2.3 Scope

Nowadays, curtain walls take over all functions of the building envelope. In order to regulate the "placing on the market" and CE marking of curtain walls in Europe uniformly, the product standard for curtain walls (curtain walling) EN 13830 was published for the first time in 2003 and is now available in a second revised version (04/2015). This regulates all requirements that are placed on curtain walls at European level.
Transparent curtain walls and their associated opaque areas are dealt with, which do not have a supporting function in the overall structure (secondary supporting structures). These constructions are regulated in the standardization by EN 13830 - curtain walls and DIN 18516 or ETAG 034 - external wall cladding.

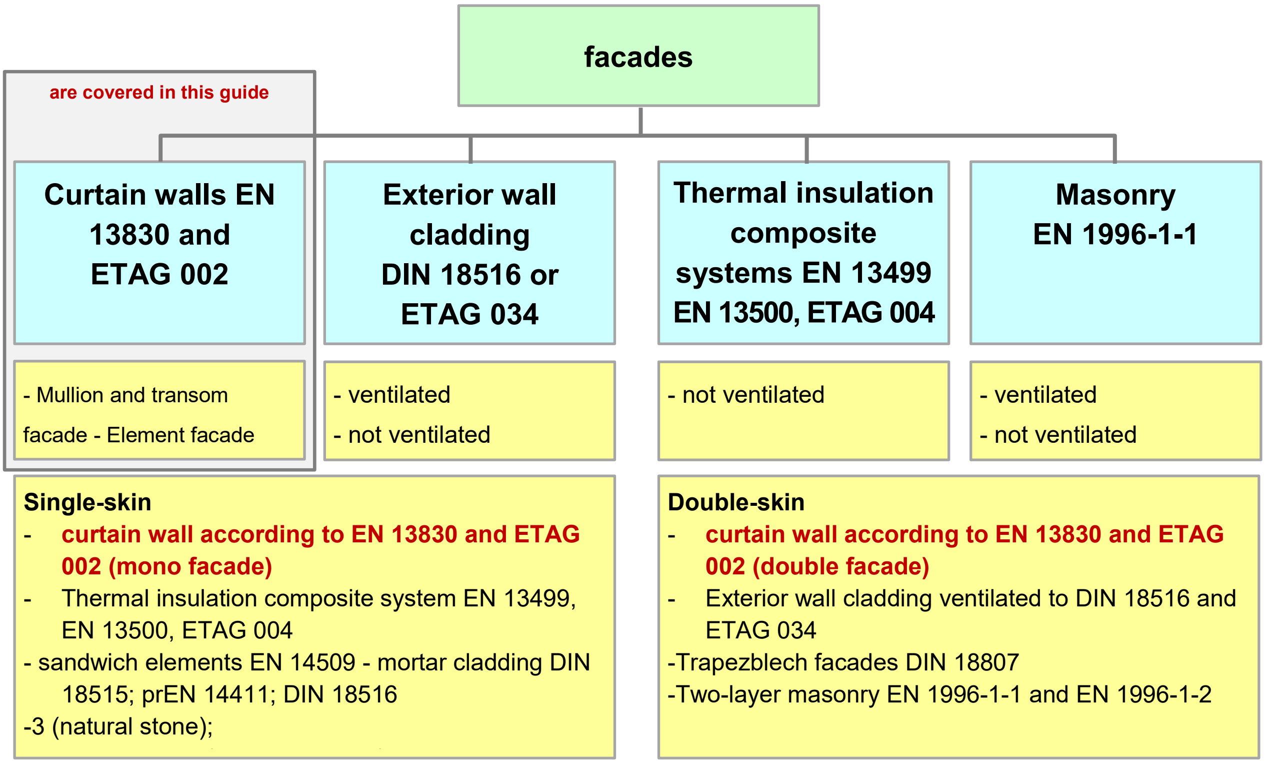


Figure 2.5 Facades in standardisation

Curtain walls of this type have a long history behind them. At the beginning of the 19th century, the skeleton construction was developed especially for industrial buildings. The skeleton of the buildings was no longer formed from load-bearing masonry walls and ceilings, but from load-bearing columns and ceiling panels. The load-bearing opaque walls were replaced by non-load-bearing transparent curtain walls, which were hung in or in front of the building skeleton.
This also resulted in a large selection of design and execution variants, which were not previously possible. One of the pioneers of this type of construction, the architect Mies van der Rohe, therefore also referred to this design as "skin and bone architecture", in which the "skin" stands for the curtain wall and the shell of reinforced concrete or steel for the "bones".
The product standard EN 13830 regulates the following facts:

2.4.2 Element facade

Element facades are usually composed of storey-high or multi-storey curtain wall elements that are assembled in advance in the manufacturing plant and provided with infills. The elements are connected on the construction site by coupling profiles and swords, which are inserted into the profile chambers. The connection to the building is made via pre-assembled brackets on the structure (pre-assemblies) and hangings on the elements, which are often designed as fixed points.. The loose bearings are usually formed by the swords, which are also used for coupling the elements. Due to the high degree of prefabrication of the element facades, the building can be closed very quickly. The elements can be manufactured with high repeatability and quality in the manufacturing plant on production lines. The infills are usually attached from the outside using glass retaining strips, but can also be carried out with pressure strips or as a glued glass construction (see also 2.4.3). Openable elements such as windows or doors can be integrated directly into the profile geometry of the frame profiles or clamped like infills. Panel areas and other add-on components such as sun protection devices are usually pre-assembled when the elements are delivered to the construction site.

