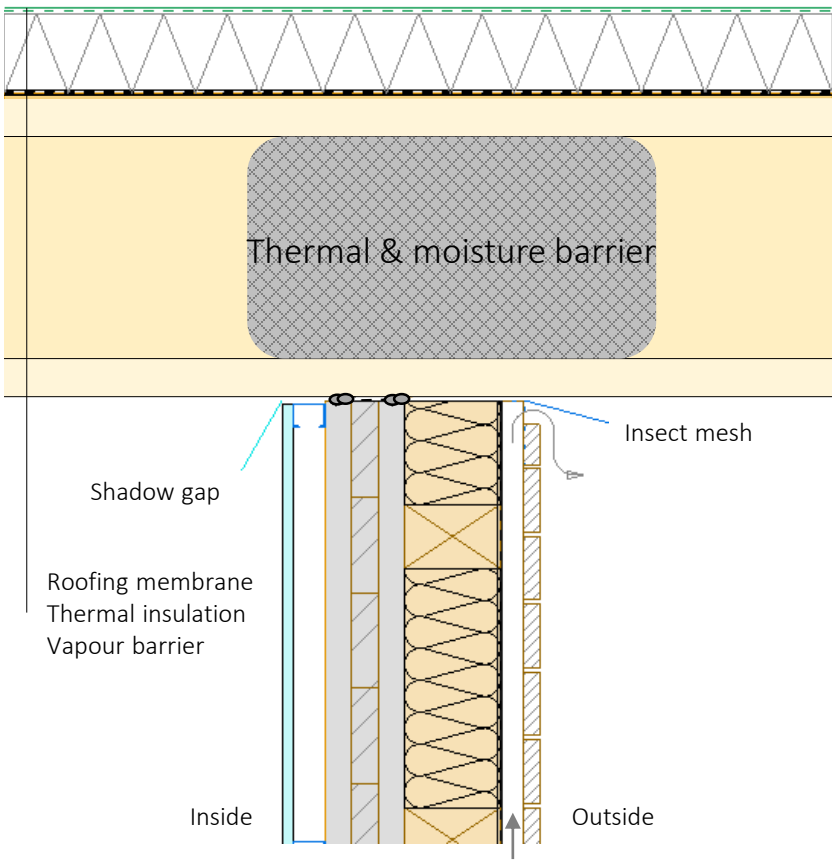
2.2 Parapet detail, CLT wall

Facade: Exterior insulation finishing system



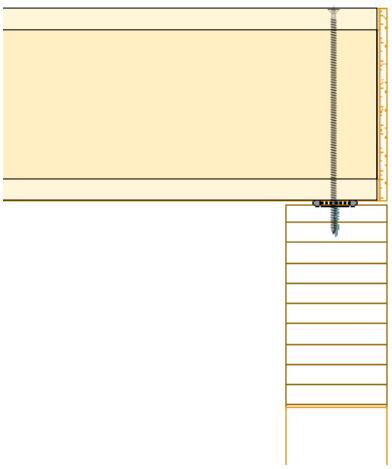
2.3 CLT wall, cantilevered projecting roof

