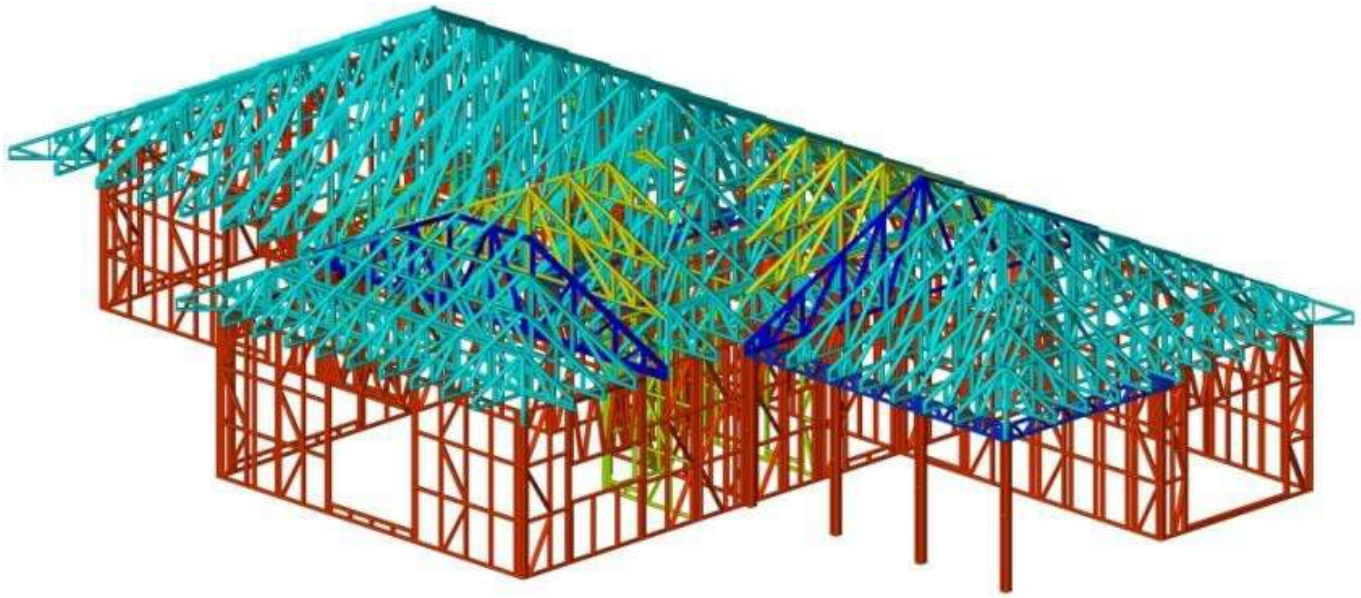
Specification for the Design of Structures Using a Structural Steel Building System



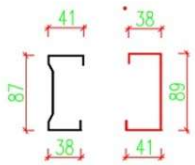
Contents of the Design Specification for Structures Using a Structural Steel Building System:

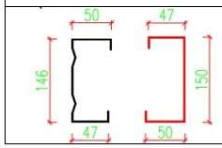
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1. What Is a Structural Steel System

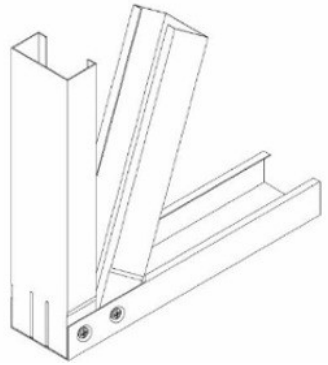
A structural steel system is a complete structural system designed for the manufacture and construction of residential, industrial and agricultural buildings. It is a frame (wall-frame) system in which individual profiles made from load-bearing galvanised steel sheet are interconnected to form a relatively rigid structure. The resulting frame structure is then filled with mineral wool thermal insulation and clad on both sides with gypsum fibreboard or wood-based particle boards. This creates a rigid core to which the external thermal insulation system and internal finishing structures are added at a later stage of construction. The cladding process is identical to that used in timber-frame construction; the only difference is the material used for the structural frame — the aforementioned steel sheet.

The C-shaped profiles are manufactured by progressively roll-forming steel coil in a forming machine. The table below specifies the basic properties of the product range.

C-profile 89	Sheet thickness	Steel grade	Weight per linear metre	Zinc coating
	0.75 mm	S 550	1.107	Z 275
	0.95 mm	S 550	1.402	Z 275
	1.15 mm	S 550 / 350	1.697	Z 275
	1.55 mm	S 350	2.287	Z 275
	1.95 mm	S 350	2.878	Z 275

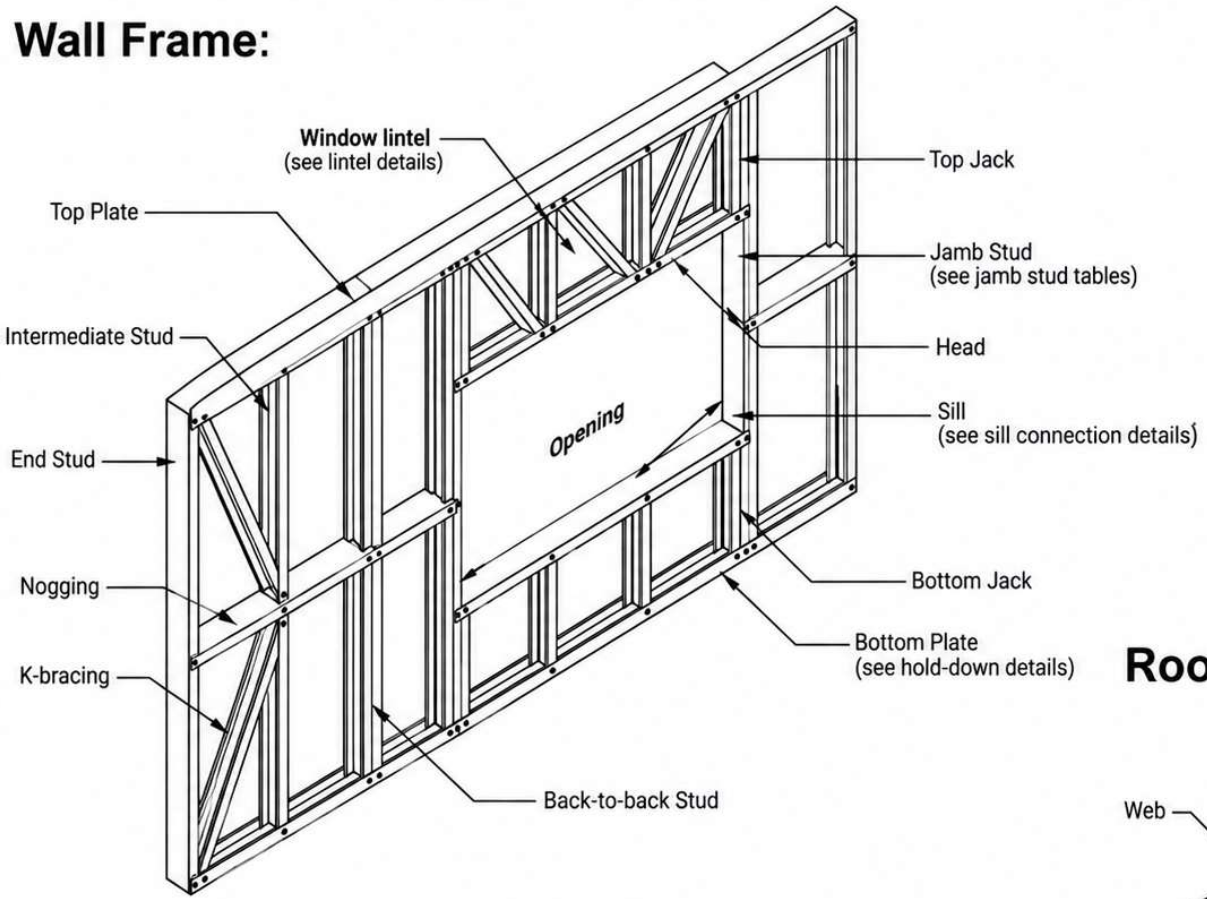
C-profile 150	Sheet thickness	Steel grade	Weight per linear metre	Zinc coating
	1.15 mm	S 350	2.390	Z 275
	1.95 mm	S 350	4.005	Z 275

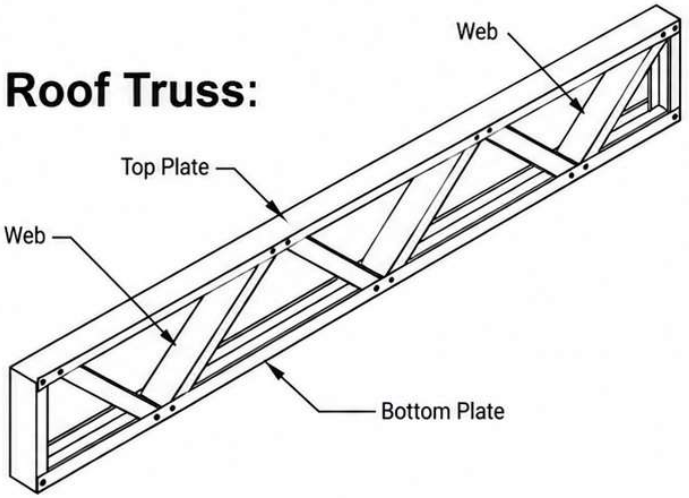
Detail of the connection between the stud, diagonal brace and bottom chord



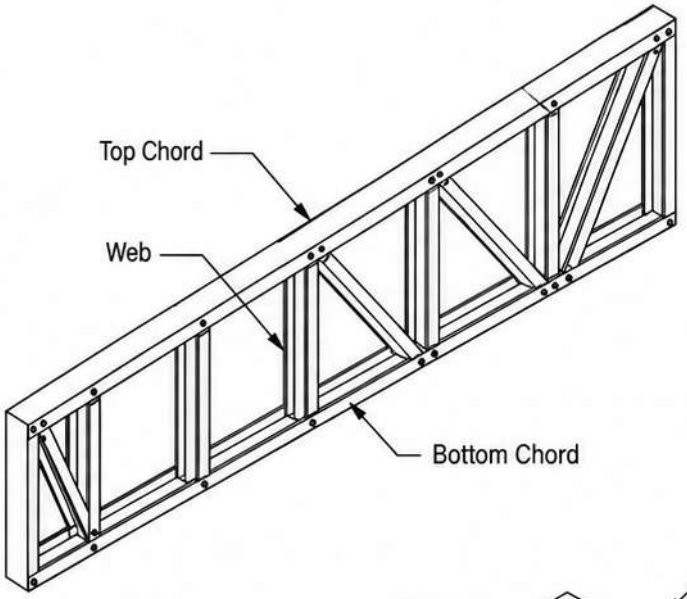
The C 89 and C 150 profiles listed above are designated as load-bearing profiles, meaning that they form the load-bearing structural elements of wall frames and ceiling and roof trusses. They can, of course, also be used in non-load-bearing structures, such as partition walls. Each profile series is manufactured in two slightly different shape and dimensional variants to ensure that one profile can fit perfectly into the other — see the detail drawing.

Terminology of the Individual Components of the Frame Structural System

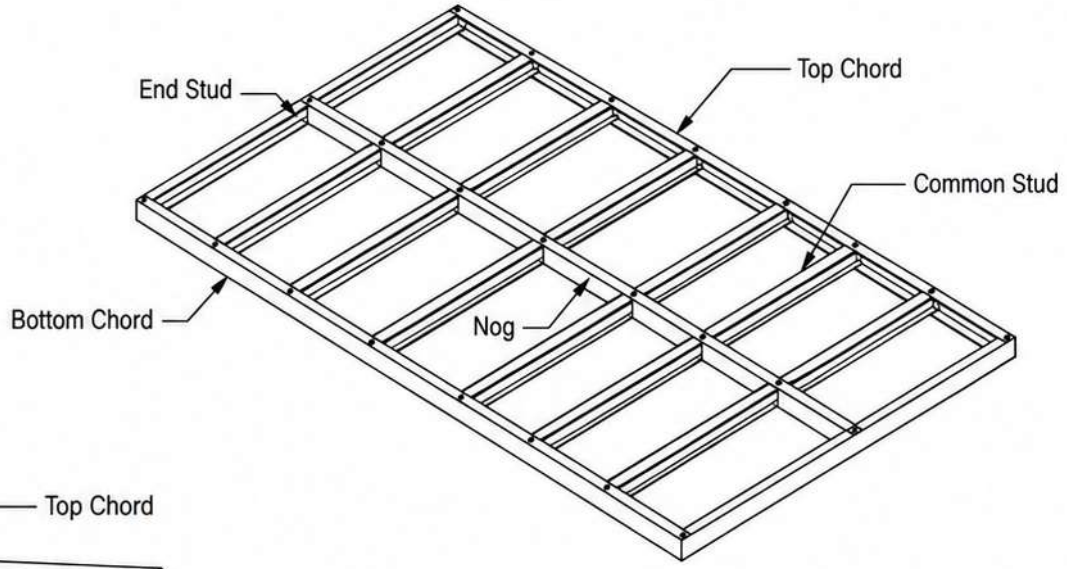


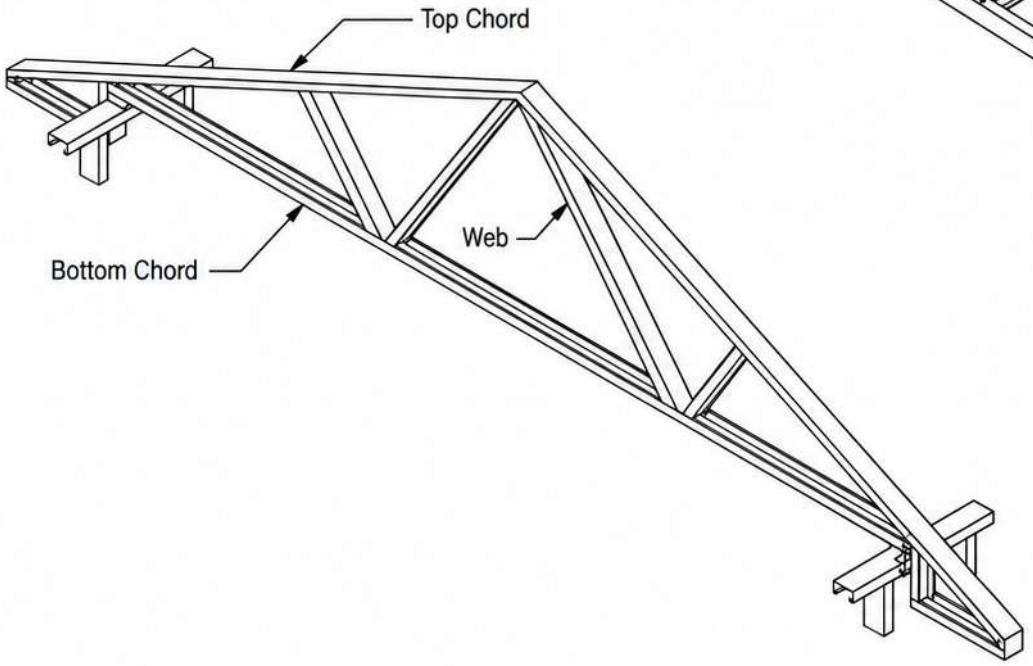


Mono-pitch roof truss



Supplementary (upper) bracing of the 'smartpanel' roof truss





1.1. Requirements for Substrate Flatness for Wall Structures

REQUIREMENTS FOR THE FOUNDATION STRUCTURE

REQUIREMENTS FOR THE CONSTRUCTION ACCURACY, STRENGTH AND DIMENSIONS OF THE CONCRETE FOUNDATION:

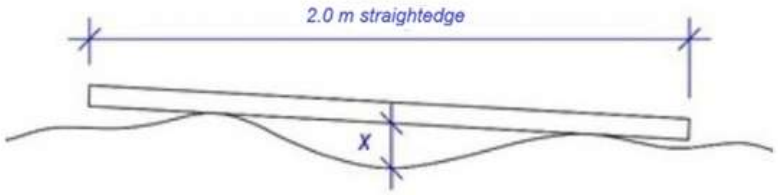
ALL FLATNESS REQUIREMENTS SPECIFIED IN THIS DOCUMENT ARE DEFINED AS MAXIMUM PERMITTED VALUES, WHILE THE REQUIREMENTS FOR THE DIMENSIONS AND STRENGTH OF THE SUBSTRATE ARE DEFINED AS MINIMUM VALUES.