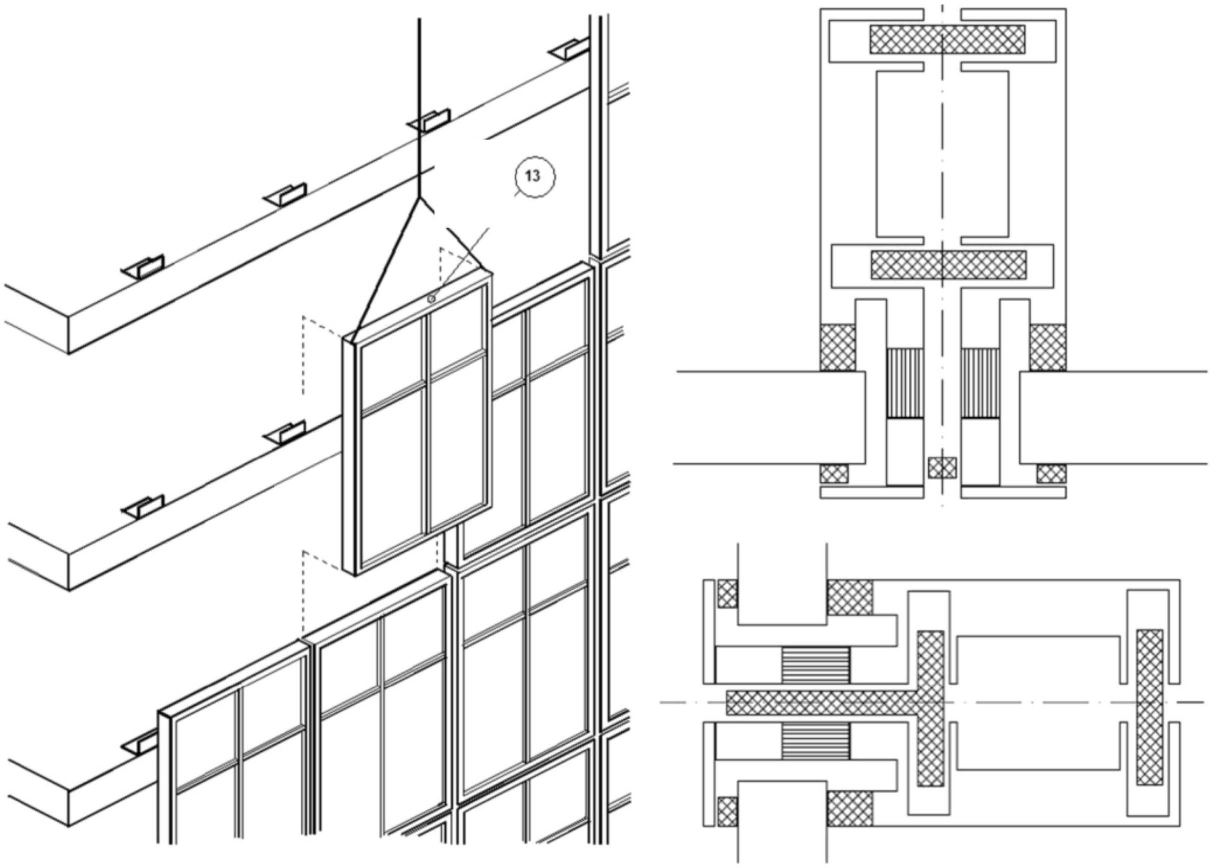
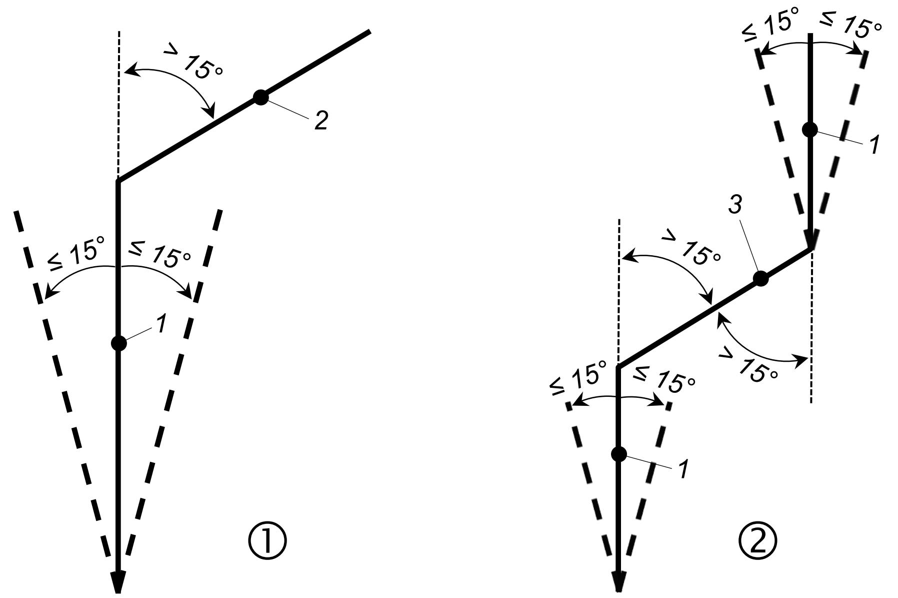


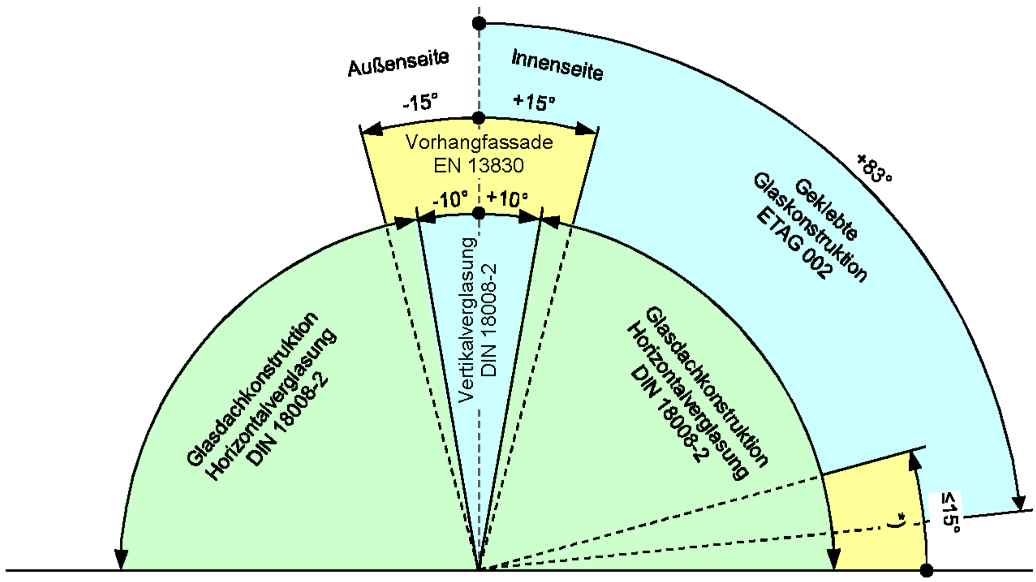
Figure 2.8 Element façade design



Legend:
1 curtain wall - from the vertical up to ± 15 ° from the vertical
2 inclined part is part of the curtain wall kit (roof glazing)
3 inclined part is not part of the curtain wall kit ((??? where is part 3))

Figure 2.12 Non-regulated roof glazing / conservatory ① and inclined part of a curtain wall integrated in EN 13830②