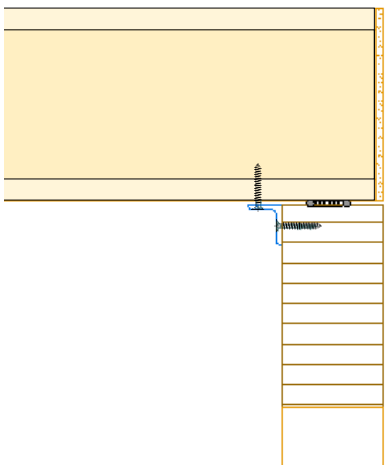
Facade: back-ventilated curtain facade

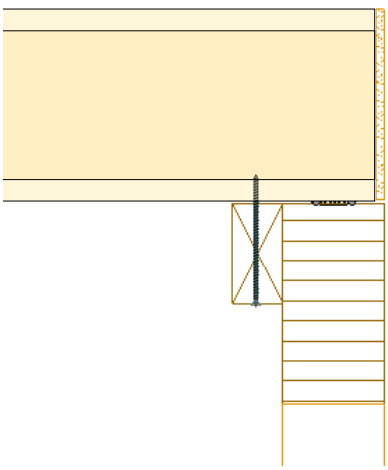


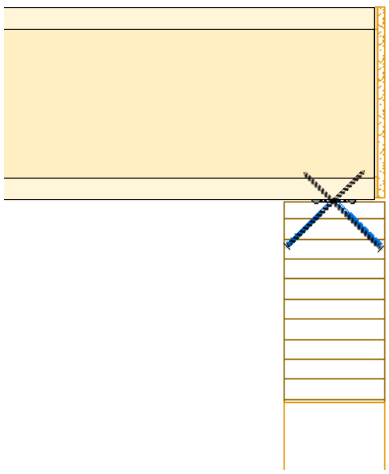
3. KIELSTEG on glulam beam

Standard screw fastening configurations



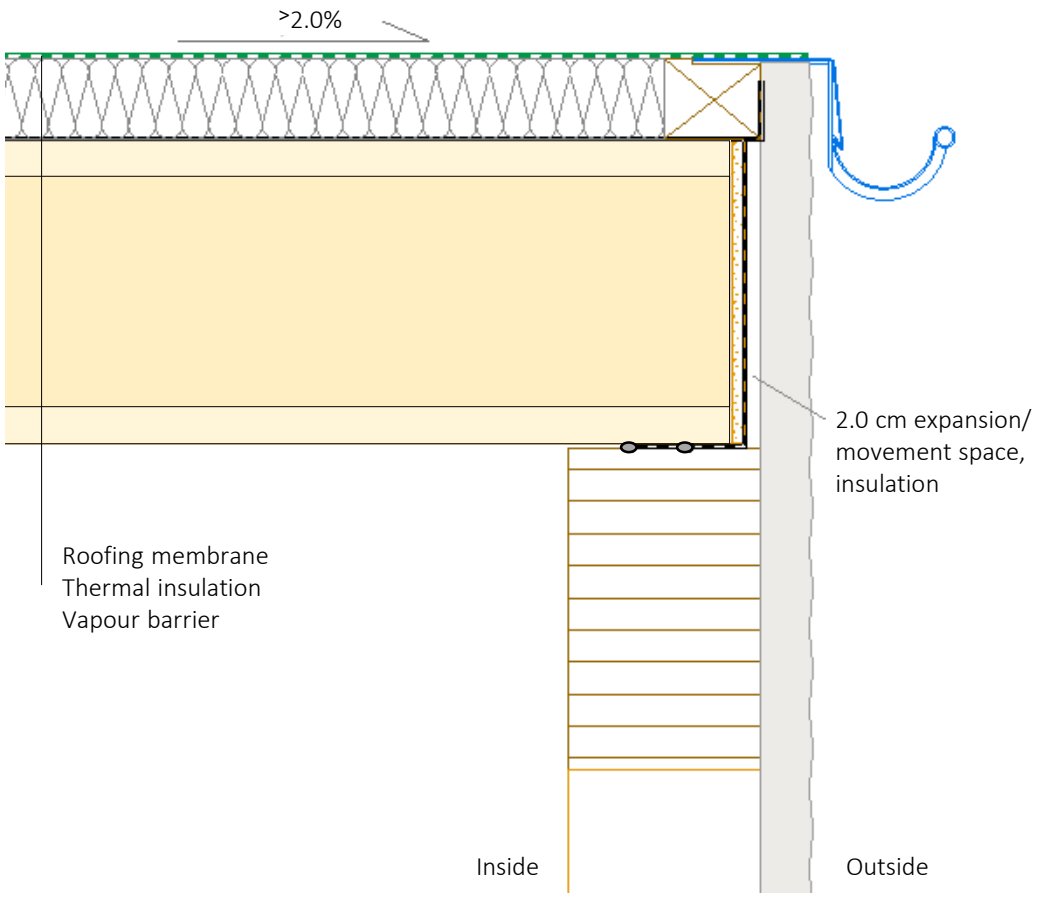






