Building physics

Thermal protection | Moisture proofing | Requirements

Thermal insulation at the base of the building
Walls and columns represent penetrations of the building envelope and thus of the insulation layer, so-called thermal bridges. Thermal bridges are local component areas in the building envelope, with which an increased heat loss is present. Thereby, lower wall surface temperatures and the danger of mould formation and the accumulation of condensation also result. The thermal bridge is evaluated via the heat transfer coefficients ψ and χ as characteristic values for the energy loss both through the temperature factor f_{Rsi}, which is based on the warm side wall surface temperature, and which represents the dimension for the danger of the condensation accumulation and mould formation.

Protection against moisture on the building footing
Protection against moisture on the building is synonymous with prevention of building damage. Therefore the building, already in the planning, is to be checked for potential points where condensation may occur. Particular attention must be given to the simultaneous occurrence of material conditioned and geometric thermal bridges. Primarily, external corners, due to this combination, tend to have particularly low wall surface temperatures. Rooms with increased air humidity (bedrooms, bathrooms and kitchens etc.), which border on external walls or above cold areas such as, for example, underground garages, are also particularly vulnerable. Furthermore, there can also be a large input of water into the building footing in the construction phase, which in combination with the thermal bridges, involves an increased hazard for the formation of mould.

Along with the danger of occurrence of condensation and the formation of mould, the thermal conductivity of wet building material also deteriorates: The wetter the building material is, the higher the thermal conductivity and the lower the thermal insulation effect.
Fundamentally, the prevention of condensation water in thermal bridges to the underground garage and unheated basements is always to be checked.

Building physics

Effects of thermal bridges
- Danger of the formation of mould
- Danger of impairments to health (allergies etc.)
- Danger of occurrence of condensation
- Increased thermal energy loss

Requirements on the thermal insulation
Because the thermal quality of our buildings is increasing, the influence of the existing thermal bridges is increasing too. That´s why thermal bridges are getting more important. An overview of the requirements is presented in the following table.

	Requirements
Moisture proofing	
Temperature factor	$f_{Rsi} \geq 0.75$
Thermal insulation with thermal bridges	
Without thermal bridge verification	an addition on the U value for the thermal bridges must be concidered
Detailed thermal bridge verification	accurate verification via ψ value calculation

Info
1) Constraints according to BRE Information Paper IP1/06: Inside temperature 20 °C in living rooms, 50% room air humidity, outside temperature 0 °C

Characteristic values of thermal insulation products

Characteristic values for the describing of thermal bridges

Several characteristic values exist for describing the effects of a thermal bridge. The property of a Schöck Sconnex® for preventing heat transfer is described by the equivalent thermal conductivity λ_{eq}. Thus it constitutes a product characteristic value.

In addition, there are also characteristic values to describe the requirements relating to moisture proofing: $\Theta_{si,min}$ and f_{Rsi} are requirements relating to the temperature of the heat-side wall surface temperature of a building to rule out condensation and mould formation.
There are also requirements relating to the energy loss through the thermal bridge. These are described for linear thermal bridges using the ψ value (length-related heat transfer coefficient) and the point thermal bridges using the χ value (point-related heat transfer coefficient).

Thermal effects	Characteristic value	Type of thermal bridge
Moisture proofing		
Condensation result, mould formation	f_{Rsi} $\Theta_{si,min}$	all
Thermal insulation with thermal bridges		
Energy loss	ψ	linear
	χ	punctual

Info

ψ, χ, $\Theta_{si,min}$ and f_{Rsi} are calculated for a specific thermal bridge – a designated design detail where Schöck Sconnex® is embedded. Therefore, these values depend on the construction. Whereas λ_{eq} and R_{eq} only describe the thermal insulation effect of a Schöck Sconnex®. Therefore, if one modifies characteristics of the construction by adjustment of the insulation thickness of the floor insulation or the type of Schöck Sconnex® used, one also modifies the heat transfer through the thermal bridge (and with this ψ, χ, $\Theta_{si,min}$ and f_{Rsi}).

The application of λ_{eq} and the calculation of ψ, χ, $\Theta_{si,min}$ and f_{Rsi} are explained in the verification procedure section.

Equivalent thermal conductivity λ_{eq}

The equivalent thermal conductivity λ_{eq} is the overall thermal conductivity of all components of a Schöck Sconnex® and is, with the same insulting element thickness, a measure for the thermal insulating effect of the connection. The smaller the λ_{eq}, the higher the thermal insulation effect. λ_{eq} values are determined through detailed thermal bridge calculations. Since each product has an individual geometry and placement specification, each Schöck Sconnex® has an individual value.

It is possible to do the calculations using commercially available thermal bridge software by means of the thermal boundary conditions according to BS EN ISO 6946. In doing so, surface temperatures Θ_{si} and the resulting temperature factor f_{Rsi} can be calculated in addition to the heat loss through the thermal bridge (ψ value).

Verification procedure thermal insulation

Detailed thermal bridge verification

The thermal bridge details are contained in the relevant thermal bridge guides or the thermal bridges are calculated with the aid of FE programs.