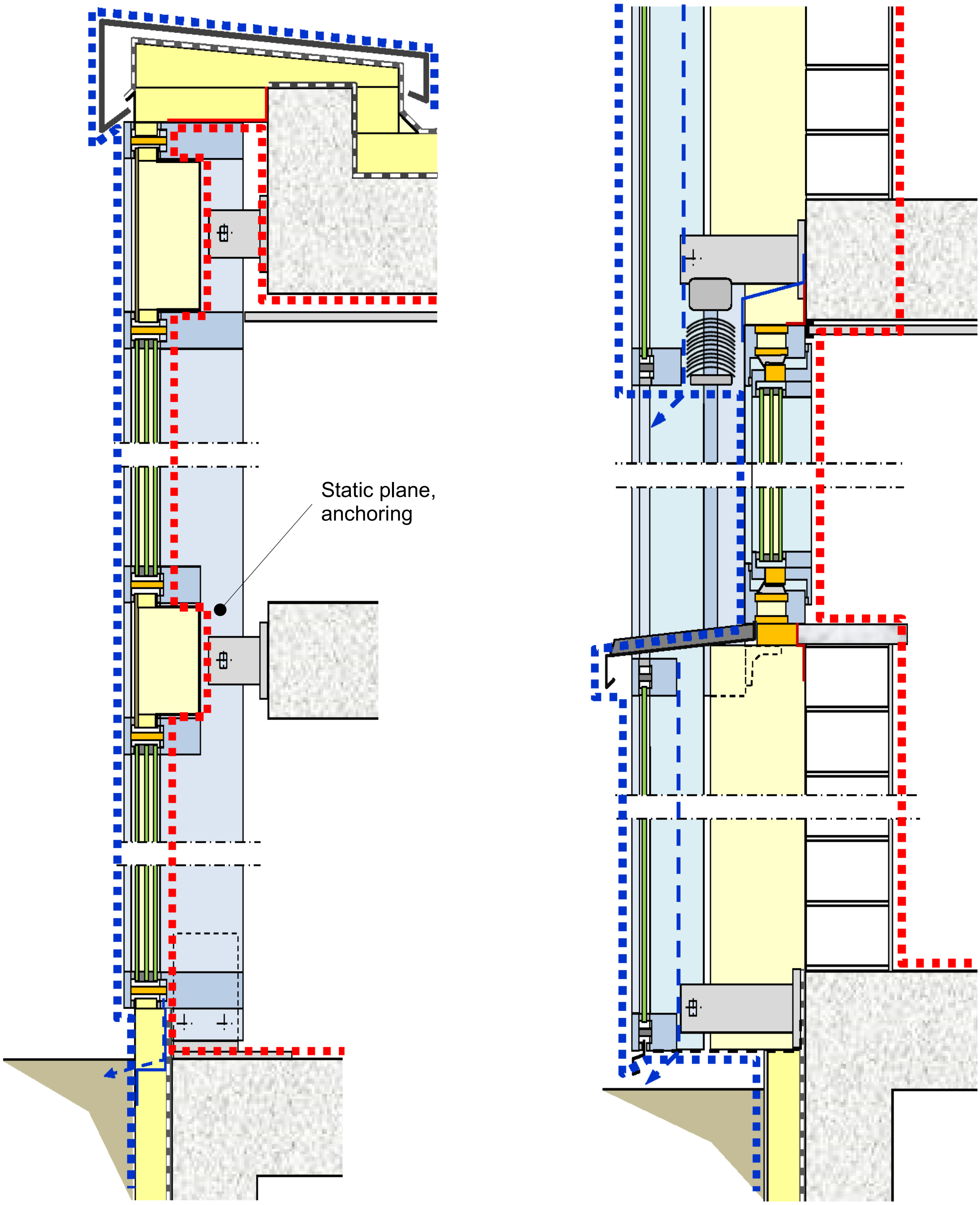
For horizontal glazing in Germany, the specified additional regulations of DIN 18008-2 - Glass in Construction - Design and Design Rules - Part 2: Line-shaped glazing, must be applied from a vertical inclination of > 10°.



**) Overhead glazing with low inclination according to ift specialist information VE-12/1*

Figure 2.13 Assignment of rules depending on the slope of the component

Warm facade: *Cold-warm facade:*



Legend:

- red dotted line: (1) Separation of room and outdoor climate (air tightness level)
- yellow bar: (2) Functional level
- blue dotted line: (3) Weather protection level

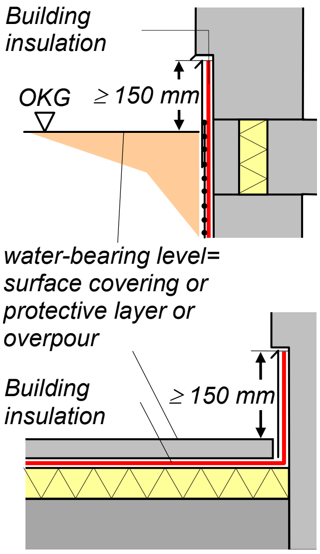
Figure 2.17 Layer model using the example of built-in curtain wall constructions

<table>
<tr><th>No</th><th>Characteristics</th><th>Existent</th></tr>
<tr><td>8</td><td>Insulation in the connection area
The connections to the building structure must be filled with insulation material as completely and seamlessly as possible. Several suitable materials are available for this purpose
The selection depends on the respective design of the connectors and must be defined or restricted accordingly. If necessary, appropriate molded parts must also be made of sheet material. Suitable joint insulation materials include:
• Mineral fibre insulation
• Thermal insulation panels (e.g. EPS, XPS)
• PU-place foam
• Spray cork
• Foam filling tapes (non-water-sucking)
The exact geometric and material design must be clearly defined in the invitation to tender and delimited to the adjacent trades</td><td>□
□
□
□
□
□</td></tr>
<tr><td>9</td><td>Airtight connection formation on the room side
According to the EnEV, the heat-transferring surrounding area of buildings including all joints must be made permanently air-impermeable according to the recognized rules of technology. The rules for this are described in DIN 4108-7 on the basis of planning and implementation recommendations and examples.
The room-side sealing must be planned and clearly written out. Several suitable materials are available for the execution:
• Sealing foils / joint sealing foils
• Sprayable sealants •
• Joint sealing tapes / foils •
• Liquid sealing / liquid membrane

The selection essentially depends on
• the installation situation and construction sequence
• the curtain wall construction •
• the adjoining structure •
• the external influences to be expected
• possible
• design aspects (e.g. with visible joints)

The professional use of these materials requires a suitable design and quality of the joint flanks / adhesive surfaces (e.g. smooth lines). Corresponding requirements are to be specified in the performance descriptions of the pre-works concerned
Additional required connection profiles/sheets must be defined and advertised in planning
In addition, when renovating curtain walls in existing buildings
Any additional measures required to produce suitable joint flanks and to compensate for tolerances on the structure for sealing and restoring the reveal on the room side</td><td>□
□
□
□</td></tr>
<tr><td>10</td><td>Ventilation planning
Due to the required airtight design of the construction connections, an uncontrolled air change (infiltration) via these joints is no longer necessary. To ensure air change for moisture protection, hygiene and energy saving, controlled ventilation must be planned</td><td>□</td></tr>
</table>

Table 3.2 Requirements for the formation of the lower connection area acc. to regulations

<table>
<tr><th>Execution options of the lower connection</th><th>Requirements for the lower connection according to the relevant set of rules</th></tr>
<tr><td>
</td><td>

DIN 18195 Building seals –
Part 9: Penetrations, transitions, fittings and closures

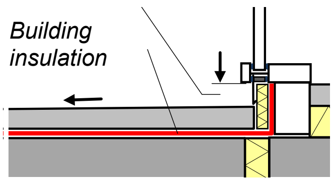
5.4.2 Building base for closures of seals in accordance with DIN 18195-4 and DIN 18195-6, section 9

In the base area, the substrate must be designed in such a way that, in the case of seals against soil moisture and intermittently accumulating leachate, the sealing can normally be carried up to 300 mm over the upper edge of terrain in order to provide sufficient adaptation possibilities for the surface area. In the final state, this value should not be less than the 150 mm dimension.