THE SPECIFIED VALUES FOR THE CONCRETE FOUNDATION MUST BE MET BEFORE INSTALLATION WORK BEGINS.

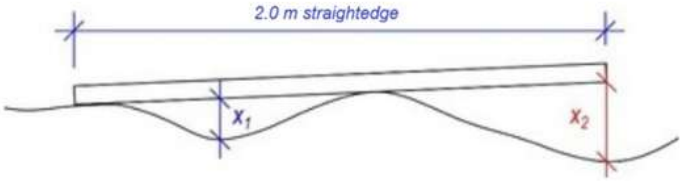
1.1.1 REQUIREMENTS FOR THE FLATNESS OF THE CONCRETE FOUNDATION SURFACE

THE FLATNESS OF THE UPPER SURFACE OF THE FOUNDATION SHALL BE MEASURED AT A MINIMUM OF FIVE LOCATIONS FOR EVERY 100 M^2 OF FOUNDATION AREA, AT POINTS BENEATH THE FUTURE WALLS OF THE ABOVE-GROUND STRUCTURE ASSEMBLED FROM THIN-WALLED STEEL PROFILES.

THE FLATNESS OF THE SUBSTRATE SHALL BE CHECKED USING A 2.0 M STRAIGHTEDGE, IN ACCORDANCE WITH THE FOLLOWING DIAGRAMS:



THE MEASURED DEVIATION IS DIMENSION X

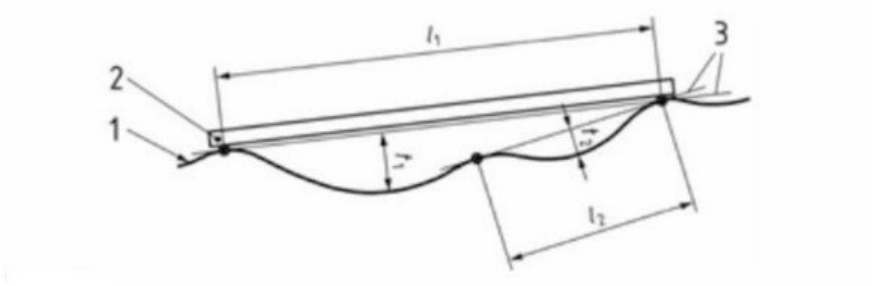


THE MEASURED DEVIATION IS DIMENSION X1; DEVIATION X2 IS NOT TAKEN INTO ACCOUNT

THE FOLLOWING MAXIMUM DEVIATIONS FROM FLATNESS ARE SPECIFIED FOR THE UPPER EDGE OF THE FOUNDATION OVER A LENGTH OF 2.0 M:

- **X = 3.0 mm** WHEN THE BASE TRACK OF THE ASSEMBLED STRUCTURE IS ANCHORED DIRECTLY, WITHOUT A PACKING LAYER
- **X = 5.0 mm** WHEN THE BASE TRACK OF THE ASSEMBLED STRUCTURE IS ANCHORED ON A PACKING LAYER MADE OF MODIFIED BITUMEN MEMBRANE (THE PACKING LAYER COMPENSATES FOR MINOR SURFACE IRREGULARITIES)

FOR THE FLATNESS OF THE UPPER EDGE OF THE FOUNDATION OVER A LENGTH OF 10.0 M, THE FOLLOWING MAXIMUM PERMISSIBLE DEVIATION BETWEEN THE ENDS OF THE STRAIGHTEDGE IS SPECIFIED:



Legend
1 Surface of the area being measured
2 Measuring straightedge
3 Plane of the underside of the measuring straightedge
l_1, l_2 Length of the measuring straightedge
t_1, t_2 Deviation between the measured surface and the underside of the straightedge

- **t = 20 mm** MAXIMUM PERMISSIBLE DEVIATION OVER A LENGTH l_1 = 10.0 m

1.1.2 REQUIREMENTS FOR THE SURFACE STRENGTH OF THE CONCRETE FOUNDATION

A MINIMUM CONCRETE STRENGTH OF 25 MPa IS REQUIRED FOR THE FOUNDATION SURFACE.

1.1.3 REQUIREMENTS FOR THE DIMENSIONS OF THE CONCRETE FOUNDATION

THE MINIMUM REQUIRED DIMENSION OF THE FOUNDATION STRUCTURE IS 180 mm.

THE THICKNESS OF THE FOUNDATION STRUCTURE IS REQUIRED TO ALLOW THE ABOVE-GROUND STRUCTURE TO BE ASSEMBLED AND ANCHORED USING MECHANICAL OR BONDED ANCHORS WITH A DIAMETER OF 10 mm OR 12 mm. THE SIZE AND LENGTH OF THE ANCHORS SHALL BE SPECIFIED BY THE STRUCTURAL ENGINEER. THE FOUNDATION THICKNESS SHALL BE DESIGNED BY THE STRUCTURAL ENGINEER ACCORDING TO THE REQUIRED LOAD-BEARING CAPACITY; HOWEVER, THE MINIMUM THICKNESS MUST BE 180 mm.

TO OPTIMISE THE ANCHORING AND INCREASE THE LOAD-BEARING CAPACITY OF THE ANCHORS (OR, WHERE APPLICABLE, TO REDUCE THEIR REQUIRED LENGTH), REINFORCING THE FOUNDATION STRUCTURE ON BOTH SIDES (AT BOTH THE BOTTOM AND TOP SURFACES) WITH REINFORCING STEEL IS RECOMMENDED.

2. Purpose of the Specification for the Design of Building Structures Using the Steel System

This specification was developed primarily as a guide for design engineers, with the aim of helping them translate their proposed building structures into the steel system more easily. In general, the specification is intended to simplify and standardise their work.

The purpose of this specification is not to address structural calculations as such, but rather to provide information on the results of the hygrothermal assessment of the steel system, which must be taken into account when designing the structure. Ultimately, even the best structural concept for a building made from load-bearing thin-walled profiles has potential drawbacks, including the risk of thermal bridges and unwanted water vapour condensation within the building envelope. These interrelated adverse effects of building physics occur frequently in structures incorporating steel load-bearing systems and are often overlooked. They are, however, a logical consequence of a fundamental physical property of steel: its very high thermal conductivity (W/m·K).

For this reason, steel load-bearing structures must be designed so that thermal bridges (thermal bridging paths) are completely eliminated, thereby not only reducing risks to occupants but also preventing an increase in the building's energy demand. Accordingly, this system has been subjected to a building-physics assessment, with simulations carried out using indoor design temperatures and humidity levels representative of residential spaces. The results of these analyses are presented below and in the subsequent chapters of this specification.

Figure 1a shows the optimum solution: a steel structure suitably used in a building with a simple shape, completely "wrapped" on the external side with effective thermal insulation. This prevents heat from being transferred from the interior to the exterior, with particular emphasis on minimising thermal bridges (thermal irregularities) within the insulated structure.

Figure 1b, by contrast, shows a possible solution for preventing heat transfer. However, the building's complex shape incorporates numerous challenging construction details that must be considered before the steel structure is designed. The load-bearing structure itself must generally be adapted accordingly — see the following chapters.

Materials that provide effective thermal insulation compared with steel also include timber and composite profiles. These can be used not only as suitable barriers to prevent heat transfer, but, more importantly, to replace steel as a load-bearing material in locations where the original steel structure could otherwise create thermal bridges.

Figure 1a: OPTIMAL STRUCTURAL DESIGN

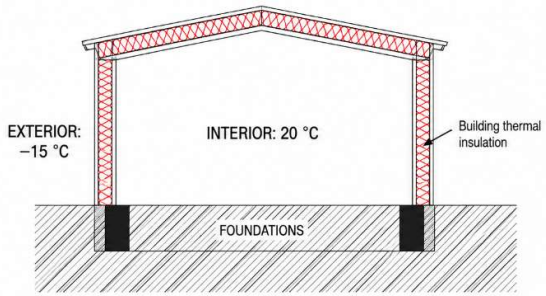
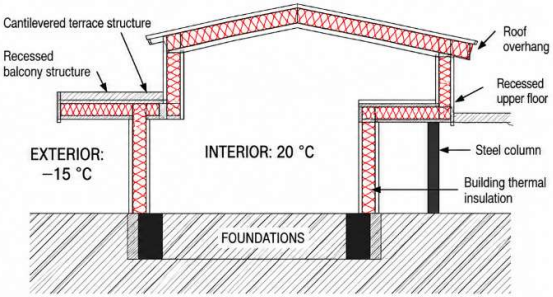


Figure 1b: ATYPICAL STRUCTURAL DESIGN



** effective thermal insulation can be provided by building materials with a thermal conductivity coefficient (lambda) of 0.04 or lower. The most commonly used materials include expanded polystyrene (EPS), extruded polystyrene (XPS), stone wool and glass wool (MW), polyurethanes (PUR), polyisocyanurates (PIR), and wood-fibre boards (WFB)*

3. Design of Steel Structures versus Building Physics and Thermal Performance

As stated in the previous chapter, the design of steel structures is significantly influenced by building physics and thermal performance. To a large extent, the proposed design is determined by findings derived from simulations of temperature fields at selected (critical) details of the specific building.

During winter, the temperature difference between the interior and exterior reaches its greatest gradient, resulting in the highest heat flows through the building envelope (walls, ceilings, roof, floor and openings). Heat flow through individual building elements is closely linked to moisture flow, which depends on the pressure gradient — that is, the difference between the air pressure, including the partial pressure of water vapour, inside the building and that outside. Unwanted moisture flow through building elements can be effectively controlled or even eliminated by using vapour barriers or by correctly arranging materials with high resistance to water vapour diffusion within the building envelope. This can prevent condensation not only within the building element itself, but especially at critical locations where thermal bridges are likely to occur.

For building envelope assemblies designed in this way for the steel system, and for the system's key construction details, we can be confident that the future building's energy performance requirements have been taken into account. In addition, unwanted condensation within assemblies and details is kept under control. Such condensation could cause corrosion of metal components, thereby shortening the service life of the structure, as well as degrading the thermal insulation materials within the assemblies and consequently increasing the building's energy demand.

To prevent the effects described above, it is therefore essential to select and install a **CONTINUOUS** vapour barrier or vapour control layer in the building elements (see Figures 2a and 2b). This layer should be positioned as close as possible to the internal surface of the structure, thereby restricting or significantly reducing moisture flow into the assembly. By contrast, the thermal insulation should be positioned as close as possible to the external surface of the structure, preventing heat loss from the heated interior and effectively insulating the steel load-bearing frame from low outdoor temperatures. This minimises the effects of thermal bridges and thermal bridging paths.

Figure 2a: POSITION OF THE VAPOUR BARRIER AND THERMAL INSULATION IN A SIMPLE (SINGLE-STOREY) BUILDING

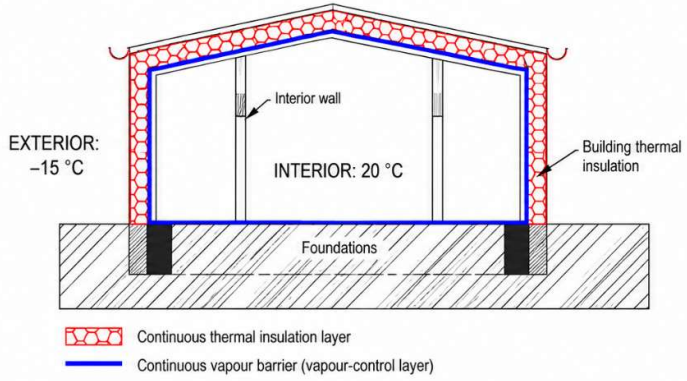
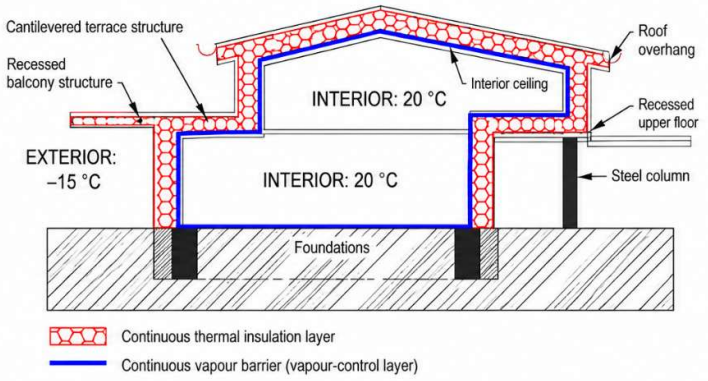


Figure 2b: POSITION OF THE VAPOUR BARRIER AND THERMAL INSULATION IN AN ATYPICAL BUILDING



The examples presented above (and the calculation simulations) demonstrate that the building as a whole will function reliably — that is, without thermal bridges or areas of water vapour condensation on the surface or within the building element assemblies — only if the vapour control layers (vapour barriers) and the effective thermal insulation layer are perfectly sealed and continuous.

While the thermal insulation follows the external shape of the building envelope, the vapour barrier (vapour control layer) must, in certain cases, particularly around cantilevered or recessed structures, follow a stepped or angled route. Nevertheless, this layer must remain perfectly continuous to eliminate the risk of condensation forming within the structure.

Typical examples of such critical details include projecting structures (balconies, bay windows) and recessed structures (a set-back lower storey). This is illustrated clearly in Figure 3 below.

It is also necessary to ensure that, where internal structures (walls and partitions) connect to external structures (roofs) separating the interior from the exterior — **THAT IS, AT THE BOUNDARY BETWEEN HEATED AND UNHEATED SPACES** — the vapour barrier (vapour control layer) in the external structures is always connected continuously. This is achieved by inserting a strip of vapour barrier (vapour control layer) at the junction. This makes the junction airtight and prevents water vapour from entering the building element assembly at that point.

Such connection details between individual structural elements can have a significant influence on the structural design of the entire load-bearing steel structure. Figure 4 illustrates, schematically, one possible connection between two separate structural units of this type, using an inserted strip of vapour barrier (vapour control layer), followed by the structural connection of the two components (e.g. using brackets and bolts).