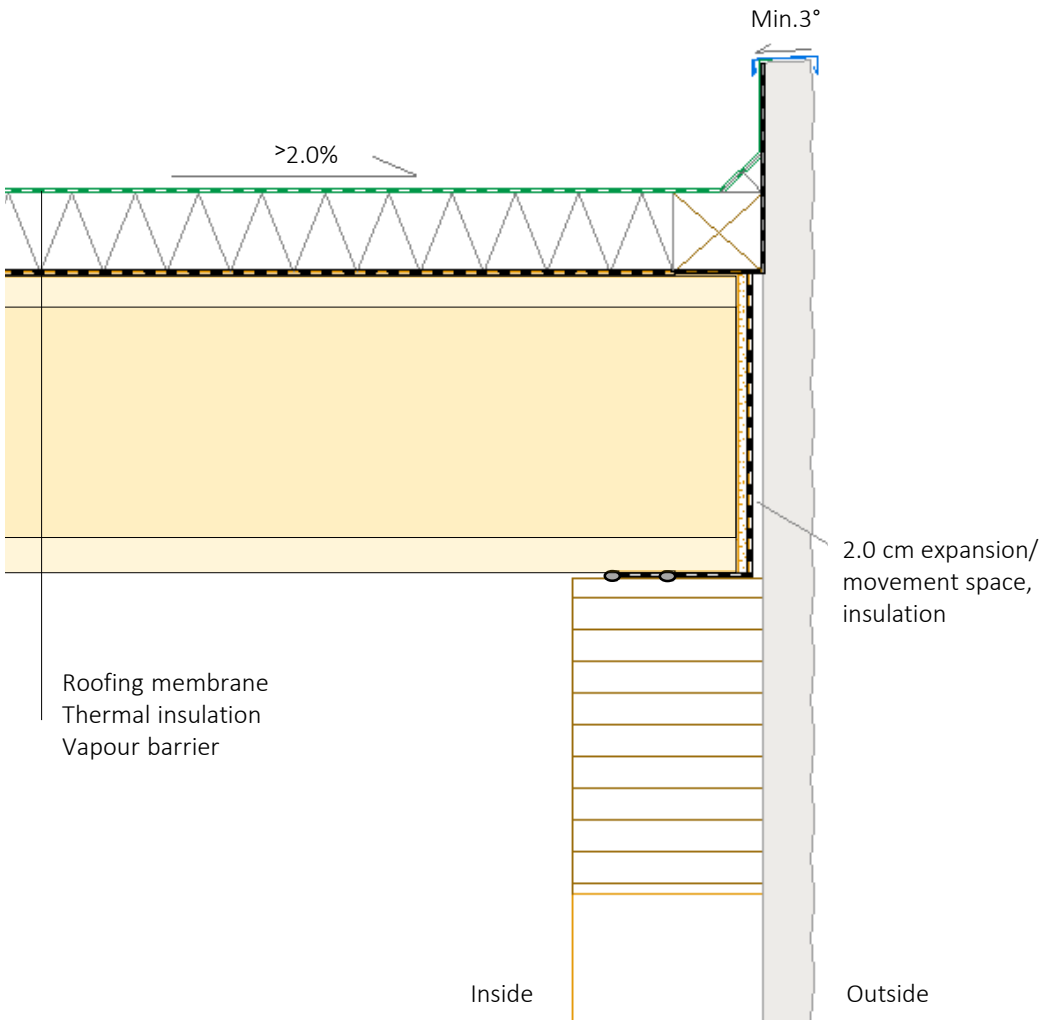
3.1 Glulam beam, roof edge with gutter

Facade: PUR sandwich panels



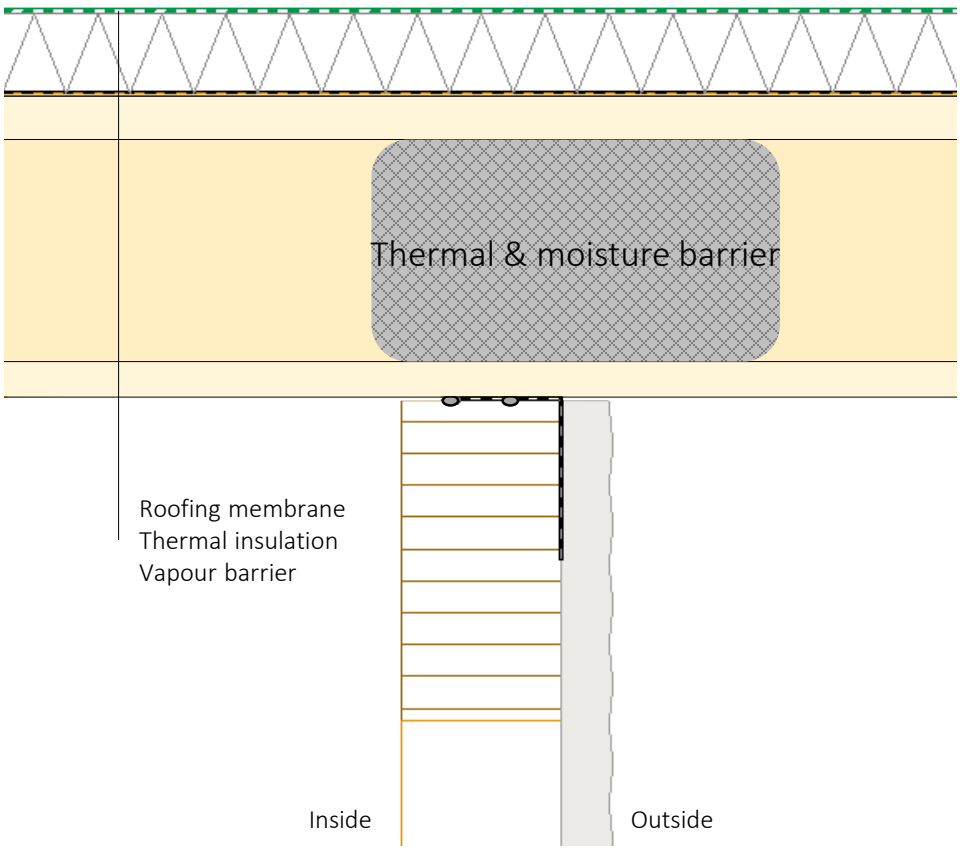
3.2 Parapet detail, glulam beam

Facade: PUR sandwich panels



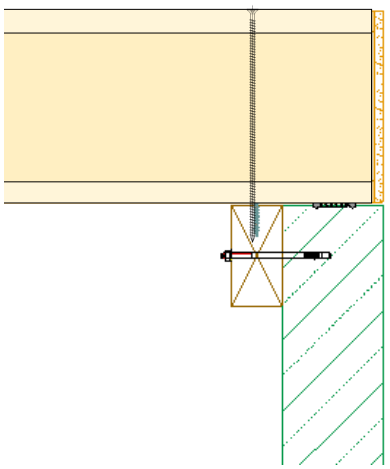
3.3 Glulam beam, cantilevered projecting roof