5.4.3 Closures for seals in accordance with DIN 18195-5

When sealing horizontal and slightly inclined surfaces, the rising components are to be designed in such a way that the seal extends well beyond the worst case water loading. The water loading may come from surface, spray and/or leachate and must normally be at least 150 mm above the protective layer. The surface of the covering or the overburden must be raised and secured and kept on a largely gapless, level, stable reserve to prevent it from sliding off. ...
</td></tr>
<tr><td rowspan="2">

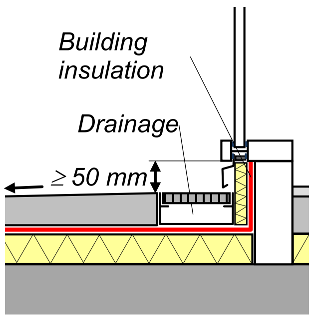
Falling below the sealing height, taking into account accompanying measures, permitted acc to local requirements


</td><td>

5.4.4 Arrangement of the seal for door sills

If the sealing heights mentioned under 5.4.2 and 5.4.3 cannot be produced in individual cases (e.g. with barrier-free house entrances, patio doors, balcony or roof terrace doors), there are special measures against the ingress of water or the backing of the waterproofing to be planned. For example, door sills and door posts must be driven from the seal or designed on their outer surface in such a way that the sealing can be connected water tightly, e.g. with clamping profiles.

Threshold ends with low or no edging must also be protected from heavy water pollution, e.g. by sufficiently large canopies, facade backs and/or directly drained gutters with gratings. The surface gradient should not be directed towards the door.

In the case of roof terraces with a closed parapet, overflows must be so low that the threshold cannot be over-jammed if the drain is blocked.
</td></tr>
<tr><td>Examples of the arrangement of seals are given in DIN 18195 - supplement 1.</td></tr>
<tr><td>
</td><td>

Specialist rule for roofs with waterproofing - flat roof guidelines

5.3 Connections to doors

(1) The connection height should be 0.15 m above surface covering or gravel filling.

(2) A reduction of the connection height is possible if a flawless water drainage in the door area is ensured at all times due to the local conditions. This is the case when there are terrace drains or other drainage options in the immediate door area. In such cases, however, the connection height should be at least 0.05 m (upper end of the seal or of connection plates under the weather bar / base profile).

(3) Barrier-free transitions are special designs
</td></tr>
</table>

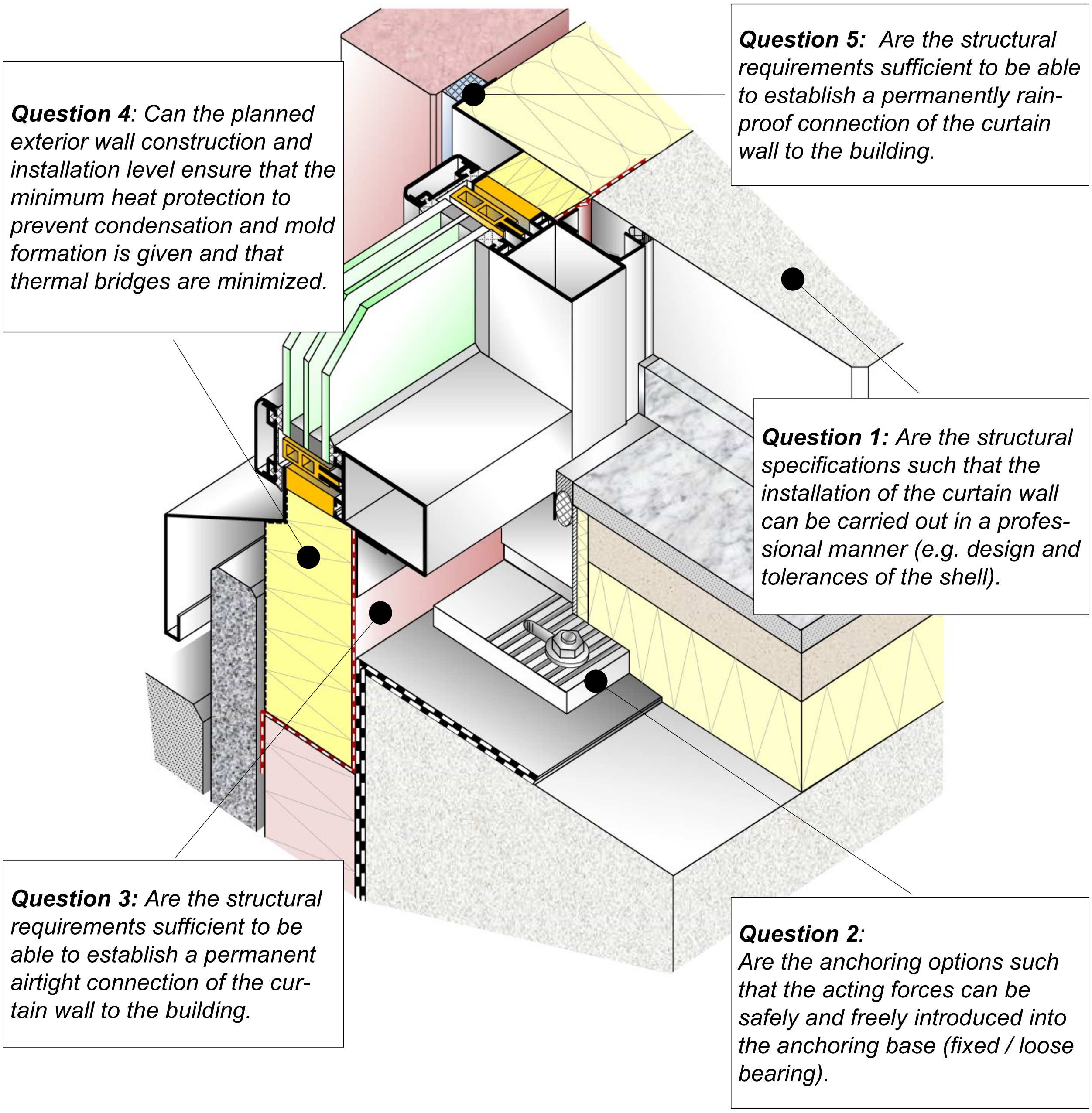


Figure 3.5 Key questions in the examination of the conditions for assembly planning

With regard to Question 2 (Fig. 3.5), it should be noted that all forces that occur at right angles and in the facade level on the curtain wall must be safely introduced into the building. Due to the chosen anchorage, the curtain walls to be installed must not be rigidly integrated into the building structure. For this purpose, information on movements and deformations of the building in the area of the outer wall opening for the curtain facade must be provided or obtained by the planner. Only sufficiently corrosion-protected, approved anchoring agents must be used for anchoring (see Chapter 5).