Figure 3: POSITION OF THE VAPOUR BARRIER AND THERMAL INSULATION IN A MULTI-STOREY BUILDING

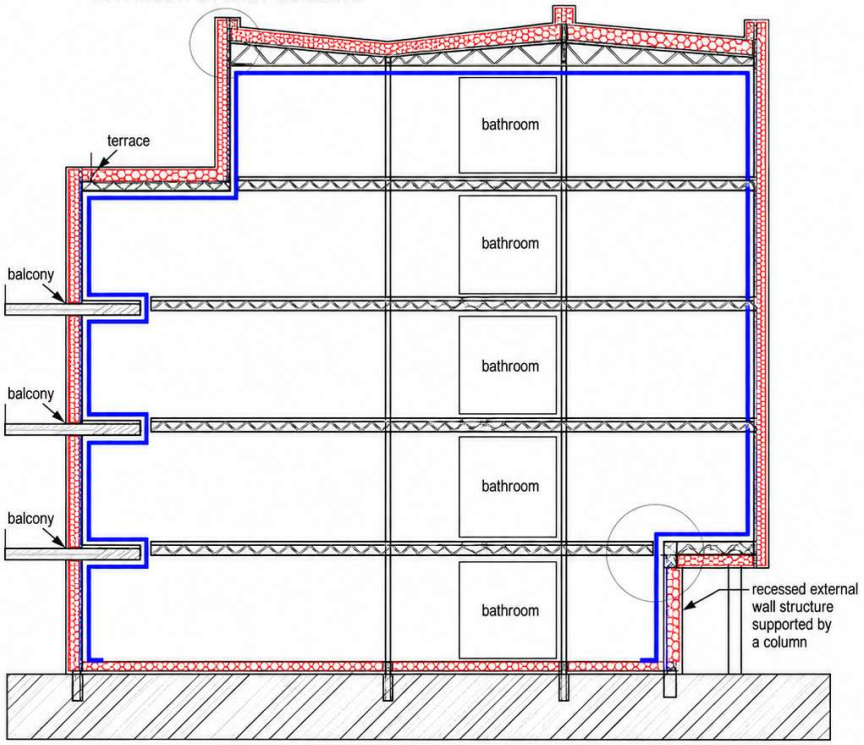


Figure 5: IMPLEMENTATION OF A ROOF ATTIC WITH "WRAPPED" THERMAL INSULATION

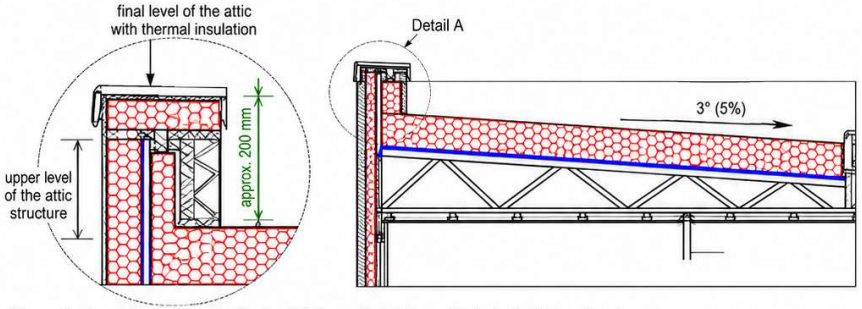


Figure 5 shows that, when designing this type of structure, the height of the attic structure must be distinguished from the final (required) height of the building.

Figure 3 schematically illustrates the continuity of the vapour barrier (vapour control layer) and thermal insulation layers in a multi-storey building. As stated above, the entire load-bearing steel structure must be adequately "wrapped" in thermal insulation on the external side, including projecting vertical and horizontal structures (e.g. parapets and projecting storeys). An exception in this case is made for cantilevered balcony beams, which, due to the material used — timber — do not pose a significant risk of increased heat transfer from a thermal performance perspective. However, to minimise water vapour diffusion at the junction between the steel floor structure and the timber balcony beams, these structures must also be separated from each other at this point by installing a suitable vapour barrier (vapour control layer).

In residential buildings where similar moisture conditions can be expected (the environment between individual flats), spaces subject to occasional but short-term increases in relative humidity, such as bathrooms and kitchens, can generally be assumed to be adequately ventilated, either naturally (through windows) or mechanically (by extraction). Consequently, these short-term increases in air humidity will not contribute significantly to the accumulation of water vapour within the building structure. For this reason, a vapour barrier (vapour control layer) is generally not specified for these rooms. However, if the building designer nevertheless requires a vapour barrier (vapour control layer) in bathrooms, we recommend cladding the walls and ceilings of these rooms with Rigips Hsd boards, which serve both as a load-bearing element and as a vapour control layer due to their higher resistance to vapour diffusion. Despite the above recommendation, we advise carrying out a hygrothermal assessment of the building element assembly and its details in these cases.

Figure 4: VARIANT OF FLOOR-JOINT DESIGN AT THE VAPOUR BARRIER PENETRATION

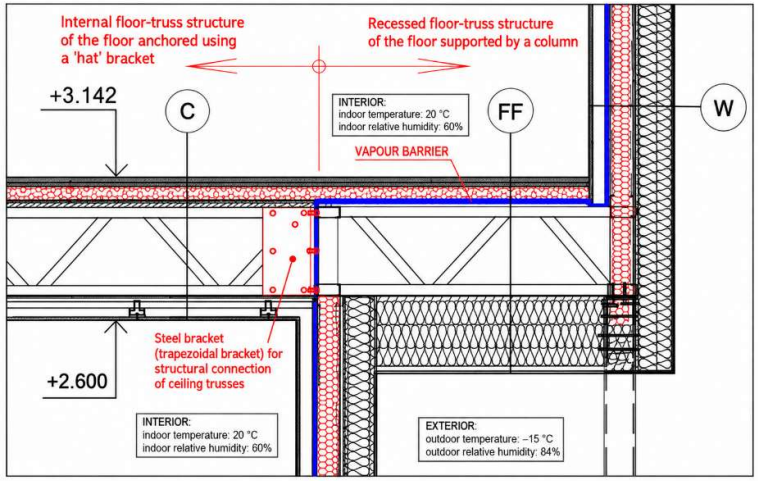
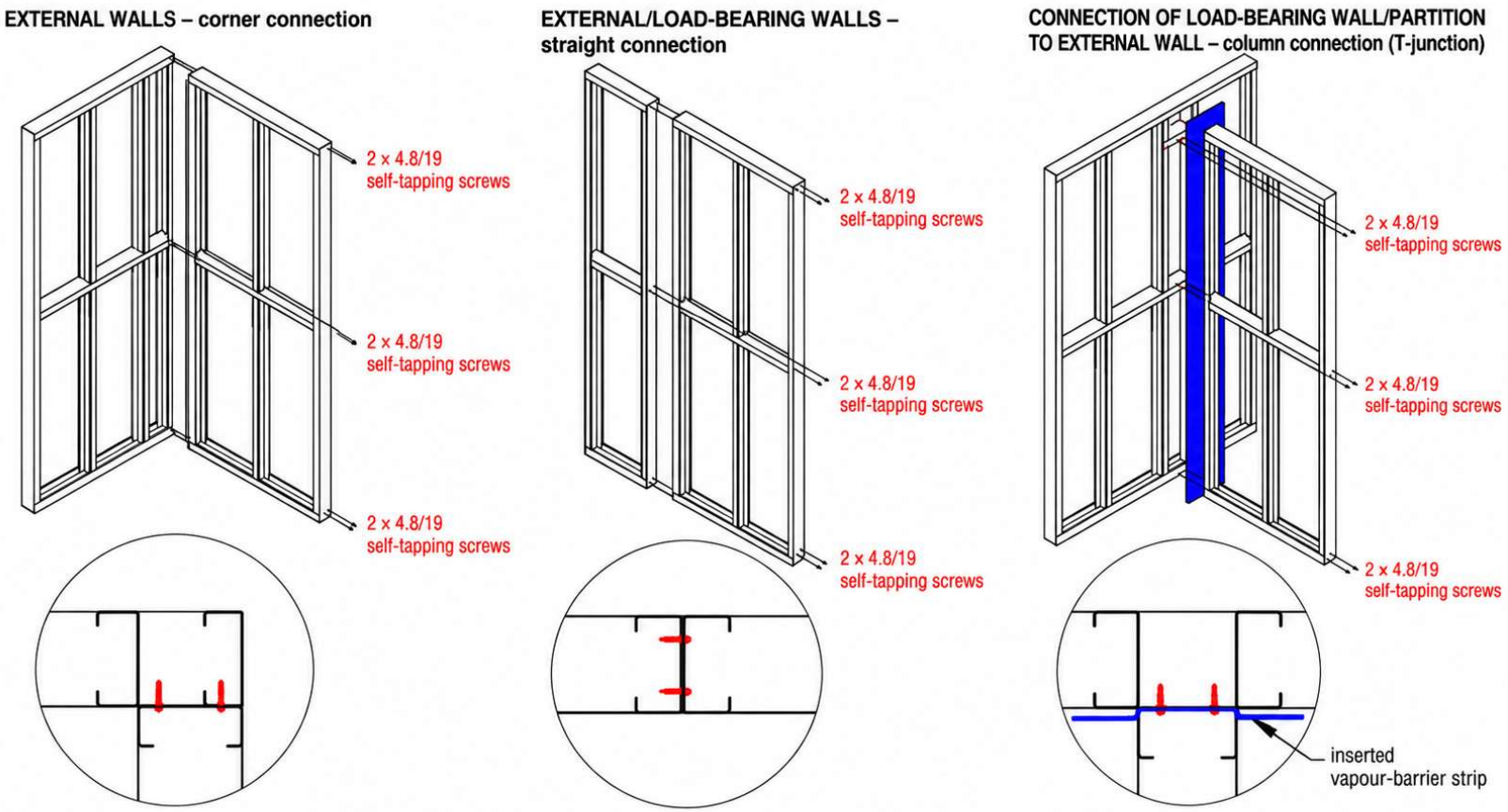


Fig. 6: EXAMPLES OF CONNECTIONS BETWEEN INDIVIDUAL WALL FRAMES, INCLUDING THE INSERTION OF THE VAPOUR BARRIER

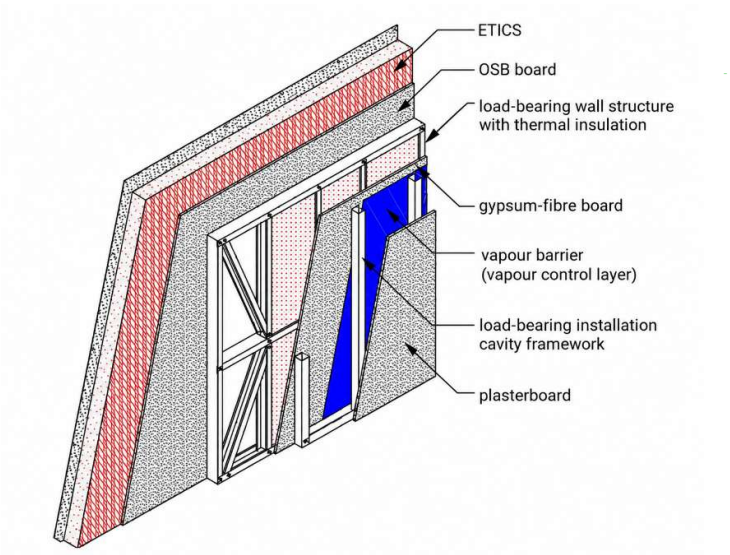


In all the variants shown below, the individual wall frames are connected using at least 6 screws.

IMPORTANT INSTALLATION NOTICE:

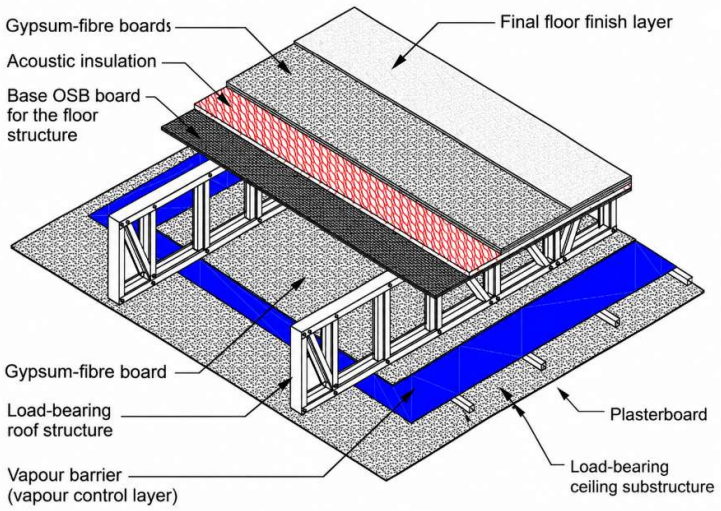
- When connecting internal walls and partition walls to external walls (as well as when connecting walls and partitions to roof trusses), a strip of vapour barrier MUST be inserted into the joint during installation, before the components are screwed together! Failure to carry out this measure may result in the aforementioned risks of water vapour condensation within the building element assemblies.
- When positioning wall frames vertically, they must be stabilised (secured) immediately using carpentry clamps, optionally in combination with temporary structural bracing! The clamps may only be removed after the anchors and connecting fasteners, or gusset plates, have been fully installed. If the wall frames are not secured to one another, there is a risk of injury to workers if the frames fall!