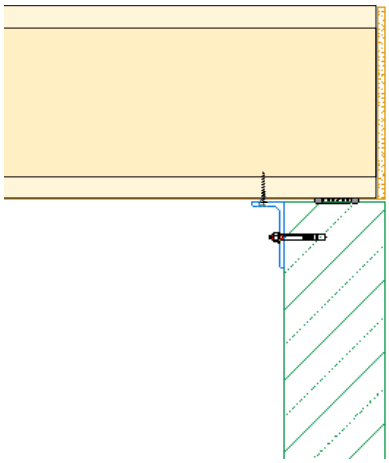
Facade: PUR sandwich panels

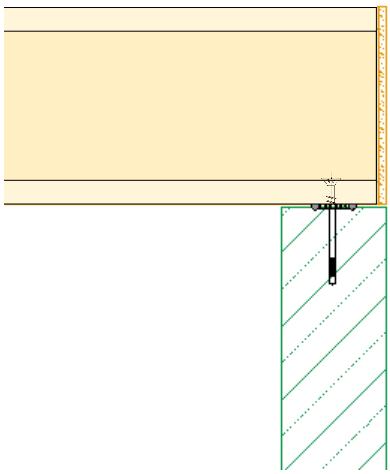


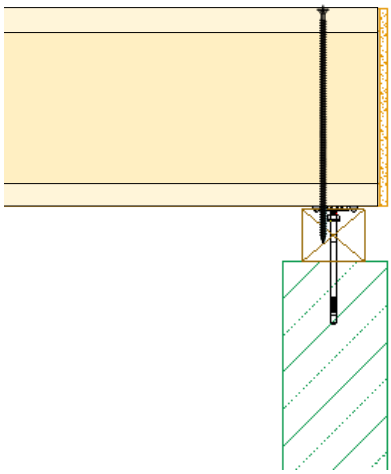
4. Masonry or concrete wall

Standard screw fastening configurations



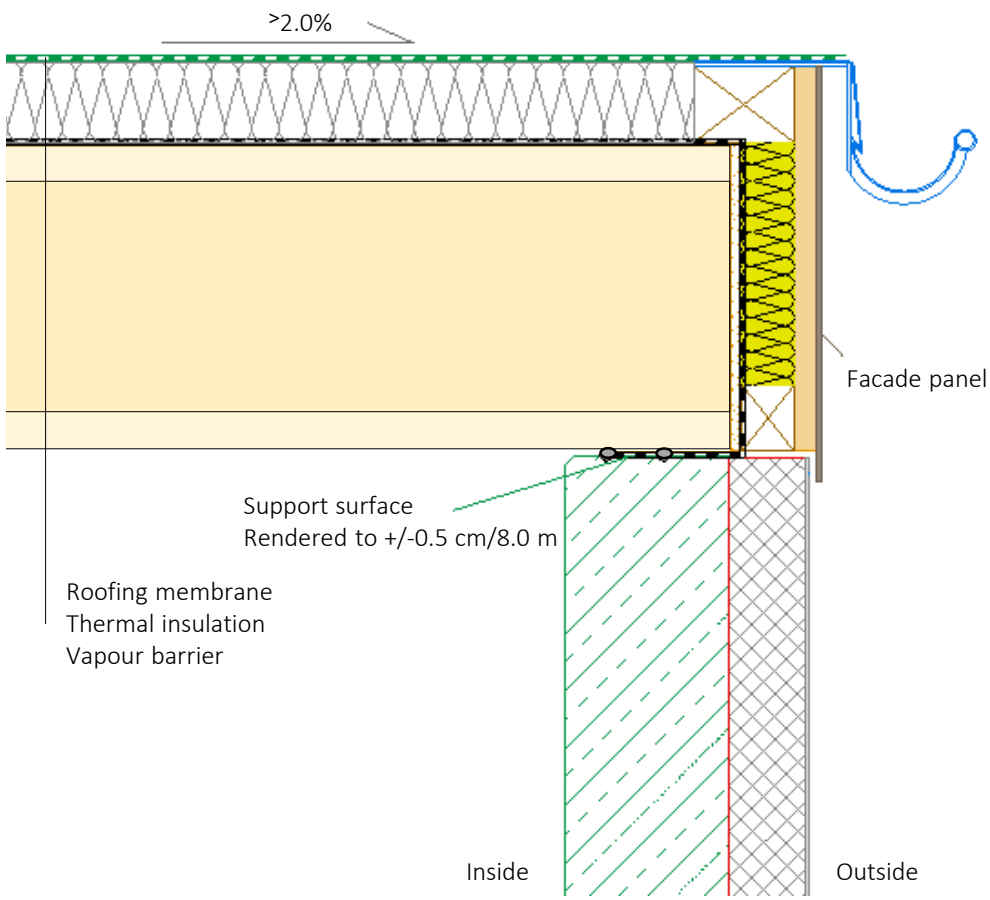






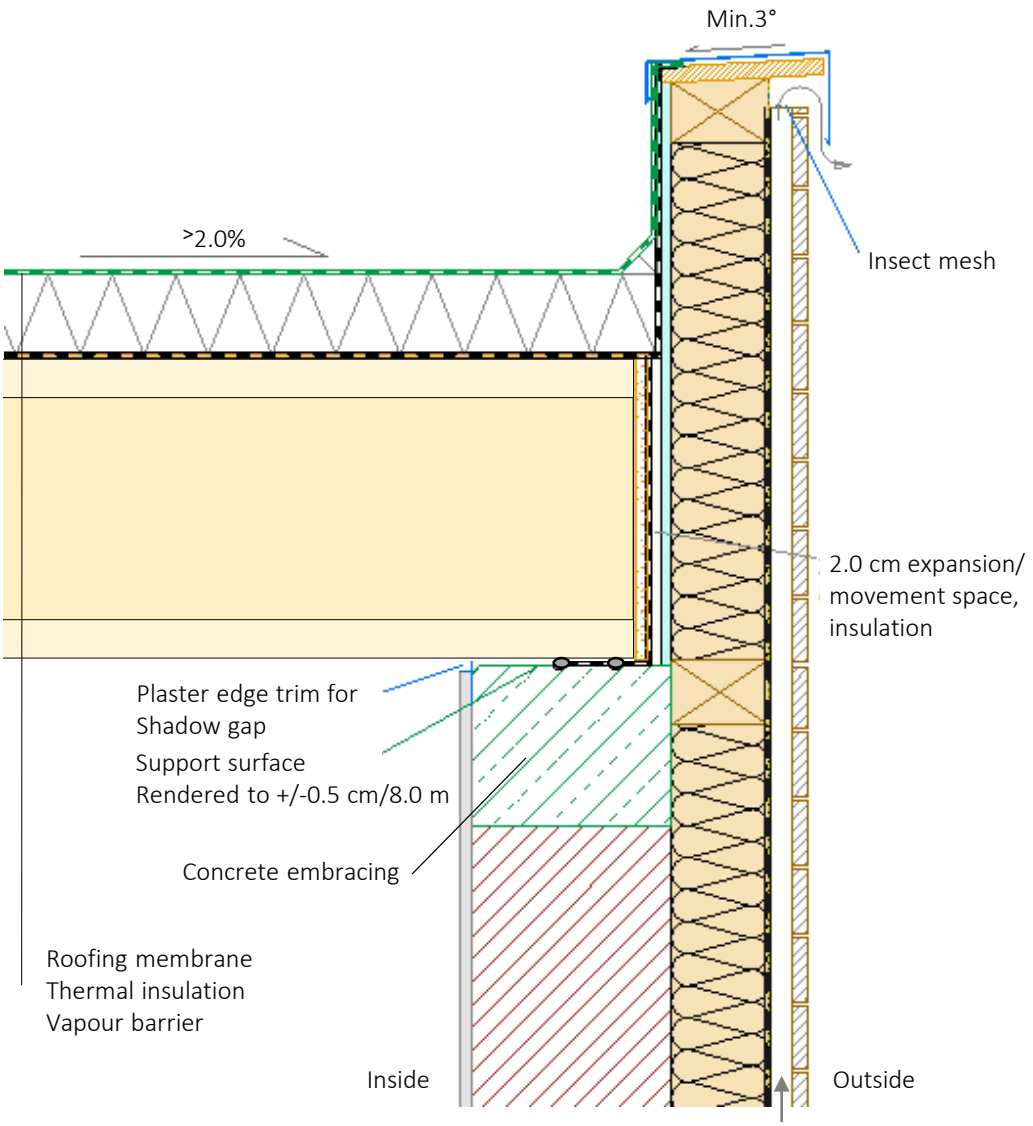
4.1 Concrete wall, roof edge with gutter