4.2.2.2 Minimum thermal insulation, thermal bridges

Minimum requirements for thermal protection in the area of thermal bridges are necessary in order to avoid the formation of condensation and mold on room-side component surfaces. Evidence can be provided via the temperature factor f_{Rsi}, by means of a mathematical calculation according to DIN EN ISO 10211 or using sample designs from thermal bridge catalogs. Constructive thermal bridges must also be minimized from the point of view of economy. The influence of the remaining thermal bridges on the transmission heat loss must be taken into account in the energy balance.

Note on German Building Law:
Since the introduction of the Energy Saving Ordinance (EnEV) in 2002, thermal bridges, and thus also the structural connection of curtain walls, have been assessed and taken into account in terms of moisture and heat technology. The EnEV provides the following procedure for the area of thermal bridges in accordance with § 7 "Minimum thermal insulation, thermal bridges".

humidity [1] [2]	**heat [1]**
Minimum thermal insulation requirements must be met in accordance with recognized technical rules	Constructive thermal bridges are to be minimized from the point of view of economy. The influence of the remaining thermal bridges on the transmission heat loss must be taken into account in the energy balance.
DIN 4108-2 Section 6, Minimum requirements for thermal insulation in the area of thermal bridges. Avoidance of condensation and mold formation on component surfaces on the room side • equivalent design according to DIN 4108, supplementary sheet 2 3) 4) otherwise • Evidence of temperature factor fRsi - using thermal bridge catalogs (e.g. Chapter 8) or - by calculation according to EN ISO 10211;	EnEV Taking thermal bridges into account • *by a flat rate supplement* *ΔU_{WB} = 0,10 W/(m² · K)* *for the entire area of thermal transfer perimeter or* • when applying the planning examples according to DIN 4108, supplement 2 (with proof of equivalence), reduced surcharge ΔU_{WB} = 0,05 W/(m² · K) [3] [4] sau • detailed proof of thermal bridges; Determination of the heat transfer coefficient related to length • (Value Ψ) - Using thermal bridge catalogs (e.g. chapter 8) or - mathematical calculation according to EN ISO 10211;;

[1] Note: For conventional (selective) fasteners when installing windows, no proof of the thermal bridge effect has to be provided (DIN 4108-2, Section 6).

[2] Note: The formation of condensation is temporary and permitted in small amounts of windows and mullion-transom constructions if the surface does not absorb the moisture and appropriate measures are taken to avoid contact with adjacent sensitive materials (DIN 4108-2, Section 6).

[3] Note: DIN 4108, Supplement 2, only contains examples for the new building sector

[4] Note: Proof of equivalence does not have to be provided if the adjacent components have smaller heat transfer coefficients than specified in Supplement 2 in the sample solution.

Figure 4.3 Consideration of thermal bridges according to EnEV.

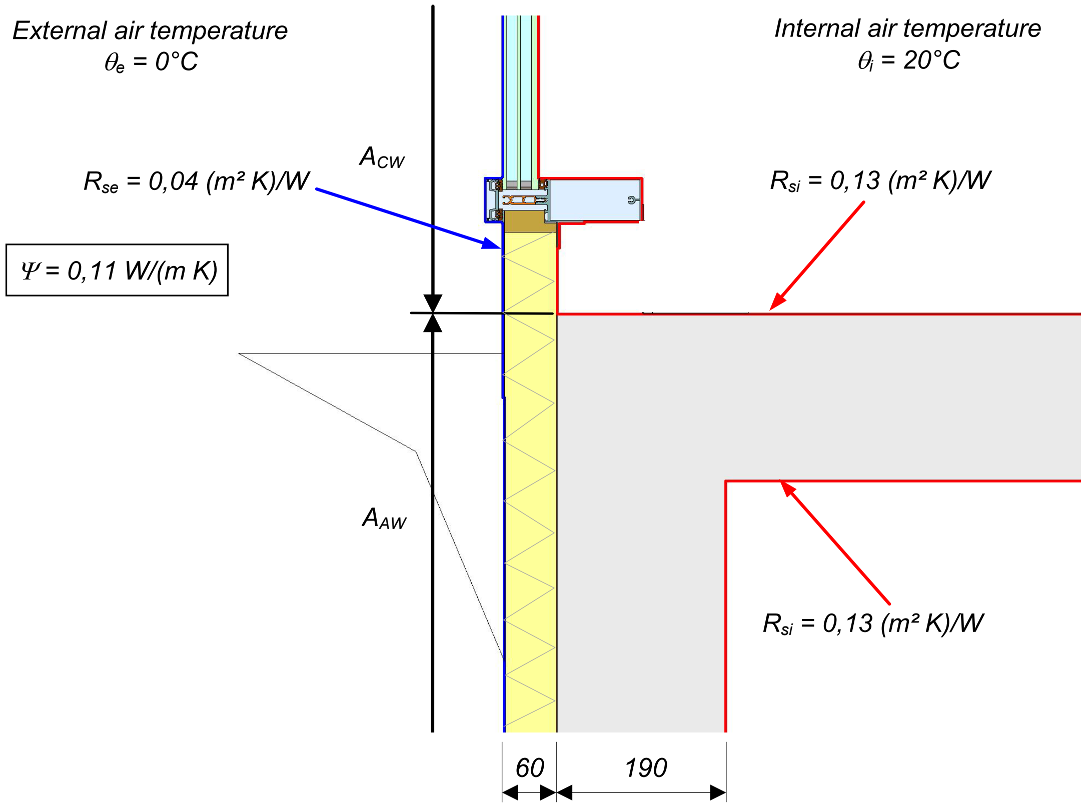


Figure 4.11 Boundary conditions for the calculation of the length-related heat transfer coefficient Ψ of a bottom curtain wall connection