Figure 7: *GENERAL ARRANGEMENT OF THE INDIVIDUAL LAYERS AND THEIR FUNCTIONS IN STEEL STRUCTURE ASSEMBLIES*



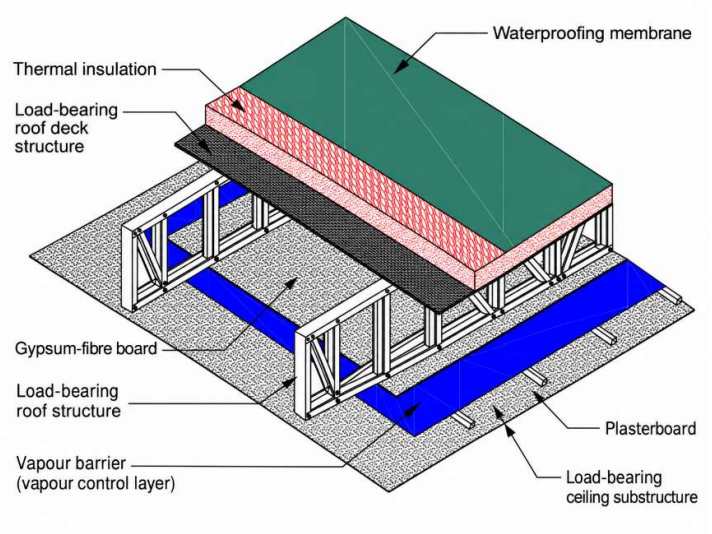
External Wall Build-up (from Outside):

Layer:	Function within the construction assembly:	Typical thickness of boards/components:
ETICS (external thermal insulation composite system) (thin-coat render, adhesive mortar, thermal insulation, reinforcing mesh, fixing elements)	- protective (against weathering) - thermal insulation - fire protection (if mineral-wool insulation is used)	from 120 mm upwards
Gypsum-fibre board	- partly structural - substrate for ETICS - fire protection	15 mm
Load-bearing wall structure, including ISOVER insulation	- structural - thermal insulation	89 mm
Gypsum-fibre board	- partly structural - substrate for installation of the vapour barrier - fire protection	12.5 mm
Vapour barrier (vapour control layer)	- continuous barrier preventing water vapour from entering the structure	up to 1 mm
Load-bearing frame for the installation cavity	- structural - space for routing services (water, heating, electrical) - substrate for fixing interior plasterboard	from 50 mm
Plasterboard	- visible finished surface - fire protection (when RED board is used)	12.5 mm



Typical Floor Build-up Between Heated Spaces (from Top):

Layer:	Function within the construction assembly:	Typical thickness of boards/components:
Final floor finish layer – PVC, laminate, vinyl, cork, carpet, etc.	- finished surface (floor covering) - partial thermal insulation	typically up to 12 mm
Gypsum-fibre boards	- load distribution - substrate for installation of the final floor covering - fire protection	2 x 12.5 mm
Acoustic insulation	- impact sound insulation - substrate for the load distribution layer - thermal insulation	30 mm
Base OSB board for the floor structure	- structural - fire protection (when using OSB boards type Firestop or fibre-cement boards)	2 x 18 mm
Load-bearing floor structure	- structural	from 350 mm
Gypsum-fibre board	- partly structural - substrate for installation of the vapour barrier (vapour control layer) - fire protection	12.5 mm
Vapour barrier (vapour control layer)	- continuous barrier preventing water vapour from entering the structure (especially relevant in spaces with higher humidity, e.g. bathrooms, and in buildings with low ventilation, with higher indoor humidity) – the need for installation is always determined by the structural engineer	up to 1 mm
Load-bearing framework for the ceiling substructure	- structural - space for routing services (water, heating, electrical) - substrate for fixing interior plasterboard	from 50 mm
Plasterboard	- visible finished surface - fire protection (when RED board is used)	12.5 mm



Flat roof build-up with conventional layer arrangement (from outside):

Layer:	Function within the construction assembly:	Typical thickness of boards / components:
Asphalt roofing, e.g. bitumen or foil waterproofing membranes	- protective (against weathering, especially wind uplift and rain penetration)	up to 4 mm
Thermal insulation	- thermal insulation - fire protection (if mineral wool insulation is used)	from 260 mm
Base structural board	- structural - fire protection (if OSB Firestop boards or Cetris boards are used)	from 36 mm (e.g. 2 × 18 mm)
Load-bearing roof structure	- structural - sloped (fall towards drainage)	from 350 mm
Gypsum-fibre board	- partially structural - substrate for installation of the vapour barrier - fire protection	12.5 mm
Vapour barrier (vapour control layer)	- continuous barrier preventing water vapour from entering the structure	up to 1 mm
Load-bearing ceiling substructure	- structural - space for routing services (water, heating, electrical) - substrate for installation of the interior plasterboard	from 50 mm
Plasterboard	- visible finished surface - fire protection (when RED board is used)	12.5 mm

Table No. 1: *GENERAL MANUFACTURING DIMENSIONS* OF BOARD MATERIALS USED FOR CLADDING STRUCTURES

Board / manufacturer:	Cladding application:	Dimensional range (thickness / length / width):
Plasterboard RB (A) / Rigips	- for cladding interior partition frames and ceilings only	12.5 / 2000 / 1250
Gypsum-fibre board DFRIEH2 RigiStabil (structural board) / Rigips	- for cladding frame walls on both sides	12.5 / 1800 / 1250 12.5 / 2000 / 1250 12.5 / 2200 / 1250 12.5 / 2650 / 1250 12.5 / 2750 / 1250 15 / 2750 / 1250
Wood-chip (OSB) board / EGGER	- for upper cladding of floor and roof trusses	15 / 2500 / 1250 18 / 2500 / 1250 22 / 2500 / 1250 25 / 2500 / 1250
Wood-chip (OSB) board Firestop / KRONOSPAN (increased fire resistance)	- for upper cladding of floor and roof trusses	16 / 2500 / 625

4. General Principles for the Design of Steel Structures and Related Considerations

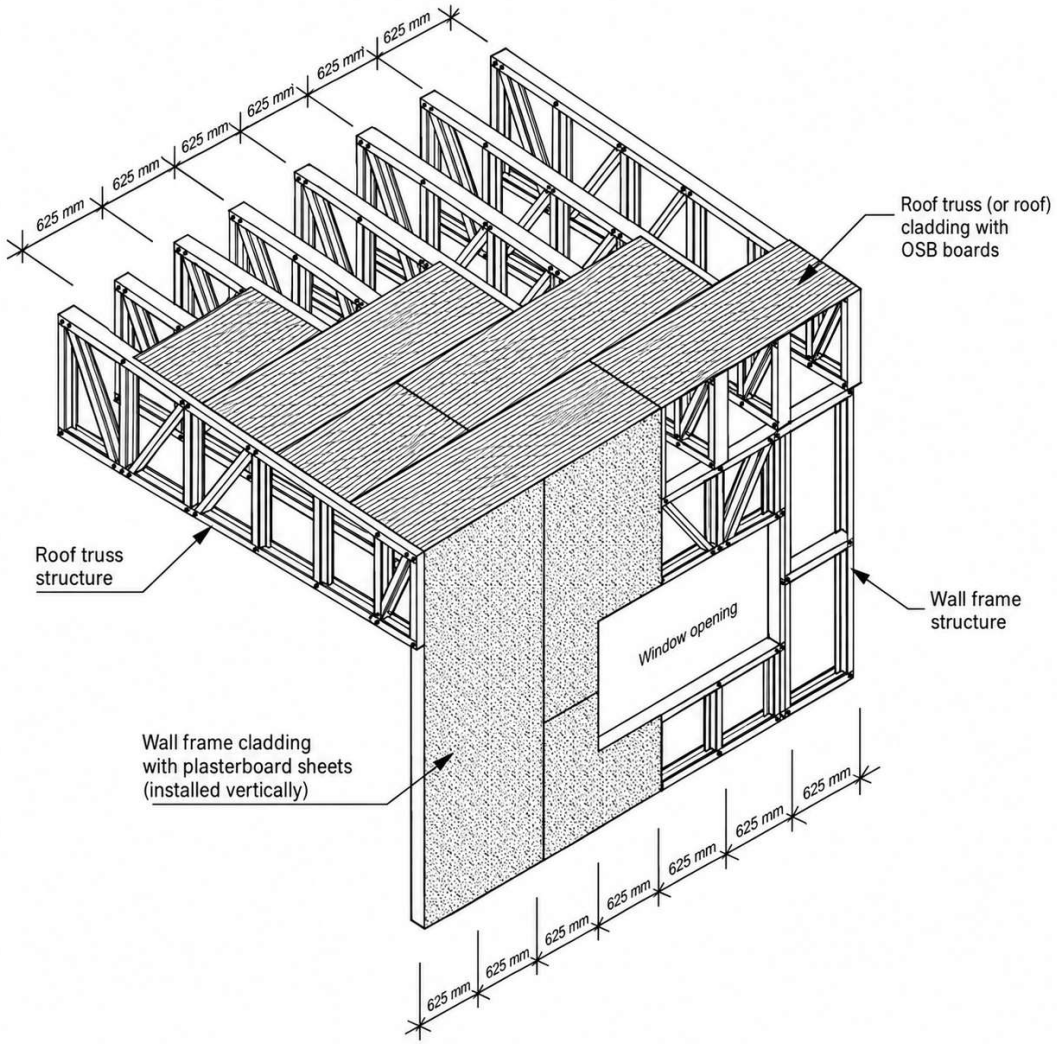


Figure 8: CLADDING OF WALL FRAMES AND ROOF TRUSS STRUCTURE WITH THE REQUIRED BOARD MATERIALS

The centre-to-centre (modular) spacing of the load-bearing C-profiles in wall frames is 625 mm. This spacing is determined by the manufacturing dimensions of the board materials used to clad the walls, ceilings and roofs of steel structures.

The same spacing, or multiples thereof, is also used between the centre lines of floor and roof trusses — see Figure 8.

Steel frames are clad primarily with two types of material: gypsum fibreboard (SDV) or plasterboard (SDK), and oriented strand board (OSB). Their most common standard manufacturing dimensions are specified in Table 1 above.
Gypsum fibreboards and plasterboards are used only for cladding vertical structures, i.e. walls and partitions. Each board is fixed to the structure along its perimeter and at the midpoint of its length. When these boards are used to clad horizontal or inclined ceiling structures, it must be ensured that they are not subjected to any additional loads, due to their relative brittleness.

OSB boards are used wherever gypsum fibreboards or plasterboards are unsuitable. They are therefore primarily used for cladding floor and roof structures, where the boards can be fixed to the supports (trusses) while also transferring additional loads applied between the supports. OSB boards are generally installed in two layers, one on top of the other (minimum 2 × 15 mm), with the layers screwed together. The second layer is laid with the joints staggered by half a board, in a similar way to the bond pattern used in brick masonry. Where a floor structure separates two flats, full-surface separation between the OSB boards is recommended to prevent potential squeaking between them, for example by using a layer of Miralon.

Board installation must always follow the installation (technical) instructions issued by the relevant manufacturer. As a general rule, gypsum fibreboards used for wall cladding are installed vertically, with their longitudinal axis parallel to the vertical studs. OSB boards used for roof and floor cladding are laid with their longitudinal axis perpendicular to the centre lines of the truss structures. For this reason, the centre-to-centre (modular) spacing of the structural members must be observed from the design stage onwards, to minimise board offcuts during installation and ensure that all board joints fall on a profile.

4.1 Roof Structures

The primary criterion for classifying roofs for structural design purposes is their pitch. The following categories are distinguished:

- **Flat roofs** (a slope of 2% to 8.5%, i.e. up to 5°). A minimum recommended slope of 4% is optimal for roof design in order to prevent the formation of standing water
- **Pitched roofs** (a slope greater than 5°)

When designing a roof using steel structures, the advantages and disadvantages of each specific roof type must be considered — see Figures 9a and 9b. These are summarised below:

Figure 9a: SCHEMATIC DESIGN OF A TRUSS STRUCTURE FOR A FLAT ROOF

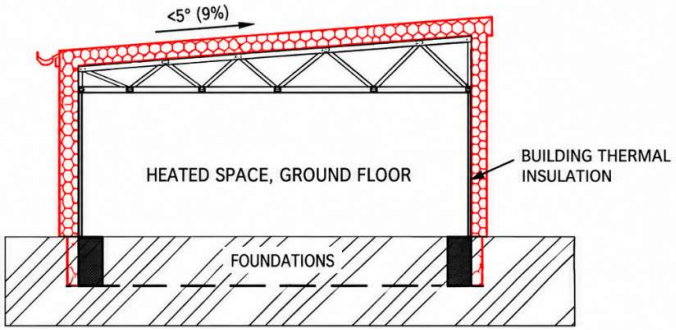
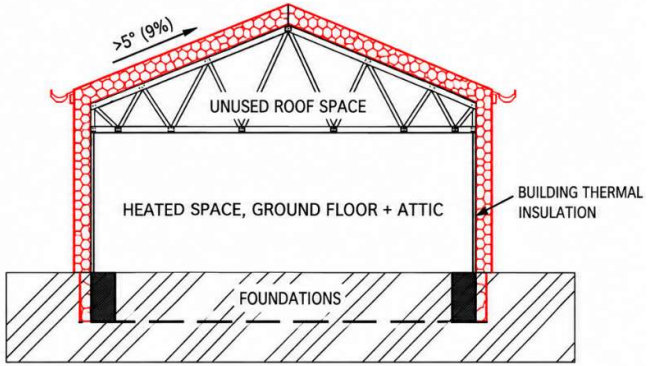


Figure 9b: SCHEMATIC DESIGN OF A TRUSS STRUCTURE FOR A PITCHED ROOF



Advantages:

- Low roof pitch (low-profile truss) = lower construction costs.
- Low-profile truss = smaller heated internal volume
- The roof truss also serves as the ceiling structure

Disadvantages:

- Steeper roof pitch (higher truss) = increased construction costs
- Larger heated internal volume
- The roof truss structure restricts the functional use of the attic space

It follows from the above that the option shown in Figure 9a appears to be the optimal solution for roof design, namely a flat roof with a low-profile truss. We design roofs with pitched-roof trusses, as shown in Figure 9b, only occasionally, either when required to comply with the applicable local planning regulations (which may require a pitched roof) or when the client requests traditional interlocking roof tiles, which generally require roof pitches of approximately 30° or more.

The different types of roof coverings used depending on roof pitch are listed in Table 2.

The diagram in Figure 10c could easily lead to the incorrect design assumption that, by insulating the walls of the first floor and the ceiling beneath the unheated attic, it would no longer be necessary to heat the attic space itself. However, this solution is entirely incorrect because, at the indicated location (marked in the figure as the critical point — the boundary between the heated and unheated parts of the building), substantial heat transfer from the interior and subsequent water vapour condensation would occur through the thin-walled steel profiles at the junction between the wall and the roof truss.
The consequences of these two phenomena during winter would include cooling of the walls, accumulation of condensate within the wall assemblies and the subsequent growth of mould. For these reasons, we categorically avoid this design approach and instead adopt the solution shown in Figure 10d.

Figure 10c: INCORRECT CONCEPT FOR A PITCHED-ROOF TRUSS STRUCTURE

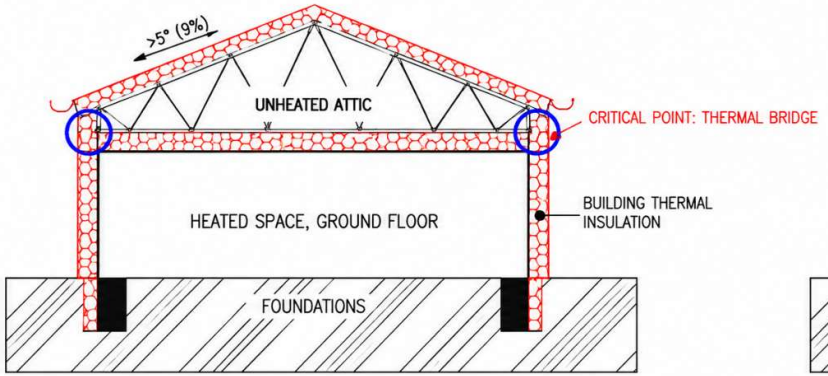
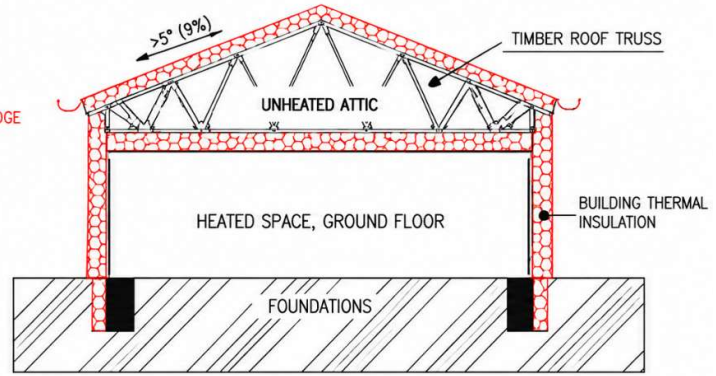


Figure 10d: CORRECT CONCEPT FOR A TIMBER PITCHED-ROOF TRUSS STRUCTURE (HYBRID CONSTRUCTION)



In general, it follows that when a thin-walled structure is inadequately protected — "wrapped" in thermal insulation of insufficient thickness — or when an insulated structure comes into direct contact with a cooled structure without an appropriate thermal break, the design of these elements reaches its structural limits. One solution is to replace steel with another, less thermally conductive material, such as timber or a composite material. This allows the roof truss to be manufactured from timber and then connected to the ground-floor thin-walled steel structure using suitable carpentry connectors. This approach leads to what are known as "hybrid" structures — see Figure 10d.