Facade: Exterior insulation finishing system



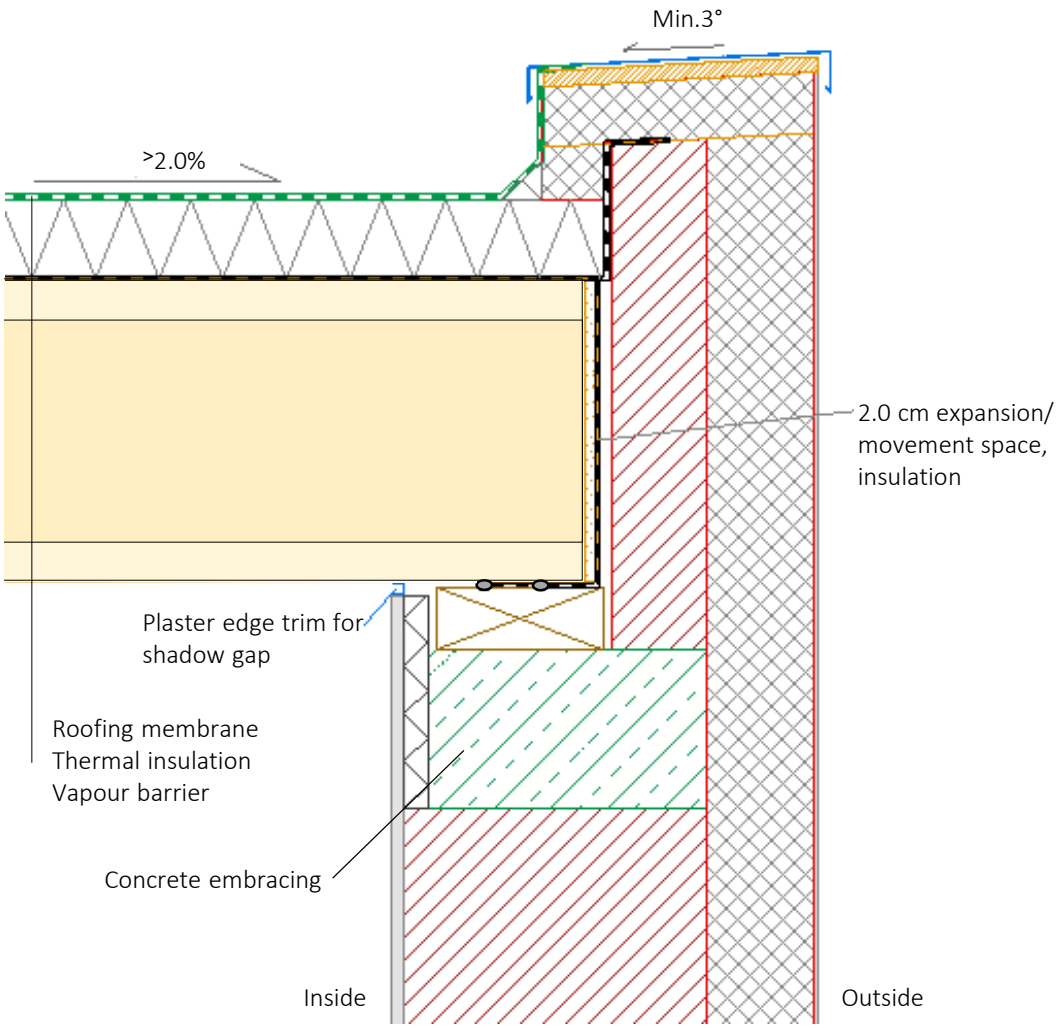
4.2 Parapet detail: masonry wall

Facade: back-ventilated curtain facade



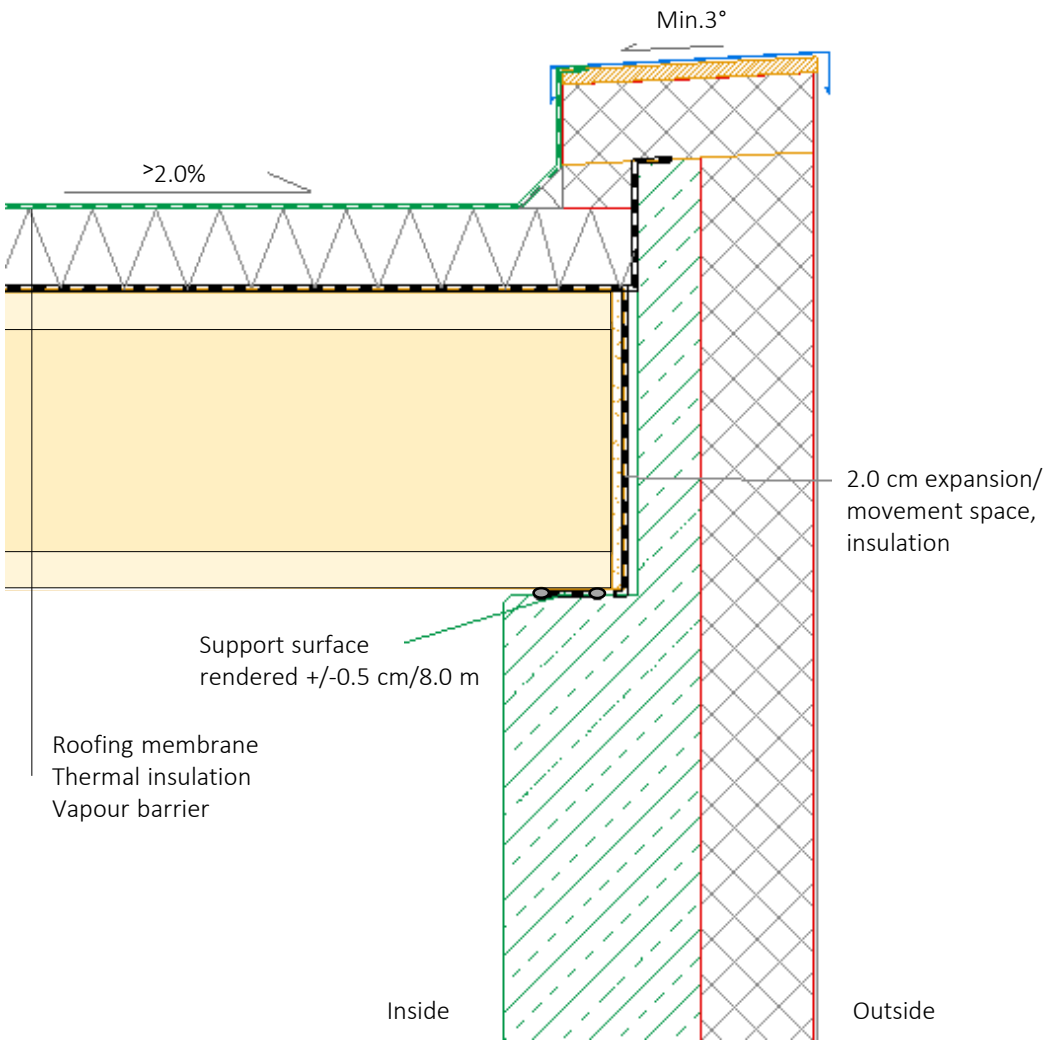
4.3 Parapet detail: masonry wall

Facade: Exterior insulation finishing system



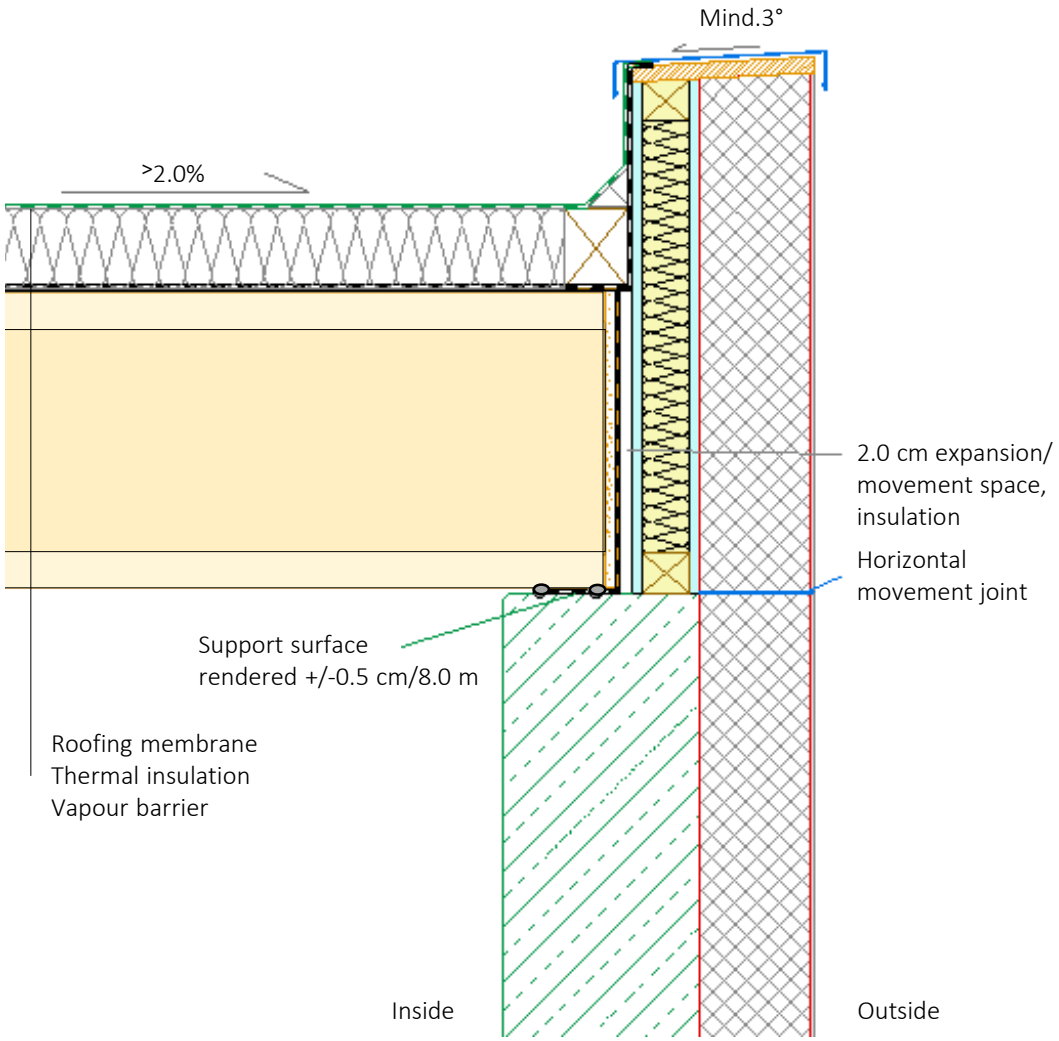