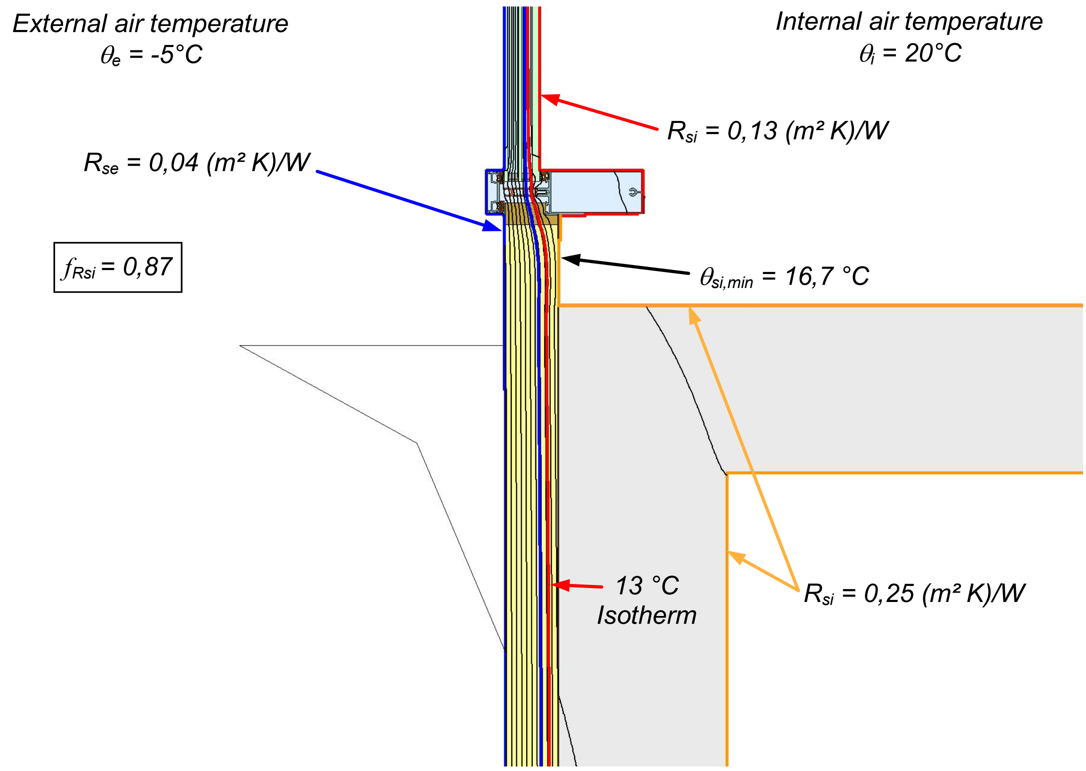


Figure 4.12 Boundary conditions for the calculation of the temperature factor f_{Rsi} of a bottom curtain wall connection

4.3.1.2 Requirements for airborne sound insulation between rooms

If the curtain wall element forms the flank between two rooms, requirements can be placed on the longitudinal sound insulation of the façade. A distinction must be made here between horizontal sound transmission between two adjacent rooms on one floor and vertical sound transmission from storey to storey (see Figure 4.27).

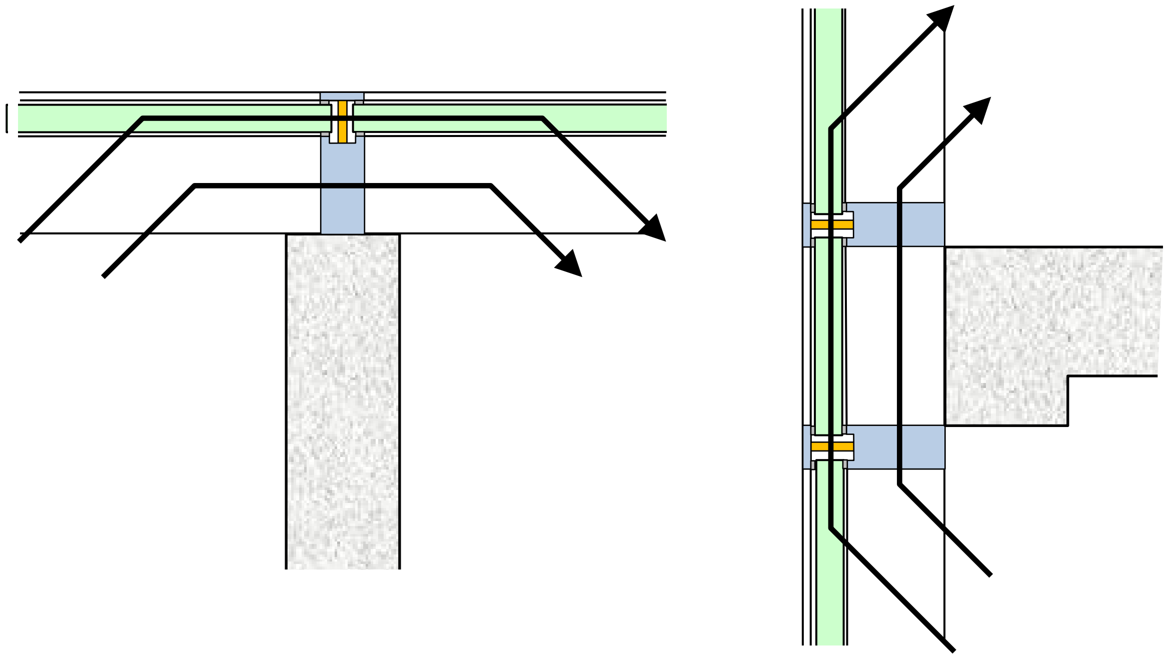


Figure 4.27 Horizontal and vertical sound transmission paths between rooms in curtain walls

In these cases, the requirement for longitudinal sound insulation results from the requirement for sound insulation between the rooms, which results from the direct sound insulation of the partition wall (or the partition ceiling) and the flank sound insulation of the adjacent components, e.g. the inner wall, a suspended ceiling, the bottom plate or the outer facade.

The characteristic value is the required sound insulation measure of the separating component part:

$$R'_w \text{ in dB}$$

In order to achieve these protection goals, requirements are made on the one hand on fire behavior and on the other hand on fire resistance.

E — **Raumabschluss** (EN 16034 Abs. 4.1, EN 13501-2 Abs. 5.2.2)
Widerstand eines Bauteils mit raumtrennender Funktion gegen Brandbeanspruchung von einer Seite, um Durchtritt von Flammen oder heißer Gase zu verhindert und so die Entzündung der dem Feuer abgekehrten Oberfläche oder in der Nähe befindlicher Materialien zu verhindern.

I — **Wärmedämmung** (EN 16034 Abs. 4.1, EN 13501-2 Abs. 5.2.3)
Fähigkeit eines Bauteils, einer einseitigen Brandbeanspruchung zu widerstehen und eine Wärmeübertragung von der dem Feuer zugekehrten Seite zu der vom Feuer abgewandten Seite zu reduzieren, um eine Entzündung zu vermeiden und Personen zu schützen (bei Feuerschutzabschlüssen in I_1 und I_2 aufgesplittet).

I_1 und **I_2** — **Wärmedämmung bei Feuerschutzabschlüssen** (EN 16034 Abs. 4.1, EN 13501-2 Abs. 5.2.3)
Begrenzung der mittleren Ausgangstemperatur auf der vom Feuer abgekehrten Seite des Türblattes auf 140 °C und der maximalen Temperaturerhöhung an jeder Stelle des Türblattes ist auf 180 °C. Bei I1 wird auf dem Türblatt ein 25 mm breiter, bei I2 ein 100 mm breiter Randbereich nicht berücksichtigt.

S — **Rauchdichtheit** (EN 16034 Abs. 4.2)
Fähigkeit eines Bauteils, den Durchtritt von Gas oder Rauch von einer Seite des Bauteils zur anderen zu verringern oder auszuschließen.