Table 2: MOST COMMONLY USED ROOFING MATERIALS AND THEIR DEPENDENCE ON THE MINIMUM ROOF PITCH:

Roof type:	Roofing material:	Minimum roof pitch:
flat roof	PVC, bituminous roofing	3% (= 1.7°)
pitched roof	standing-seam metal roofing (continuous seam from ridge to eaves)	7° (= 12.3%)
	trapezoidal metal sheet (continuous element from ridge to eaves)	10° (= 17.7%)
	roof tiles (ceramic and concrete) (with a waterproof underlay)	30° (= 58%) / 20° (= 36.5%)

4.2 Openings

This chapter deals with the design of openings in external walls, including openings for windows, doors and shopfront glazing. The connection joint between the frame and the wall opening, formed using thin-walled profiles, can once again create a thermal bridge. At the same time, the wall opening must be protected against dynamic loads, for example those caused by a window or door being slammed shut.

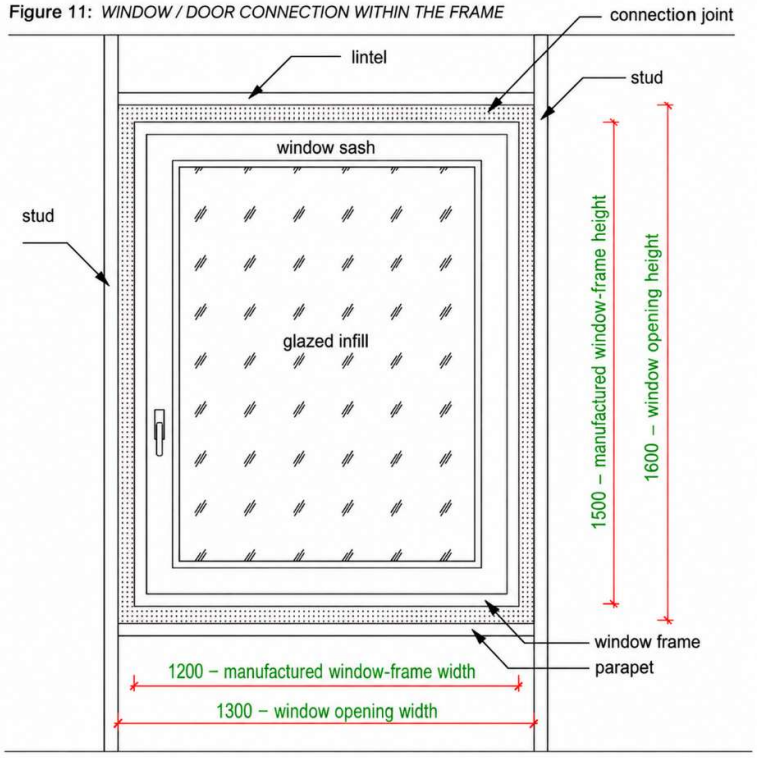
Both of these adverse effects are addressed by installing a rigid perimeter frame made of PURENIT material within the connection joint. Anchored around its perimeter to the wall opening, this frame also serves as a load-bearing, non-compressible support for fixing the window, door or shopfront frame.

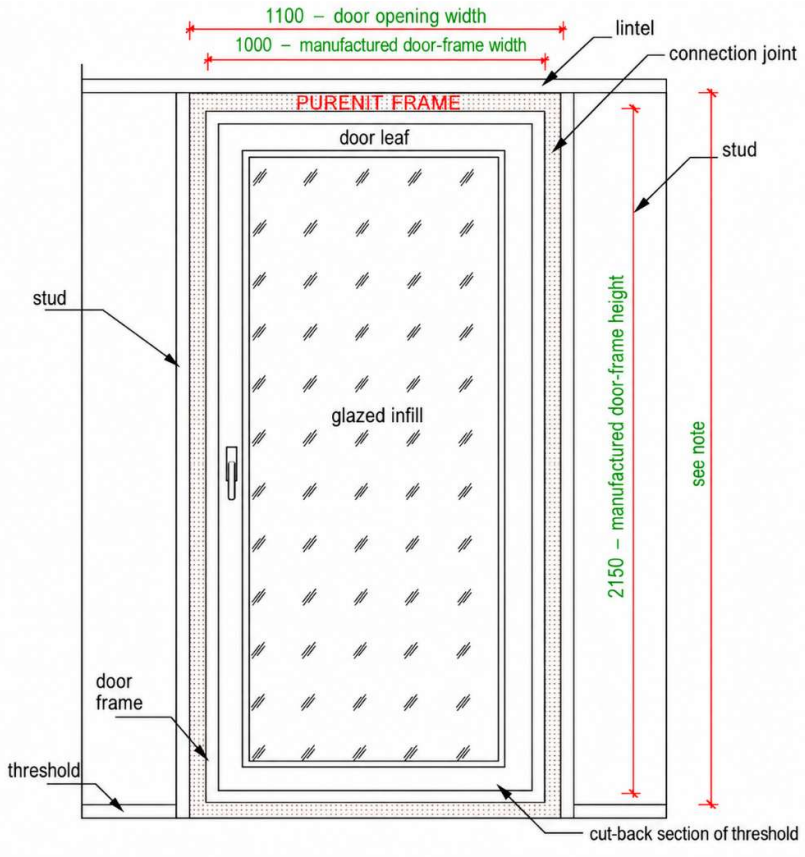
Based on the hygrothermal assessments and the considerations described above, and taking into account the PURENIT infill installed in the window or door reveals, we therefore design openings in external walls to be **50 mm larger than the manufactured dimensions of the window or door frame on each side** — see Figure 11.

Note: The height of a door opening must be determined individually, taking into account both the required door height and the thickness of the floor build-up. At the door threshold, the bottom track is cut away so that it does not obstruct the installation of the PURENIT frame

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Figure 11: *WINDOW / DOOR CONNECTION WITHIN THE FRAME*





5. Appendices – Structural (Critical) Details of the System

5.1 General external wall assembly with an external thermal insulation composite system (ETICS)

5.2 Detail of the connection between the external wall and the foundation structure, including the ground-floor build-up

5.3 Detail of window installation in the external wall

5.4 Detail of the connection between a cantilevered structure (balcony) and the external wall

5.5 Detail of the connection between the terrace structure and the external wall

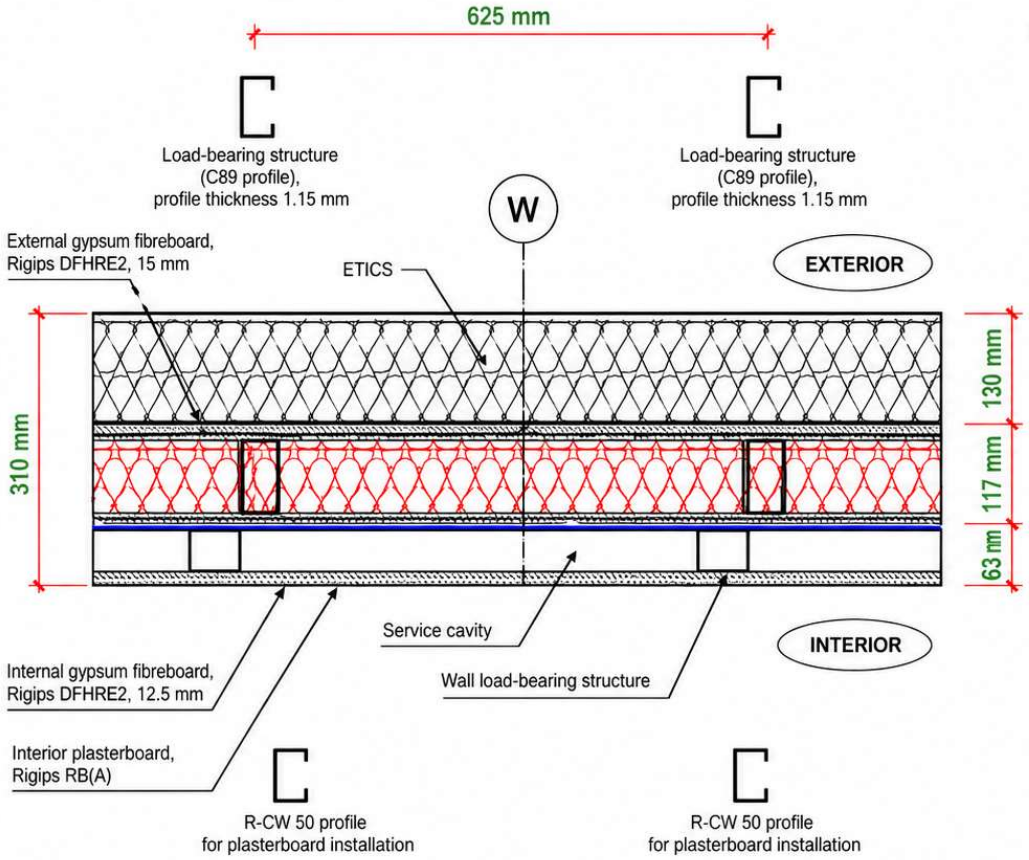
5.6 Detail of the connection between the external wall and a pitched roof (eaves)

5.7 Detail of the connection between the external wall and a flat roof (including the parapet)

5.8 Detail of the connection between a projecting upper storey and the external wall of the lower storey, supported by a steel column

5.1 General external wall assembly with an external thermal insulation composite system (ETICS)

EXTERNAL WALL – PLAN / SECTION



W **External wall build-up (from outside):**

- ETICS (external thermal insulation composite system): thin-coat render, reinforced base coat with mesh, bonded rigid ORSIL TF insulation, 120 mm, total thickness 130 mm)
- Gypsum fibreboard, Rigips Rigidur DFHRE2, 1 × 15 mm
- Structure 89 (thermal insulation ORSILAKU, 80 mm, fitted between profiles)
- Gypsum fibreboard, Rigips Rigidur DFHRE2, 1 × 12.5 mm
- Plasterboard, ISOVER XtraSafe
- Service cavity formed by galvanised R-CW 50 plasterboard profiles
- Gypsum fibreboard, Rigips RB(A) with skim coat, 12.5 mm

Total: 310 mm

Material composition:

Rigid ISOVER TF stone-wool board
(λ < 0.037 W/mK; factor μ = 1)

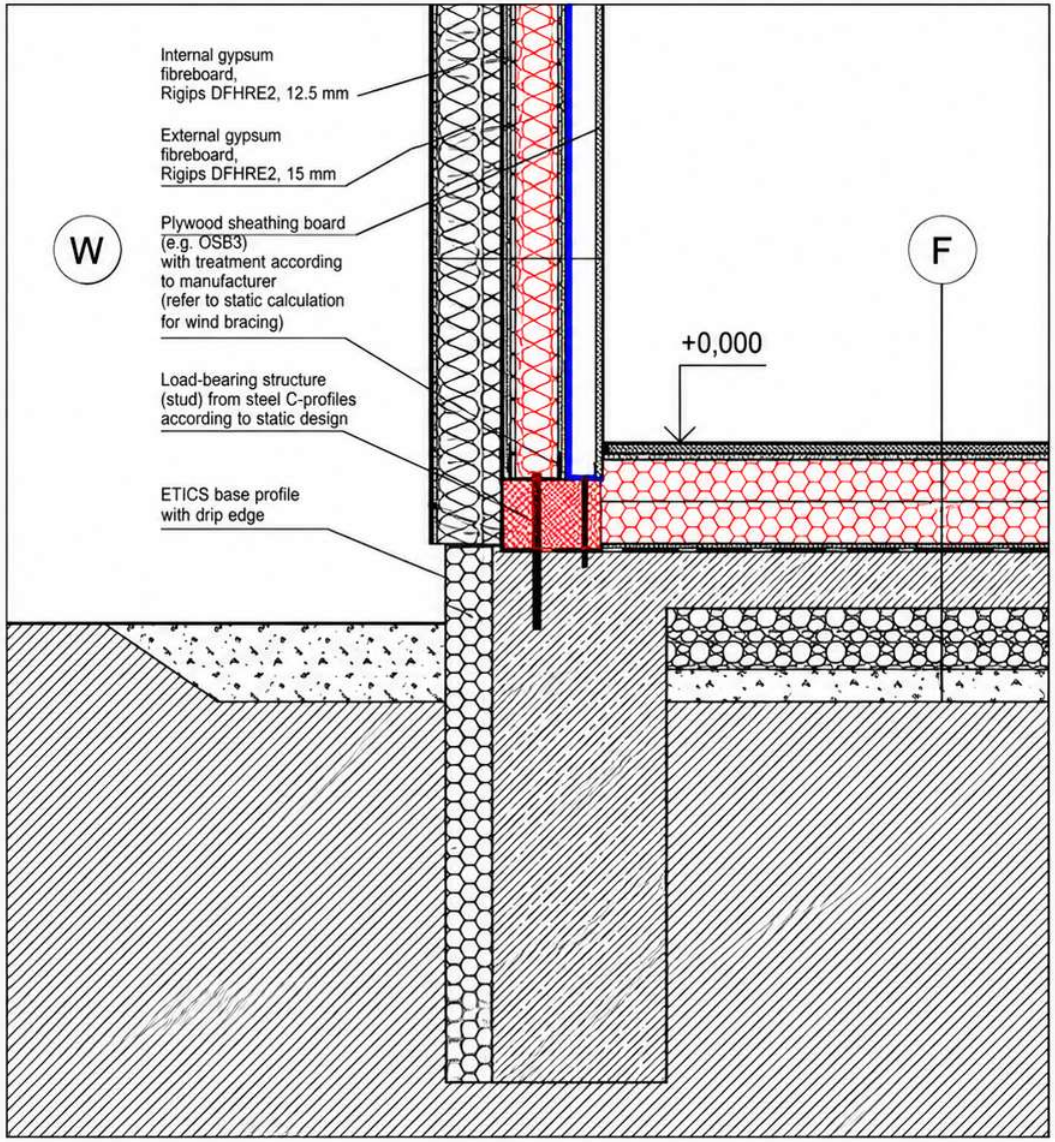
ISOVER AKU or UNI stone-wool board
(λ < 0.037 W/mK; factor μ = 1)

Rigips DFHRE2 gypsum fibreboard 15 mm and 12.5 mm
(λ = 0.15 W/mK; factor μ = 13),
or Rigips RB(A) plasterboard (λ = 0.21 W/mK; factor μ = 9)

ISOVER XtraSafe vapour barrier (Sd ≈ 20 m)

Thin-walled steel C profile 89 mm/40 mm/thickness 1.15 mm
(λ = 58 W/mK)

5.2 Detail of the connection between the external wall and the foundation structure, including the ground-floor build-up



W External wall build-up (from outside):

- ETICS (external thermal insulation composite system): thin-coat render, reinforced base coat with mesh, stone-wool insulation board ORSIL TF total thickness 130 mm (render 10 mm, base coat 3 mm, insulation 120 mm)
- Gypsum fibreboard, Rigips DFHRE2, 1 × 15 mm
- Structure 89 (thermal insulation ORSIL AKU, 80 mm, fitted between profiles)
- Gypsum fibreboard, Rigips DFHRE2, 1 × 12.5 mm
- Vapour barrier ISOVER XtraSafe
- Service cavity formed by galvanised SDK profile R-CW (50 mm)
- Gypsum fibreboard, Rigips RB (A) with skim coat, 12.5 mm