4.4 Parapet detail: concrete wall

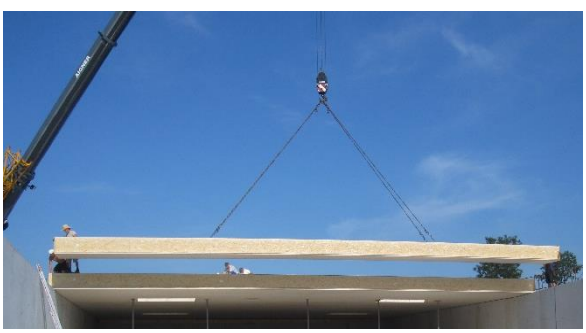
Facade: Exterior insulation finishing system



4.5 Parapet detail: concrete wall

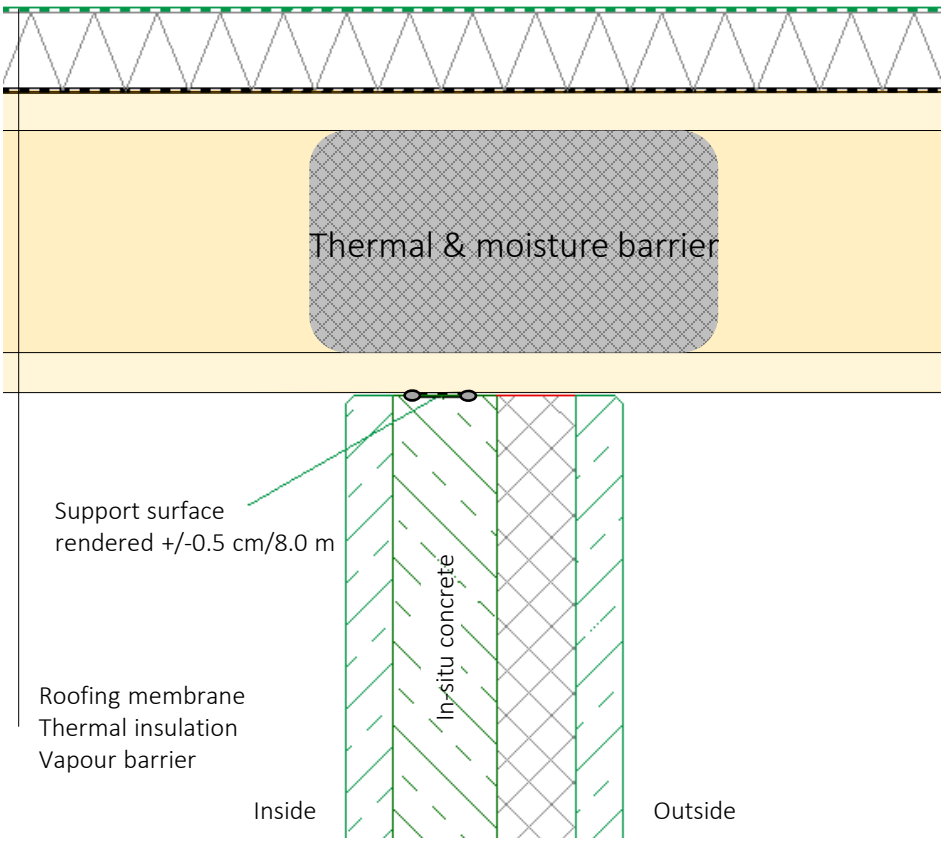
Facade: Exterior insulation finishing system





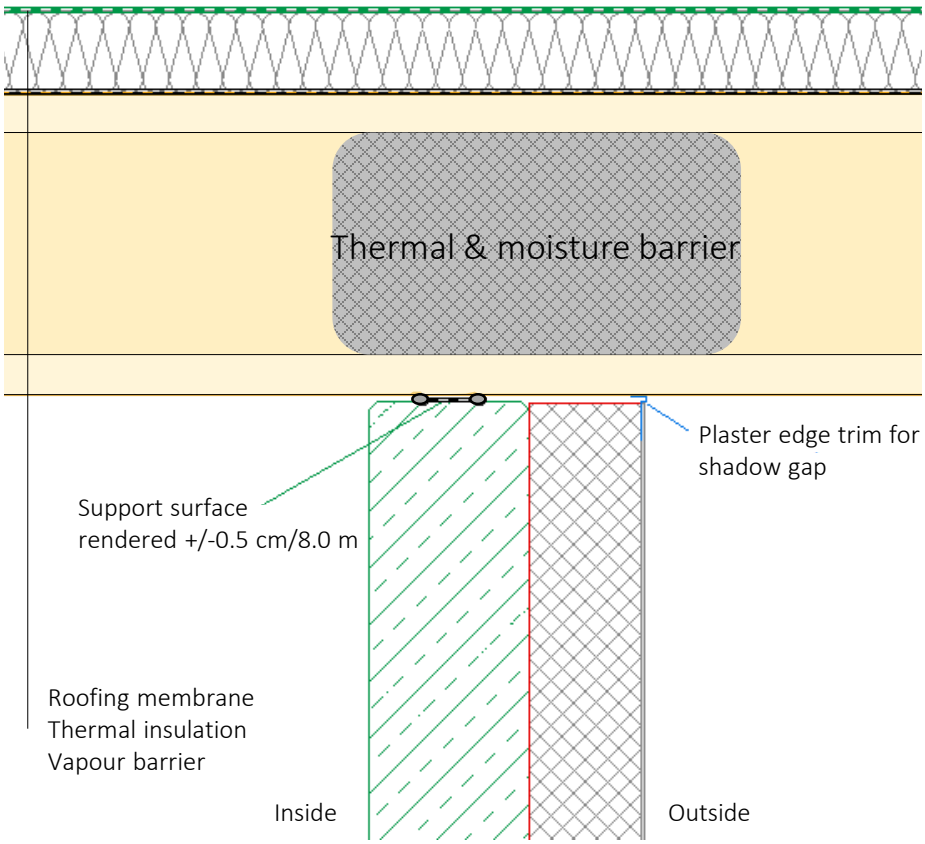
4.6 Concrete wall, cantilevered projecting roof