S_a — S_a berücksichtigt die Rauchdichtheit nur bei Umgebungstemperaturen.

S_{200} — S_{200} berücksichtigt die Rauchdichtheit bei Umgebungstemperatur und bei 200 °C.

Fähigkeit zur Freigabe (EN 16034 Abs. 4.3)
Prüfung der Feststellvorrichtung von Türen / Fenstern, um im Brandfall bzw. bei Rauchentwicklung, auch beim Ausfall der elektrischen Stromversorgung, zuverlässig zu schließen (Prüfergebnis „freigegeben").

C — **Selbstschließende Eigenschaft** (EN 16034 Abs. 4.4 und 4.5, EN 13501-2 Abs. 5.2.6)
Fähigkeit einer geöffneten Feuerschutztür (bzw. Fenster) im Brandfall vollständig zu schließen, auch beim Ausfall der elektrischen Stromversorgung, mit folgende Differenzierungen:

- **C** – Selbstschließend, Dauerhaftigkeit aber nicht geprüft
- **C0** – 1 – 499 Zyklen
- **C1** – Offen stehend gehalten (500 Zyklen),
- **C2** – Geringe Anzahl von Betätigungen durch Personen mit hoher Motivation zum sorgsamen Umgang, z. B. Türen von Privathäusern oder große Tore (10.000 Zyklen),
- **C3** – Mäßige Anzahl von Betätigungen hauptsächlich durch Personen mit einer gewissen Motivation zum sorgsamen Umgang (50.000 Zyklen),
- **C4** – Hohe Anzahl von Betätigungen hauptsächlich durch Personen mit einer gewissen Motivation zum sorgsamen Umgang (100.000 Zyklen),
- **C5** – sehr häufige Betätigung (200.000 Zyklen).

Dauerhaftigkeit der Fähigkeit zur Freigabe (EN 16034 Abs. 4.5 bzw. Abs. 5.2)
Die Dauerhaftigkeit der Fähigkeit zur Freigabe wird mit Prüfergebnis „Freigabe aufrechterhalten" bzw. auf Basis einer Dauerfunktion angegeben. In Abs. 5.2.2 wird auch die Dauerhaftigkeit gegenüber Korrosion gefordert (Prüfergebnis „erzielt").

W — **Strahlungsbegrenzung** (EN 16034 Abs. 4.1, EN 13501-2 Abs. 5.2.4)
Fähigkeit eines Bauteils, einer einseitigen Brandbeanspruchung zu widerstehen, um eine Brandübertragung durch abgestrahlte Wärme zu vermeiden. Bauteile mit dem Kriterium I, I1 oder I2 erfüllen i.d.R. auch die W-Anforderungen.

Klassifizierungszeiten (EN 16034 Abs. 4.1, EN 13501-2 Abs. 6.1)
Klassifizierungszeiten (10, 15, 20, 30, 45, 60, 90, 120, 180, 240 oder 360 Minuten) müssen für jedes Merkmale in Minuten angegeben werden

Figure 4.32 Terms and parameters for fire and smoke protection according to EN 16034

5.2 Requirements for curtain walls

The requirements and design rules for fastening are derived from the following EU standards:

- Eurocode 3 - EN 1993 - design and construction of steel structures
- Eurocode 5 - EN 1995 - Dimensioning and construction of wooden structures
- Eurocode 9 - EN 1999 - Dimensioning and construction of aluminum structures
  and their national annexes

If proof cannot be provided according to the aforementioned rules, a general building inspectorate approval (AbZ) or a European technical assessment (ETA) is required. This also applies to load-bearing anchorages (e.g. dowels) of curtain walls on the building structure, which must have a European technical approval / assessment (ETA) in order to be able to use them (see also 5.5).

5.3 Static systems

5.3.1 Mullion -transom facade

The mullion-transom facade is essentially anchored in the axis of the respective mullion profiles at only one point of force application per floor (see Figure 5.1). The posts can be designed as single-span carriers (1) or multi-span carriers (3) and attached to the shell in a standing (1) or hanging (2) (3) manner. The two-span girder has the advantage over the single-span carrier that it has less deflection with the same load and profile geometry. This means that a larger span can be achieved with the same profile depth while observing the permissible deflections.

$$f_2 \approx 0{,}42 \cdot f_1$$

With:

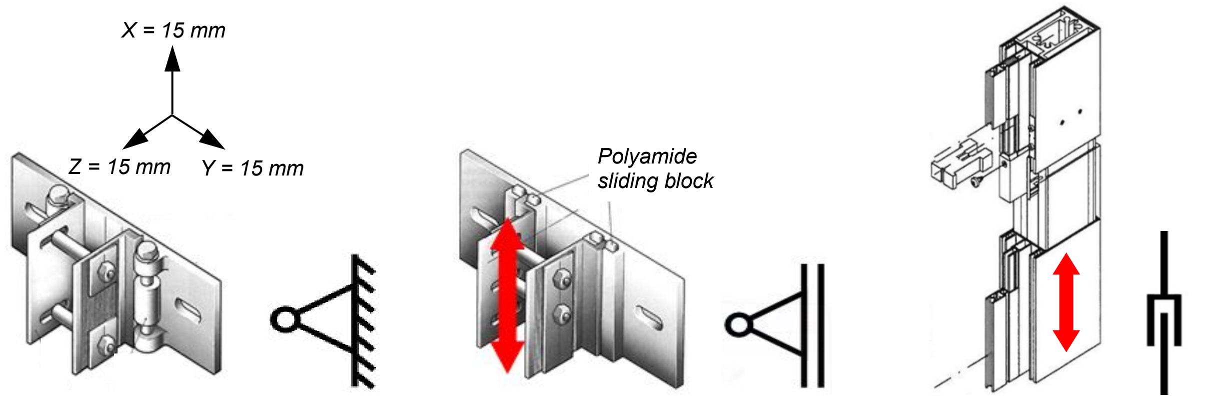
f_1 deflection of the single span beam in mm

f_2 deflection of the double span beam in mm

Note on German Building Law:

In Germany , the Eurocodes are listed in the technical building regulations (VVTB) administrative regulation and thus anchored in building law.

Furthermore, DIN 18008 " Glass in Building - Dimensioning and Construction Rules and DIN 18807 " Trapezoidal Profiles in Building Construction "are German standards that are relevant for the facade.



(1) fixed bearing   *(2) movable bearing*   *(3) Profile coupling, usually articulated, pushing* [1)]

[1)] Profile coupling can also be made rigid due to the long inserts and defined connection to the profiles.

Figure 5.3 Examples of supports and coupling for mullion-transom facades

5.4.2 Anchor points for element facades

5.4.2.1 Suspensions

The supports for element facades are usually made up of two parts and consist of a pre-assembly (e.g. angle bracket) that is connected to the shell and a suspension structure (e.g. hook) that is attached to the element

The pre-assembly has adjustment options that allow the console to be aligned horizontally on the shell. This is often done by long holes and a toothing in the surface for position securing. Other options are pressure plates or discs that are secured against movement by errands and notch pins, or welding after adjustment with the console.