Total: 310 mm

F Floor build-up (from interior):

- 2× gypsum-fibreboard, Rigips Stabil (2 × 12.5 mm)
- EPS insulation board 150S (140 mm)
- Adhesive for EPS floor insulation (10 mm)

Total: approx. 180 mm

- Waterproofing layer – modified bituminous asphalt (4 mm)
- Reinforced-concrete floor slab or concrete blinding layer
- Compacted thermal-insulation sub-base (crushed expanded clay aggregate, fraction 0–63 mm)
- Compacted sub-base (e.g. gravel)

Rigid stone-wool board ISOVER TF (lambda < 0.037 W/mK; f.d.o. [m] = 1)

Stone-wool board ISOVER AKU or UNI (lambda < 0.037 W/mK; f.d.o. [m] = 1)

XPS board (lambda < 0.037 W/mK; f.d.o. [m] = 50)

Cellular-glass block FOAMGLASS PERINSUL (lambda < 0.06 W/mK; f.d.o. [m] = practically unlimited)

C Thin-walled steel "C" profile 89 mm/40 mm/thickness 1.15 mm (lambda = 58 W/mK)

Vapour barrier ISOVER XtraSafe (Sd ≈ 20 m) / in floor asphalt waterproofing (Sd ≈ 1,500 m)

Gypsum-fibreboard, Rigips DFHRE2, 15 mm and 12.5 mm (lambda = 0.15 W/mK; f.d.o. [m] = 13), or gypsum board, Rigips RB (A) (lambda = 0.21 W/mK; f.d.o. [m] = 9)

Waterproofing layer – modified bituminous asphalt (4 mm) (f.d.o. [m] = 30,000)

Reinforced concrete (lambda = 1.5 W/mK)

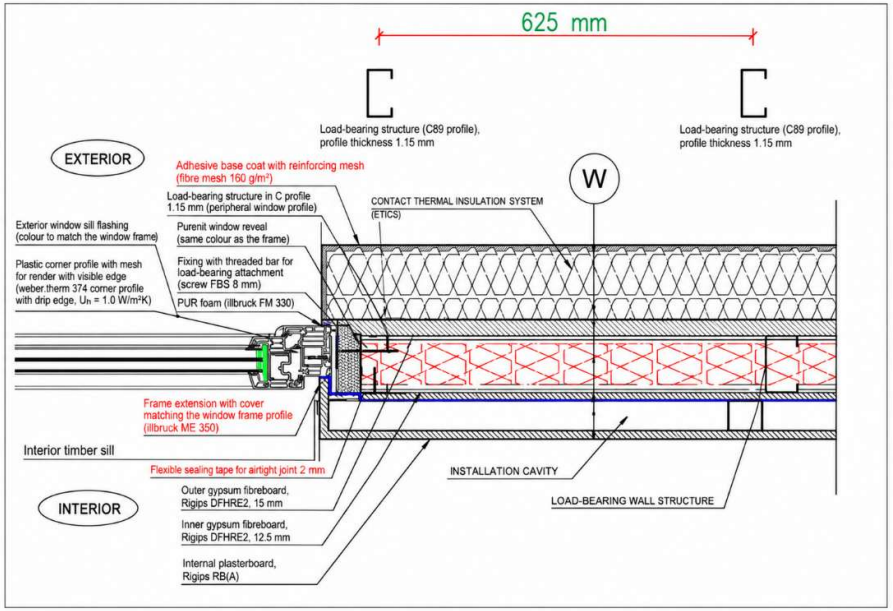
Expanded-clay sub-base (thermal insulation)

Gravel sub-base

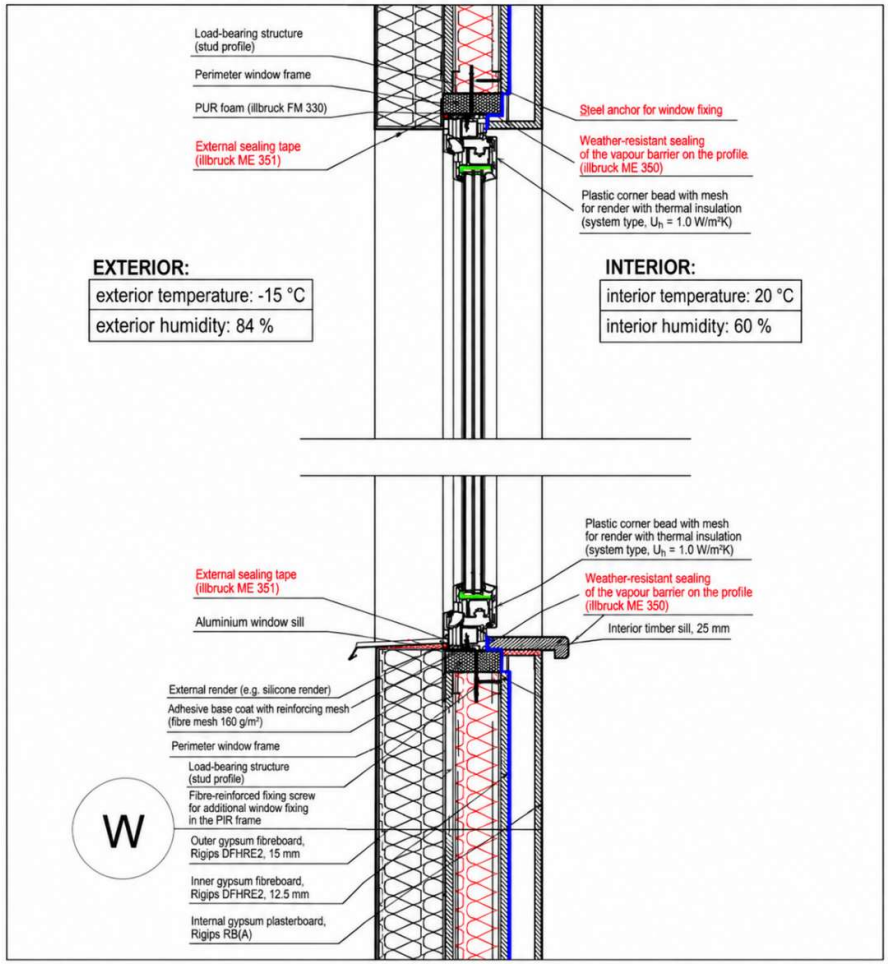
Existing ground

5.3 Detail of window installation in the external wall

EXTERNAL WALL PLAN WITH WINDOW REVEAL



VERTICAL SECTION THROUGH EXTERNAL WALL WITH WINDOW

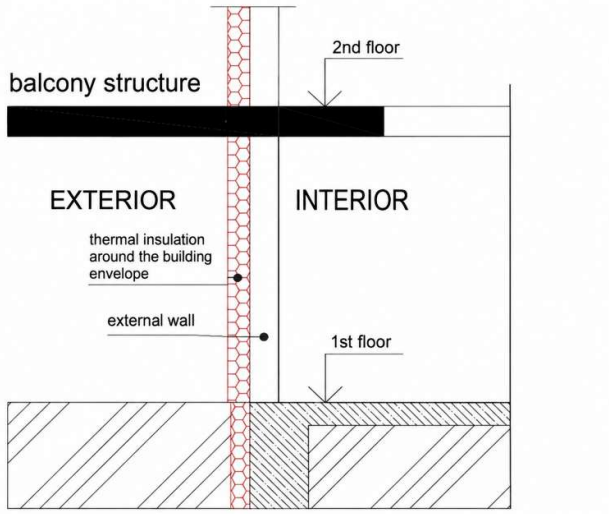


Installation procedure for window and door units in the steel structure (to be carried out by the window and door supplier):

- Install the PURENIT frame around the entire perimeter of the prepared opening (reveals) — see Section 4.2
- Secure the PURENIT frame to the opening frame using screws with washers (to interrupt the thermal bridge between the future window and the wall frame)
- Install strap-type L-brackets on the reverse side of the window/door frame
- Apply the sealing system (windproof and vapour-tight tapes) around the entire perimeter of the window/door frame
- Level the window/door frame and then secure it to the wall frame (reveals, sill and lintel) using screws through the strap-type L-brackets
- Seal the installation joint with suitable PUR foam
- Connect the sealing system (windproof and vapour-tight tapes) of the window/door frame to the wall's vapour barrier/vapour control layer

5.4 Detail of the connection between a cantilevered structure (balcony) and the external wall

FIGURE 4: CANTILEVERED BALCONY STRUCTURE (VERTICAL SECTION)

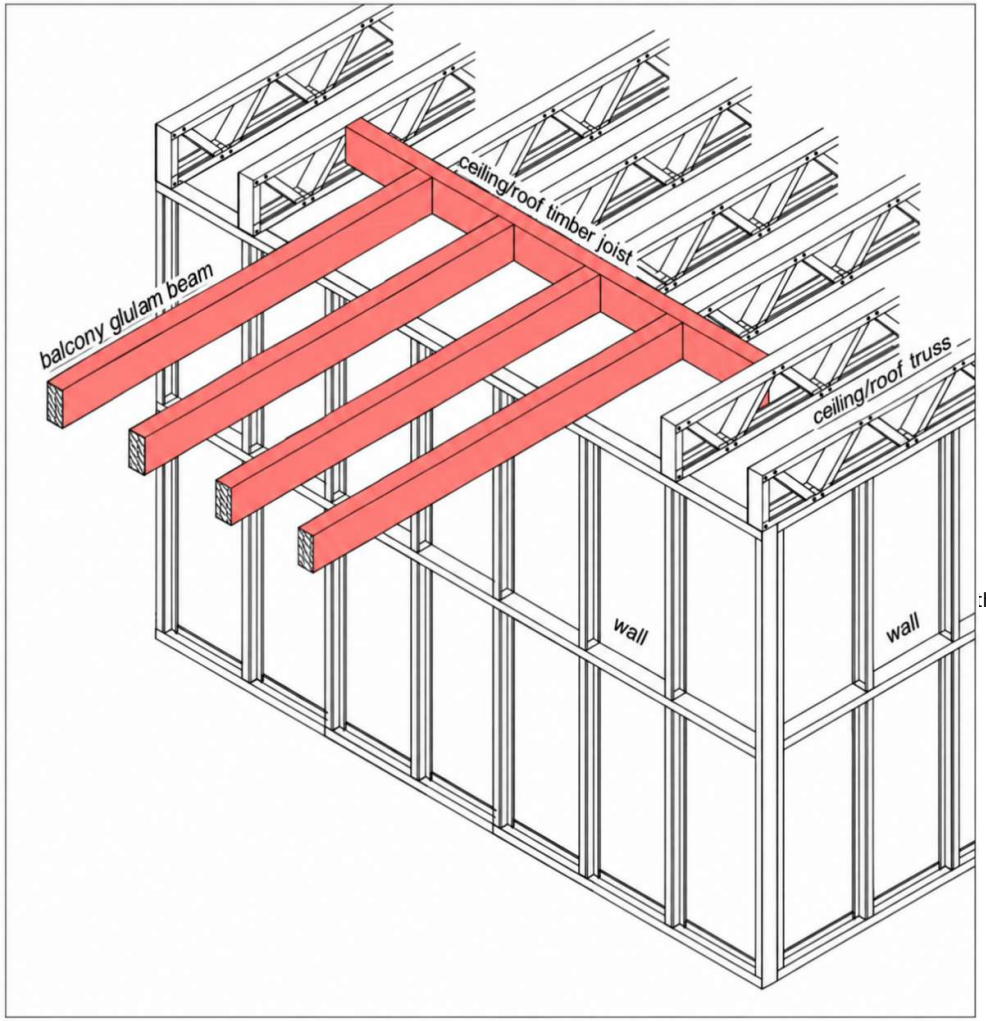


Cantilevered projecting structures, such as balconies, cornices, etc., are not designed using the steel load-bearing structure. Instead, to eliminate thermal bridges, they are advantageously replaced with a slenderer timber load-bearing structure, as shown in the diagram to the right of text.

The floor structure formed by trusses terminates, at the point before the balcony projection, with a timber or steel trimmer beam. Timber BSH (glulam) beams are then cantilevered perpendicular to this beam to form the actual load-bearing structure of the projecting balcony. This approach advantageously combines the steel floor structure inside the building with a projecting balcony structure made of timber.

The illustration on the following page shows this structural arrangement in greater detail. However, the basic proportions of projecting structures must always be determined by structural calculations. As a general rule of thumb, the maximum projection of the timber beam structure beyond the external face of the wall is 1.5 m, using beam cross-sections such as 100 × 200 mm and a maximum centre-to-centre spacing of 1,000 mm. Cantilevered structures are usually clad with non-combustible board materials, such as fibre-cement boards.

FIGURE 5: AXONOMETRIC VIEW OF THE CANTILEVERED BALCONY STRUCTURE

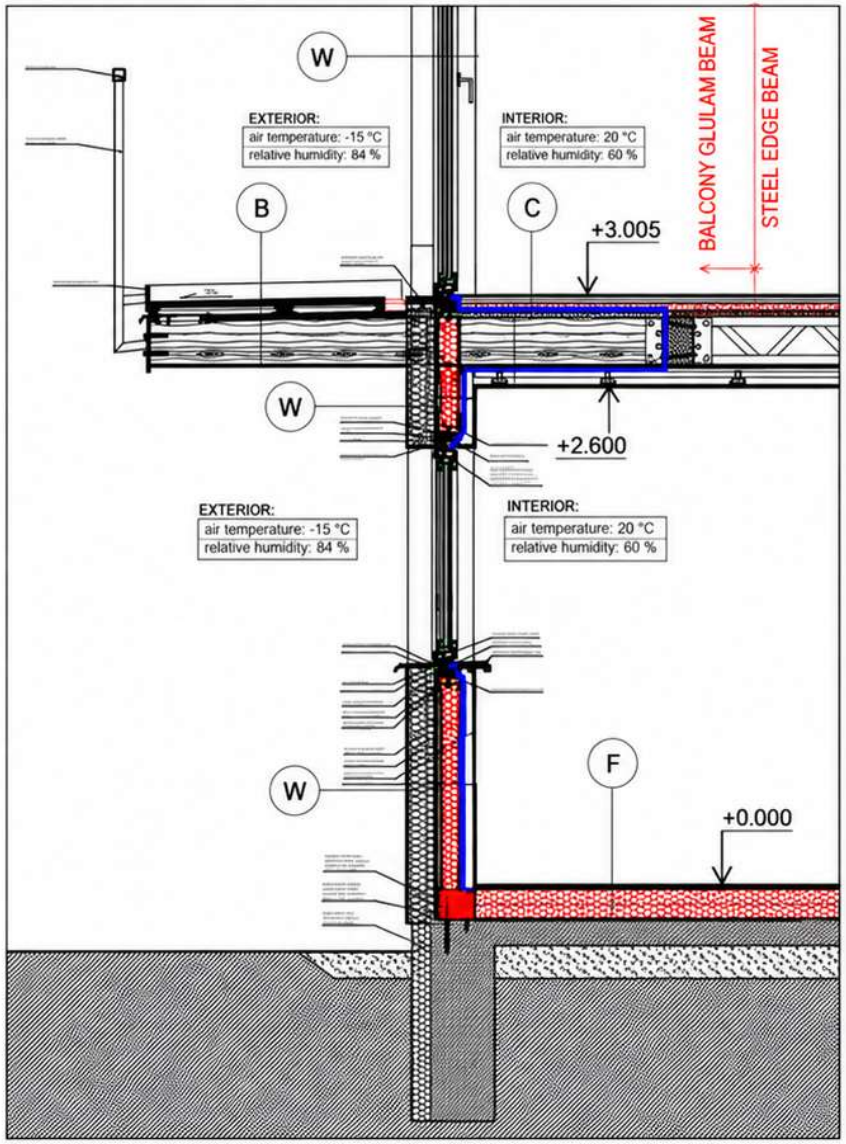


:he

In addition to timber beams, composite materials are also used to create cantilevered balcony structures. These materials have similarly low thermal conductivity to timber and are manufactured in a range of shapes comparable to rolled steel sections. Composite materials consist of two or more components with significantly different physical and chemical properties, combining greater strength than steel with lower weight. Their disadvantages include a low modulus of elasticity and poor fire resistance. They must therefore be protected with non-combustible board materials, such as fibre-cement boards