Facade: 3-layer prefabricated insulated wall



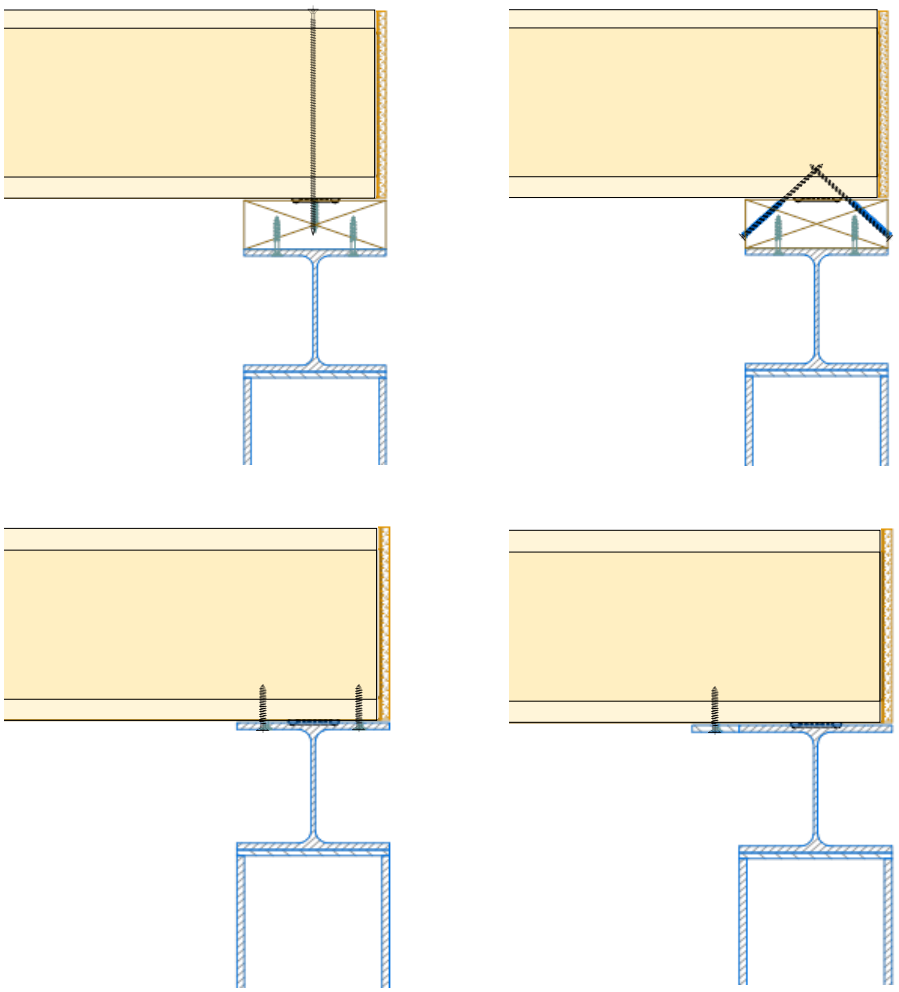
4.7 Concrete wall, cantilevered projecting roof