. The attachment at the fixed bearings (Figure 5.4, Figure (1)) usually has a possibility to adjust (adjustment) in the vertical direction. This is very often achieved by metric screws, which allow the fitter to align the curtain wall exactly in height. In the case of loose bearings (Fig. 5.4, Figure (2)), however, free sliding in the vertical direction is desired. The adjustment or sliding range depends on the permissible building and component tolerances and the expected structural reductions as well as the dilation.
The elements are aligned horizontally parallel to the shell on the pre-assemblies in such a way that there is a regular joint pattern of the element frames and a correct position of the elements to the building axes. Then one of the brackets is secured against displacement (horizontal, fixed-body parallel fixed bearing), while the second bracket acts as a horizontal, rough-shell parallel floating bearing. It is of course sensible to always design the same side as a fixed bearing in order to maintain the regular joint pattern even after component movements.

5.4.2.2 Element coupling

Element coupling (Figure 5.4, Figure (3)) is responsible for stretch balancing in the vertical direction and load transfer in the horizontal direction. It is usually located directly in the coupling

For the external components, e.g. press bars of mullion-transom facades much larger temperature fluctuations can be expected. This can also lead to tension and deformation (bimetallic effect). In individual cases, noise emissions are also caused by changes in length. Therefore, it is important that length changes can be made continuously through a sliding, frictionless bearing. Discontinuous / sudden changes in length lead to crackling noises. Deformations can be expected both in the curtain wall level and perpendicular to it.

When assessing changes in length, depending on the material and the surface design, the following temperature fields can be assumed:

Table 7.4 Temperature fields of various curtain wall building materials in use

Material	color	outside		inside *	
		Min.	Max.	Min.	Max.
Aluminum, thermal separated construction	bright	- 15 °C	+ 50°C	+ 14° C	+ 50°C
	dark	- 15 °C	+ 65°C	+ 14° C	+ 65°C
plastic (without fiber reinforcement)	bright	- 5 °C	+ 40°C	+ 16°C	+ 40°C
	dark	- 5 °C	+ 50°C	+16°C	+ 50°C
Solid wood, glued wood, Wood materials	bright	- 5 °C	+ 45°C	+ 16°C	+ 45°C
	dark	- 10 °C	+ 65°C	+ 16°C	+ 65°C

* heated building with room temperatures ≥ 19°C

Extreme temperature differences e.g. due to partial shading (trees, neighboring buildings or parts of buildings, ...), component geometries (facade to reveal, building corner, ...) or different room areas (inside to outside), the length expansion of the individual components must be taken into account! This can lead to large differences in length.

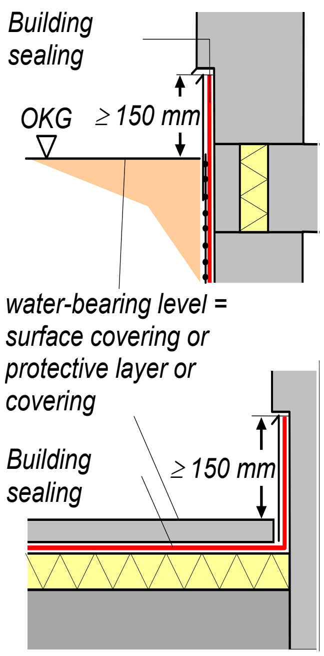
The thermal changes in length of rod-shaped components such as mullions, transoms or rungs are calculated as follows:

$$\Delta l_t = \Delta T \cdot \alpha_l \cdot l_0$$

with:

Δl_t = Change in length in mm
ΔT = temperature difference in K
α_l = coefficient of length expansion in K^{-1}
l_0 = length of the component in mm

Table 7.9 Section 1 of DIN 18195-9, Building seals - penetrations, transitions, fittings and closures

Execution options of the lower connection	Requirements for the lower connection according to the relevant regulations
	*5.4.2 Building base for sealing and closures* In the base area, the substrate should be planned in such a way that in the event of soil moisture and temporarily accumulated water, the sealing can normally be carried up to 300 mm over top edge terrain in order to ensure sufficient adaptation possibilities of the terrain surface. In the final state, this value should not fall below the dimension of 150 mm. *5.4.3 Closures for seals according to* In the sealing of horizontal and slightly inclined surfaces, the rising components shall be designed in such a way that the sealing is carried up to significantly above the unfavourable water stress of surface, spray and / or leachate water, as a rule at least 150 mm over the protective layer, the surface of the covering or the overburden can be raised and secured and stored against sliding off on a largely complete, level, stable reserve. **Note on German Building Law:** In Germany, the DIN 18195 part 4.5 and 6 must be observed

Transfer to curtain walls:

If there are no design requirements – such as the requirement for barrier-free execution of doors – or design requirements by the architect, the curtain facade base should enable this sealing height. Below is an example of this:

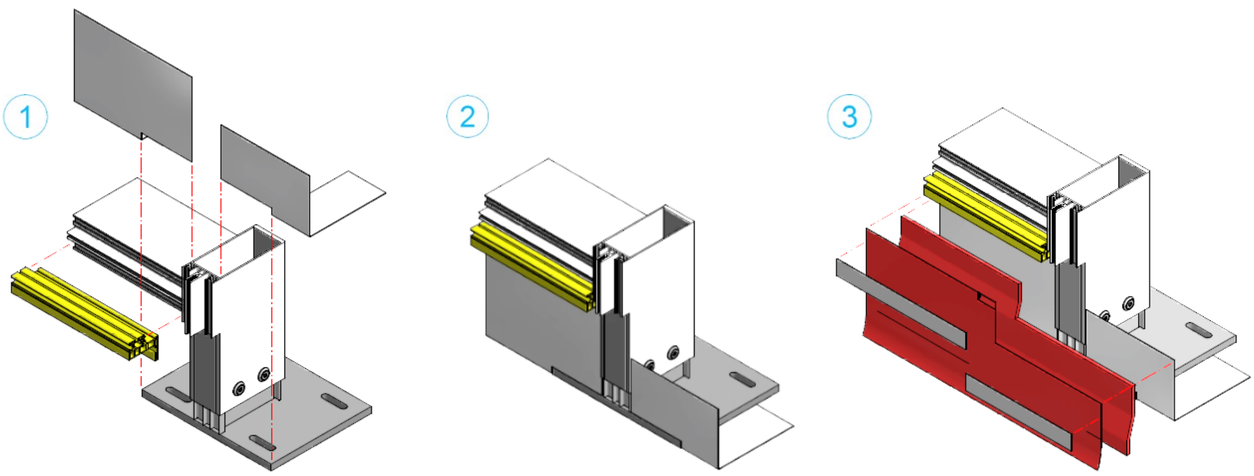


Figure 7.4 Representation of the transition between the curtain walls area that cannot be opened and the control area (left field) and the field for an emergency door (right field): A stable metal bracket is installed to connect the building sealing.