CANTILEVERED BALCONY STRUCTURE – DETAIL

SYSTEM BUILD-UP – VERTICAL SECTION



C **Floor build-up between apartments (from upper apartment):**

— finish layer (e.g. PVC, laminate or vinyl floor covering, up to 10 mm)
— gypsum fibre board, e.g. Rigidur 2 x 12.5 mm
— wooden acoustic insulation board, e.g. PAVATEX II, 30 mm
— vapour barrier ISOVER XtraSafe
— OSB 2 x 18 mm
— timber ceiling joist from BSH glulam (e.g. 80/220)
— gypsum fibre board RigipsStabil DFIREH2 (1 x 15 mm)
— vapour barrier ISOVER XtraSafe
— suspended substructure from galvanised SDK profiles R-CD (50 mm)
— gypsum board Rigips RB (A) with paint (1 x 12.5 mm)

total thickness: approx. 520 mm

B **Balcony structure build-up (from above):**

— finish layer (ceramic tiles laid loose on supports, 20 mm)
— plastic pedestals (height approx. 40 mm)
— waterproofing layer PVC-P (e.g. Fatrafol 807)
— full formwork from Cetris boards (min. 25 mm) or OSB boards (2 x 18 mm)
— timber floor boards from BSH glulam (e.g. 220 mm high, upper edge chamfered for drainage)
— support from Cetris boards (min. 12 mm)

total thickness: approx. 320 mm

W **External wall build-up (from outside):**

— ETICS (contact insulation system – thin-coat render, fiberglass mesh layer with reinforcement, including adhesive, thermal insulation board ORSIL TF t. 120 mm, total t. 130 mm)
— gypsum board RigipsStabil DFIREH2 1 x 15 mm
— metal frame construction 89 mm (witth thermal insulation profiles ORSIL AKU t. 80 mm)
— gypsum board RigipsStabil DFIREH2 1 x 12.5 mm
— vapour barrier ISOVER XtraSafe
— installation layer from galvanised SDK profiles R-CW (50 mm)
— gypsum board Rigips RB (A) with paint (12.5 mm)

total thickness: approx. 310 mm

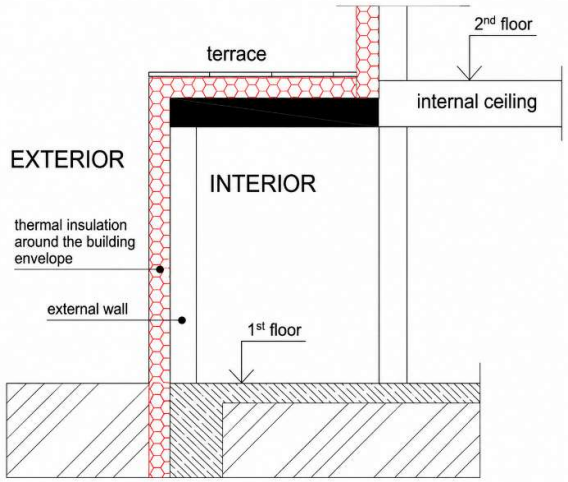
F **Floor build-up (from interior):**

— 2 x gypsum board RigipsStabil (2 x 12.5 mm)
— thermal insulation EPS150S (140 mm)
— adhesive for EPS (10 mm)
— waterproofing layer – modified bitumen membrane (4 mm)
— reinforced concrete floor structure board or foundation concrete slab
— compacted sub-base (e.g. crushed stone)

ISOVER TF wood fibre board (lambda < 0.037 W/mK; f.d.o. [m] = 1)
ISOVER AKU or UNI wood fibre board (lambda < 0.037 W/mK; f.d.o. [m] = 1)
TOPDEK 022 PIR board (lambda < 0.025 W/mK; f.d.o. [m] = 34)
EPS board (lambda < 0.038 W/mK; f.d.o. [m] = 60)
XPS board (lambda < 0.037 W/mK; f.d.o. [m] = 50)
FOAMGLASS PERINSUL solid block (lambda < 0.08 W/mK; f.d.o. [m] = practically unlimited)
Polyurethane insulation (lambda < 0.08 W/mK; f.d.o. [m] = 8)
OSB board Firestop PD
Thin-walled steel profile "C" AUKLAN 89 mm/40 mm t. 1.15 mm (lambda = 58 W/mK)
Vapour barrier ISOVER XtraSafe (Sd = 20 m) laid on asphalt waterproofing (Sd = 1500 m)
Gypsum fibre board RIGIPS DFIREH2 t. 15 mm and 12.5 mm (lambda = 0.15 W/mK; f.d.o. [m] = 13), incl.gypsum board Rigips RB (A) (lambda = 0.21 W/mK; f.d.o. [m] = 9)
Reinforced concrete structure (lambda = 1.5 W/mK)
Crushed stone sub-base
Compacted soil

5.5 Detail of the connection between the terrace structure and the external wall

RECESSED STRUCTURE – TERRACE (VERTICAL SECTION)

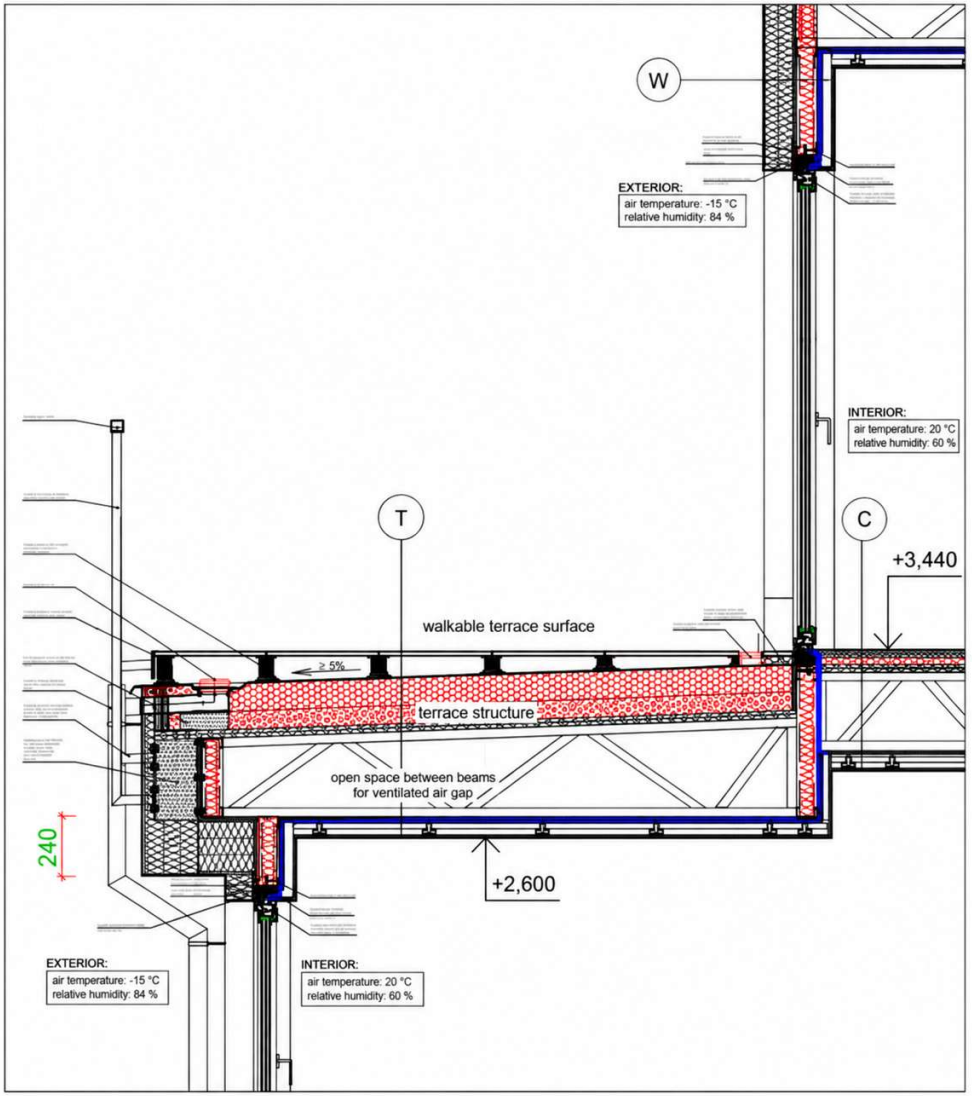


Recessed structures, particularly terraces, must also be protected against the formation of thermal bridges and the associated accumulation of condensate, as illustrated by the detail to the right of the text. It is important to recognise that a terrace not only provides a relaxation area for the upper-floor apartment but also forms the roof structure of the apartment below. Its design must therefore take this dual function into account. The terrace must meet all the requirements applicable to accessible roof structures.

The load-bearing structure of the terrace consists of a truss with a sloping top chord (with a minimum slope of 5% to ensure rapid water drainage). Two layers of OSB boards are then fixed to this structure, with thermal insulation bonded or mechanically fixed above them. The assembly is sealed at the top with a sheet waterproofing membrane. Adjustable pedestals with swivel heads are placed loosely on this membrane in a grid arrangement to support ceramic or concrete paving slabs, which form the final walking surface of the terrace.

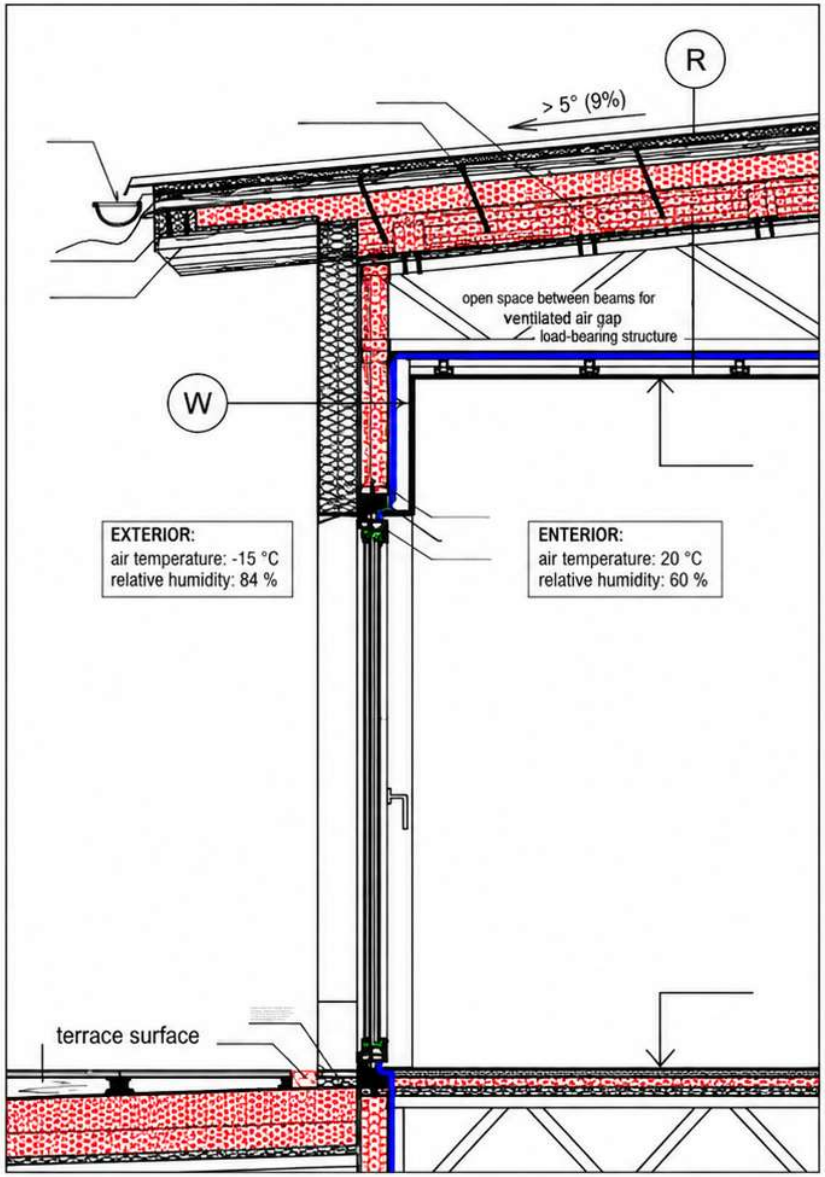
Rainwater draining from the terrace's walking surface, as well as through the perforated drainage channel near the terrace doors, reaches the sheet waterproofing membrane and is then directed into a recessed terrace drain. The drain pipe passes through the front edge of the terrace and connects to a vertical façade downpipe. Because the thickness of the thermal insulation must be reduced beneath the rainwater drain, conventional insulation is replaced in this location with aerogel insulation, which has a thermal conductivity coefficient approximately 2.5 times lower than that of commonly used insulation materials. This type of insulation is therefore used wherever a high thermal resistance is required within a limited thickness.

TERRACE DETAIL AT THE TERRACE DOOR AND LOWER FLOOR (VERTICAL SECTION)



To eliminate thermal bridges completely, the detail also incorporates a composite material element (L-section 200/100/10, with dimensions determined by the structural engineer). Its primary function is structural: it anchors the railing to the building while simultaneously preventing heat transfer between the building structure and the steel railing.