Facade: Exterior insulation finishing system



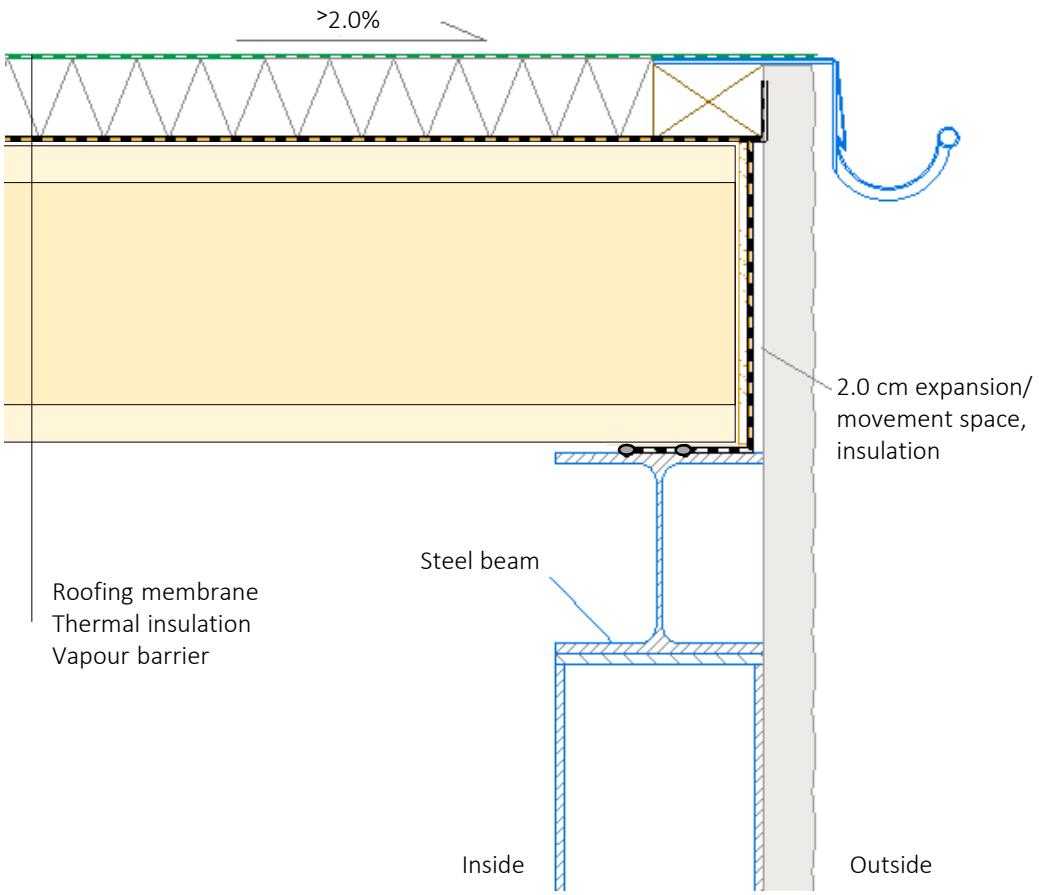
5. KIELSTEG on steel beam

Standard screw fastening configurations



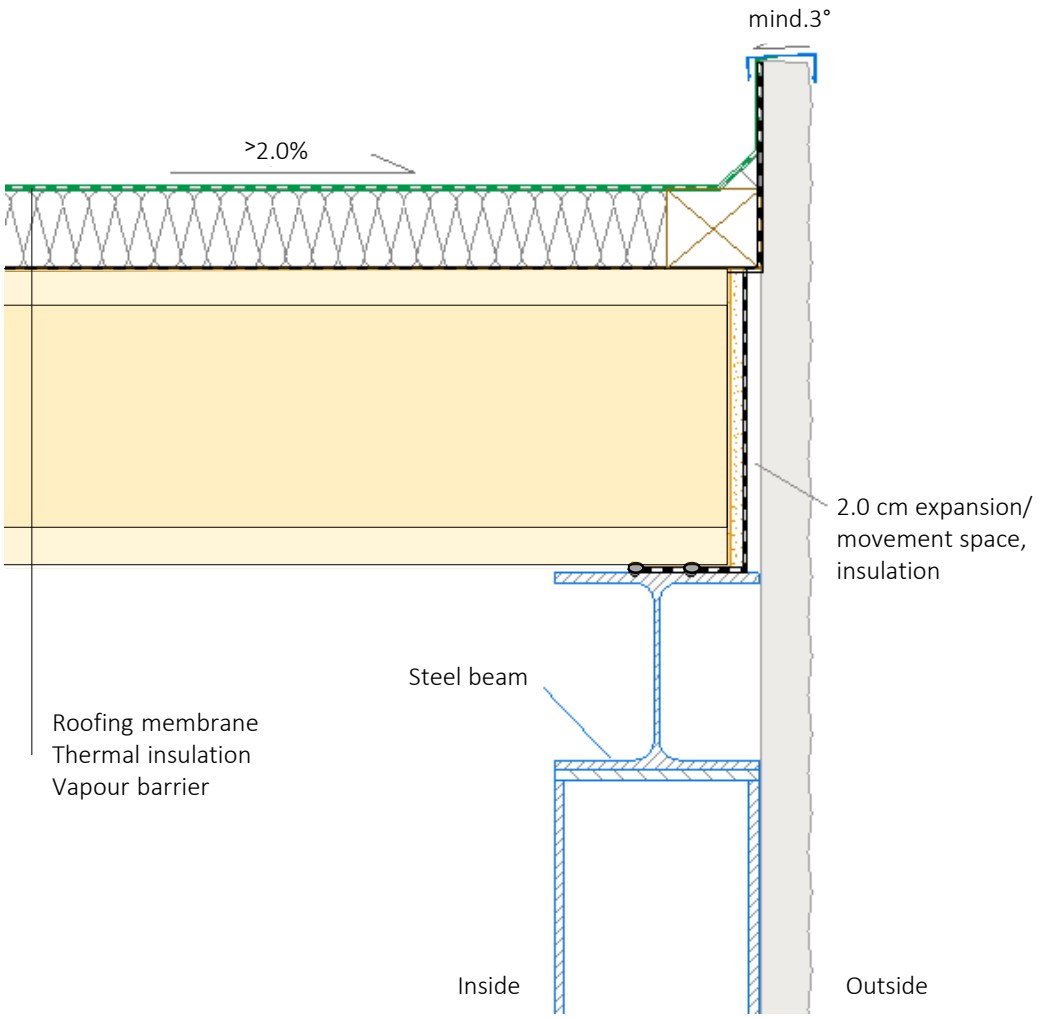
5.1 Steel beam, roof edge with gutter

Facade: PUR sandwich panels



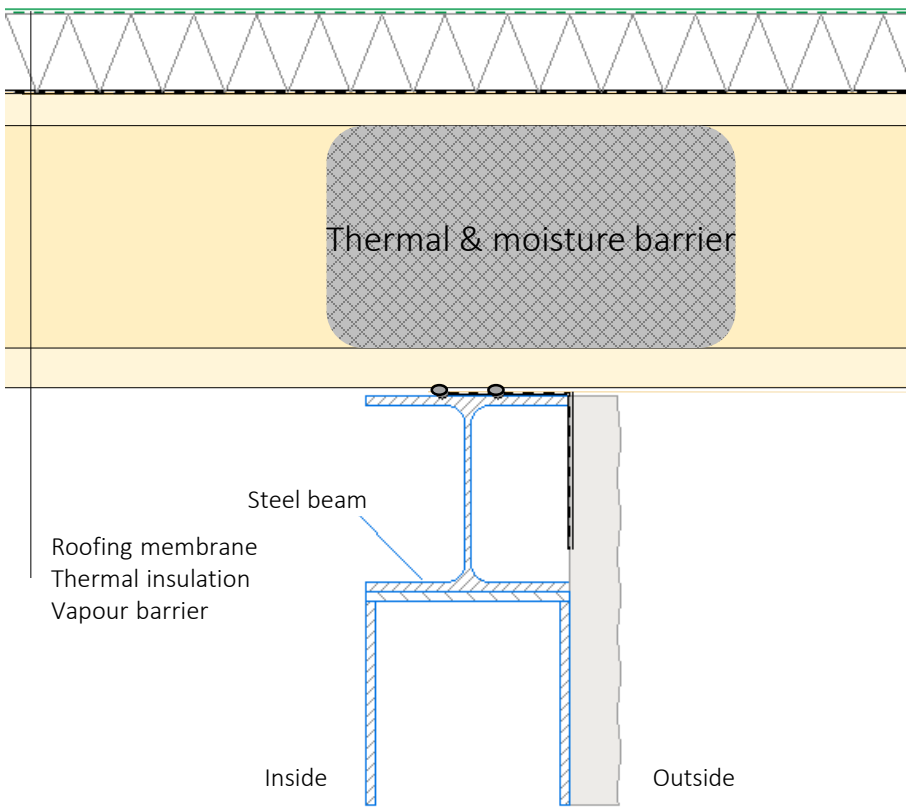
5.2 Parapet detail: steel beam

Facade: PUR sandwich panels



5.3 Steel beam, cantilevered projecting roof

Facade: PUR sandwich panels



Sample box

We are here for you

We want to make sure you have professional support for your project from beginning to end. Below you will find the contact details of the KIELSTEG representatives for your country. You can order the free KIELSTEG sample box by e-mail or telephone. We will send you one straight away. The sample box contains a sample of KIELSTEG and a description of its main advantages.

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