5.6 Detail of the connection between the external wall and a pitched roof (eaves)



R Roof build-up (from outside):

- sheet metal roofing (e.g. 0.6 mm)
- separating layer and ventilation gap (spacer PE mesh 1.4 mm)
- full formwork with impregnated timber (e.g. 25 mm) or OSB board 2.2 mm
- vapour-permeable underlay (e.g. 0.6 mm)
- ventilated air gap with truss (e.g. in framework space)
- PIR insulation board KOOLTHERM K3 (min. 80 mm) with mechanically fixed system screws
- top false ceiling with RIGIPS load-bearing CD profiles at max. 1200 mm spacing and mineral wool insulation 2 x 12.5 mm
- bottom false ceiling with RIGIPS CD profiles (e.g. in roof slope)
- RIGIPS Firestop OSB board 2 x 18 mm
- RIGIPS tongsue and groove gypsum fibreboard DFIREH2 1 x 12.5 mm
- suspended substructure with galvanized steel SDK profiles R-CD (50 mm)
- RIGIPS RB (A) gypsum fibreboard with paint (12.5 mm)

total thickness: approx. 520 mm

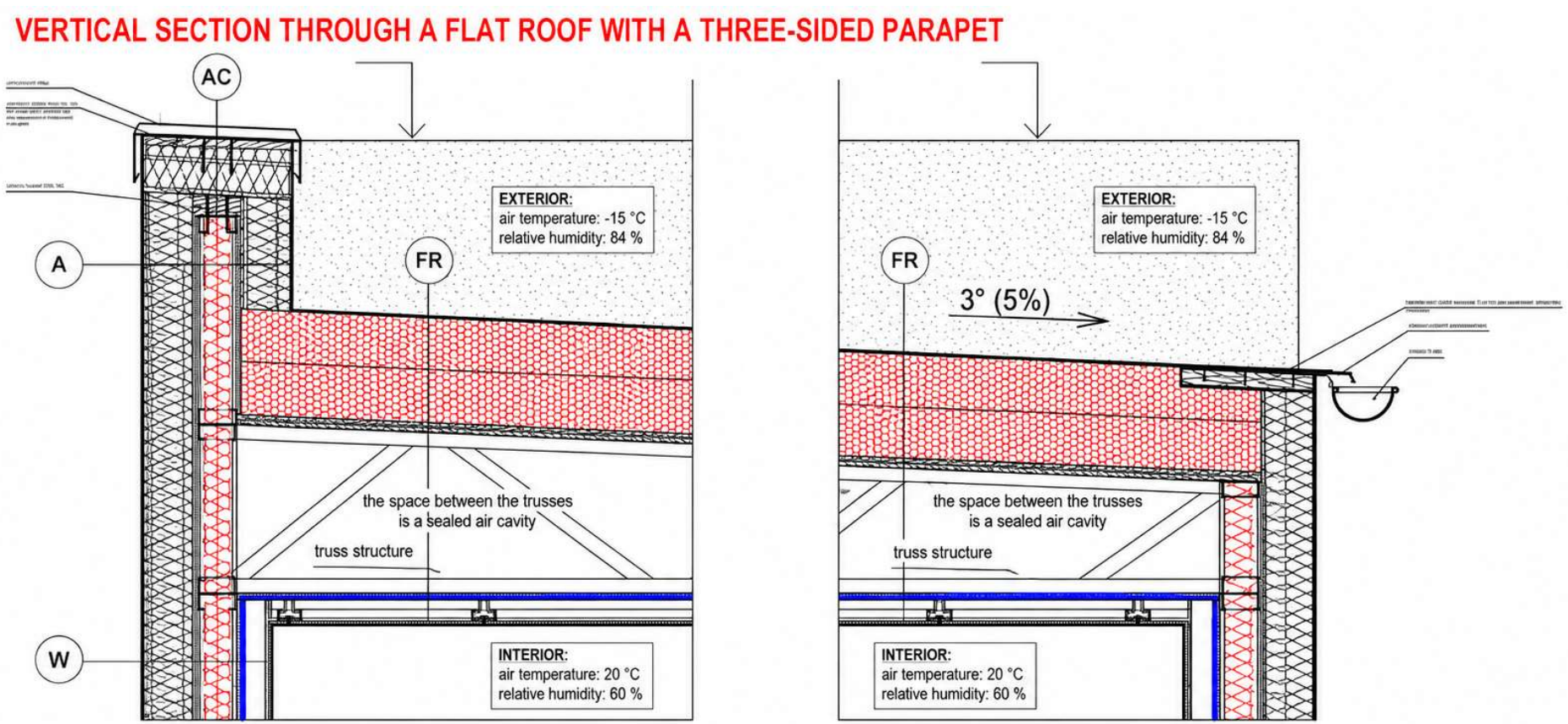
W External wall build-up (from outside):

- ETICS (external thermal insulation composite system) – thin-coat render, reinforcement mesh layer with fibreglass mesh, including adhesive, ORSIL TF thermal insulation 120 mm, total 130 mm
- load-bearing gypsum fibreboard RigiStabil DFIREH2 1 x 15 mm
- metal frame structure 89 mm (with thermal insulation in ORSIL AKU profiles 80 mm)
- gypsum fibreboard RigiStabil DFIREH2 1 x 12.5 mm
- vapour barrier ISOVER XtraSafe
- installation layer with galvanized steel SDK profiles R-CW (50 mm)
- RIGIPS RB (A) gypsum fibreboard with paint (12.5 mm)

total thickness: 310 mm

- wood-fibre board ISOVER TF (lambda < 0.037 W/mK; f.d.o. [m] = 1)
- wood-fibre board ISOVER AKU or UNI (lambda < 0.037 W/mK; f.d.o. [m] = 1)
- PIR board TOPDEK 022 PIR (lambda < 0.025 W/mK; f.d.o. [m] = 34)
- EPS board (lambda < 0.038 W/mK; f.d.o. [m] = 60)
- Purenit insulation (lambda < 0.08 W/mK; f.d.o. [m] = 8)
- OSB board Firestop PD
- thin-walled steel "C" profile 89mm/40mm t. 1.15mm (lambda = 58 W/mK)
- vapour barrier ISOVER XtraSafe (Sd = 20 m) laid on the asphalt waterproofing (Sd = 1500 m)
- RIGIPS DFIREH2 gypsum fibreboard 1 x 15 mm and 12.5 mm (lambda = 0.15 W/mK; f.d.o. [m] = 13), incl. RIGIPS RB (A) gypsum fibreboard (lambda = 0.21 W/mK; f.d.o. [m] = 9)

5.7 Detail of the connection between the external wall and a flat roof (including the parapet)



FR Flat roof build-up (from exterior):
- waterproofing layer PVC-P with substrate and mechanically fixed, e.g. 1.3 mm
- separating layer 2 x EPS 150 S (100 mm each) with top layer with milled chamfer 290 mm
- wooden board RIGIPS DFRIEH2 (top) 12.5 mm
- ventilation gap with cross battens (top of trusses, always min. 60 mm)
- load-bearing gypsum fibreboard RigiStabil DFRIEH2 1 x 12.5 mm
- vapour barrier ISOVER XtraSafe
- installation layer with galvanised steel SDK profiles for fixing SDK boards (60 mm)
- ceiling – SDK board RB(A) with paint (12.5 mm)

total thickness: approx. 380 mm

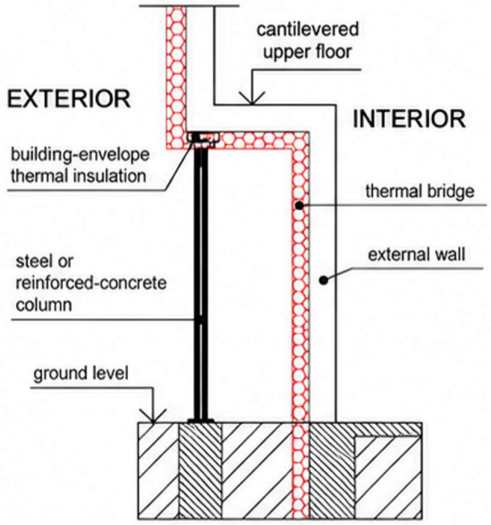
A Parapet build-up (from outside):
- ETICS (external thermal insulation composite system) – thin-coat render, reinforcement mesh layer with fibreglass mesh and adhesive
- load-bearing gypsum fibreboard RIGISTABIL DFRIEH2 1 x 15 mm
- metal frame structure 89 mm (with thermal insulation in ORSIL AKU profiles)
- gypsum fibreboard RIGISTABIL DFRIEH2 1 x 12.5 mm
- vapour barrier ISOVER XtraSafe
- ETICS (external thermal insulation composite system) – thin-coat render, reinforcement mesh layer with fibreglass mesh and adhesive, thermal insulation ORSIL TF 120 mm, total 130 mm

total thickness: approx. 380 mm

AC Parapet structure build-up (vertical assembly):
- sheet metal capping with flashings and sealed joints, 0.6 mm
- timber battens (OSB boards) 2 pcs. 8 mm for fixing sheet metal
- reinforcing timber post 120 mm x 70 mm
- thermal insulation filler 120 mm x 40 mm
- parapet frame structure 89 mm (with thermal insulation in ISOVER AKU profiles 80 mm)

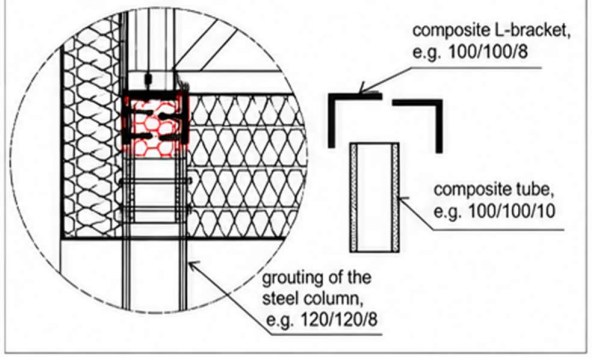
5.8 Detail of the connection between a projecting upper storey and the external wall of the lower storey, supported by a steel column

SCHEMATIC OF THE CANTILEVERED UPPER FLOOR (VERTICAL SECTION)

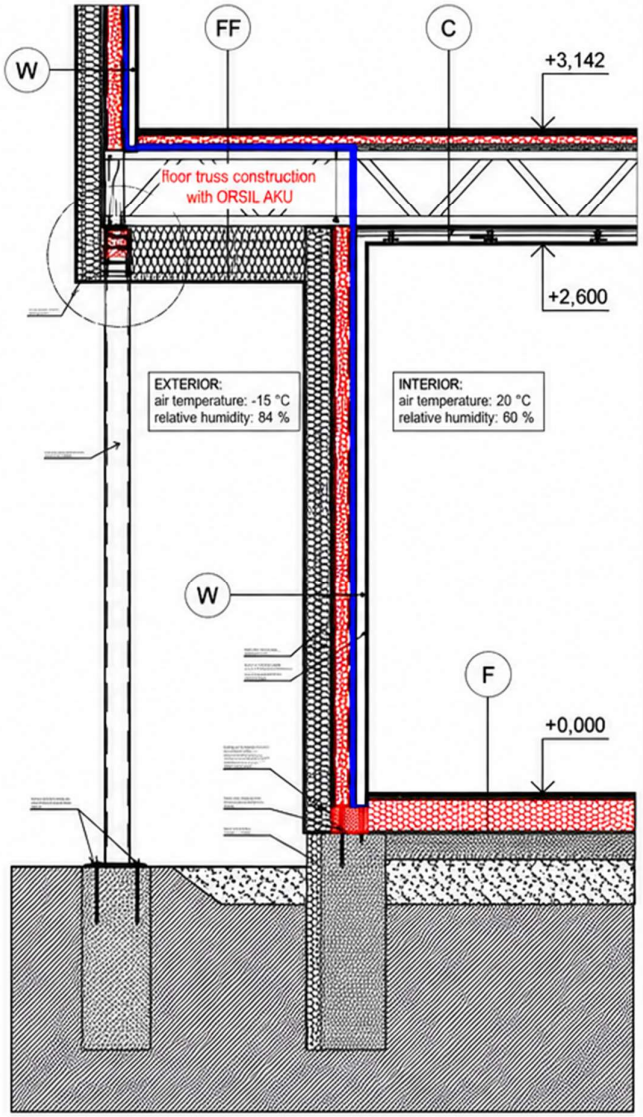


The detail on the right shows the cantilevered truss floor structure seated on a steel column. Since the steel column is a very good conductor of heat, this thermal bridge must be interrupted by a non-conductive material, using a composite element positioned within the plane of the thermal insulation. In the example shown, a composite bracket is formed from a bent section, with the steel column anchored to its lower part; the upper end of the bracket is then attached to the truss using composite L-brackets. See the detail below.

Detail of the interruption of the thermal bridge between the steel column and the floor structure.



DETAIL OF THE STEEL COLUMN SUPPORTING THE CANTILEVERED UPPER FLOOR (VERTICAL SECTION)



C Floor build-up between apartments (from the upper apartment):
- wear layer (e.g. PVC, laminate or vinyl flooring, up to 10 mm)
- gypsum-fibre floor board Rigidur 2 × 12.5 mm
- wood-fibre acoustic insulation board, e.g. PAVATEX, 30 mm
- OSB base board 2 × 18 mm
- floor truss
- RigiStabil DFIREH2 gypsum board 1 × 15 mm
- suspended substructure of galvanized steel CD profiles R-CD (50 mm)
- RIGIPS RB (A) gypsum-board ceiling with paint 1 × 12.5 mm

total max. approx. 520 mm

FF Floor build-up between apartments (from the upper apartment):
- wear layer (e.g. PVC, laminate or vinyl flooring, up to 10 mm)
- gypsum-fibre floor board Rigidur 2 × 12.5 mm
- wood-fibre acoustic insulation board, e.g. PAVATEX, 30 mm
- ISOVER XtraSafe vapour barrier
- OSB base board 2 × 18 mm
- floor truss
- RigiStabil DFIREH2 gypsum board 1 × 15 mm
- suspended substructure of galvanized steel CD profiles R-CD (50 mm)
- RIGIPS RB (A) gypsum-board ceiling with paint 1 × 12.5 mm

total max. approx. 520 mm

W External wall build-up (from outside):
- ETICS (external thermal insulation composite system) – thin-coat render, reinforcement mesh with fibreglass mesh and adhesive, ORSIL TF thermal insulation 120 mm, total 130 mm
- gypsum board RigiStabil DFIREH2 1 × 15 mm
- metal frame structure 89 mm (with thermal insulation in ORSIL AKU profiles 80 mm)
- gypsum board RigiStabil DFIREH2 1 × 12.5 mm
- ISOVER XtraSafe vapour barrier
- installation cavity with galvanized steel profiles R-CW (50 mm)
- RIGIPS RB (A) gypsum board with paint (12.5 mm)

total: 310 mm

F Floor build-up (from inside):
- two gypsum-fibre boards RigiStabil (2 × 12.5 mm)
- EPS 150 S insulation (140 mm)
- floor EPS adhesive (10 mm)
- modified asphalt waterproofing layer (4 mm)
- reinforced-concrete floor slab or concrete blinding layer
- compacted sub-base (e.g. crushed stone)

- rigid stone-wool board ISOVER TF (lambda < 0.037 W/mK; f.d.o. [m] = 1)
- stone-wool board ISOVER AKU or UNI (lambda < 0.037 W/mK; f.d.o. [m] = 1)
- TOPDEK 022 PIR board (lambda < 0.025 W/mK; f.d.o. [m] = 34)
- EPS board (lambda < 0.038 W/mK; f.d.o. [m] = 60)
- XPS board (lambda < 0.037 W/mK; f.d.o. [m] = 50)
- FOAMGLASS PERINSUL block (lambda < 0.08 W/mK; f.d.o. [m] = very high)
- Purenit insulation (lambda < 0.08 W/mK; f.d.o. [m] = 8)
- OSB Firestop PD board
- thin-walled steel "C" profile 89 mm / 40 mm, t. 1.15 mm (lambda = 58 W/mK)
- ISOVER XtraSafe vapour barrier (Sd = 20 m) laid under the asphalt waterproofing (Sd = 1500 m)
- RIGIPS DFIREH2 gypsum-fibre board 1 × 15 mm and 12.5 mm (lambda = 0.15 W/mK; f.d.o. [m] = 13), incl. RIGIPS RB (A) gypsum board (lambda = 0.21 W/mK; f.d.o. [m] = 9)
- reinforced concrete
- gravel sub-base
- existing ground