Detailed thermal bridge verification

Verification via ψ value

- Detailed calculation
  - Using software (FE, FD) for the thermal bridge analysis
  - Simplified substitute model of the Schöck product is placed in the insulation layer
  - The λ_{eq} value of the matching product is selected from λ_{eq} tables. (Sconnex® type W see page 34, type P see page 37)
  - ψ value or χ value is calculated
- Values from catalogue

ψ value or χ value is included in the transmission heat losses

$$H_T = \sum U \cdot A + H_{WB}$$

Where a detailed thermal bridge calculation is to be provided for the determination of ψ or f_{Rsi} values, the λ_{eq} value can be used in the modelling of the connection details. For this purpose, a homogeneous rectangle of the same dimensions as the Schöck Sconnex® insulting element is placed into the model in its position and the equivalent thermal conductivity λ_{eq} assigned, refer to figure. In this way, the building physics characteristic values of a design can be simply calculated.

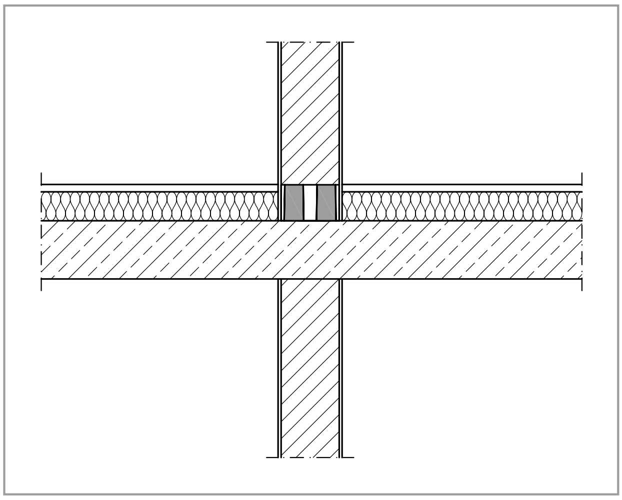


Fig. 40: Representation of a sectional drawing with detailed Schöck Sconnex® model

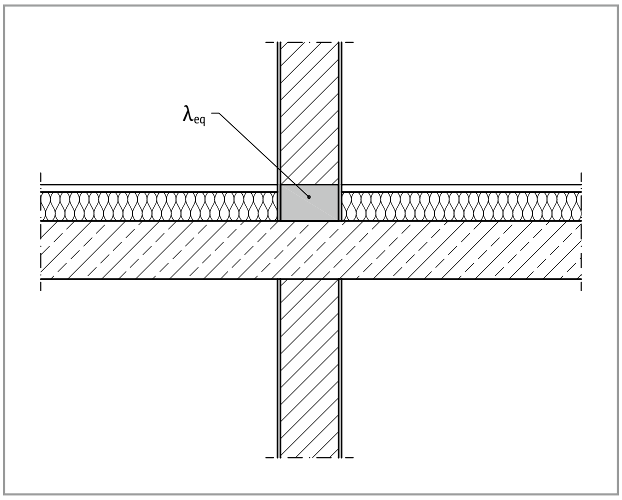


Fig. 41: Representation of a sectional drawing with simplified substitute insulating element

Please note that a large section from the construction for the model is selected so that the areas of the surrounding construction being influenced by the thermal bridge are shown in the model. A spacing of 2 metres around the thermal bridge is normally sufficient to take these boundary effects into account.

Thermal insulation using Schöck Sconnex® type W

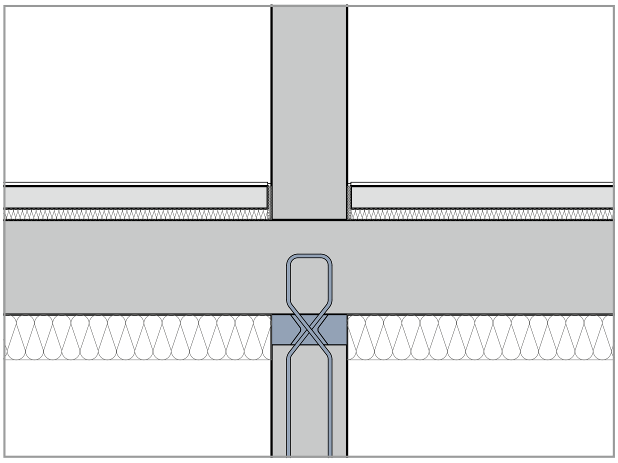


Fig. 42: Schöck Sconnex® type W with internal wall and under-slab insulation

Schöck Sconnex® type W is used in reinforced concrete walls for the insulation of the resultant thermal bridge in the connection detail to the floor and foundation slab at the foot of the wall or below the ceiling slab at the top of the wall.

Passive House standard with Schöck Sconnex® type W

Due to the very good thermal insulation performance, the wall connected with the Sconnex® type W is certified as a passive house component from the Passive House Institute (PHI) in Darmstadt. Therefore, the Schöck Sconnex® type W corresponds to the highest energetic standards.
For the certification, the heat transfer coefficient ψ and the minimum internal surface temperature for a Schöck Sconnex® type W are determined in a specified Passive House construction. These values must correspond to the quality requirements and the limit values defined by the Passive House Institute.

Types of a wall connection

Wall connections, due in particular to the large number of running metres, are a substantial thermal bridge. Thereby, the Schöck Sconnex® type W is placed flush with the floor in the insulation layer under or optionally on top of the floor.

On the following pages you will find an overview of the possible configurations of wall connections and the associated technical thermal or humidity characteristics. Constructions using comparable U values were selected.

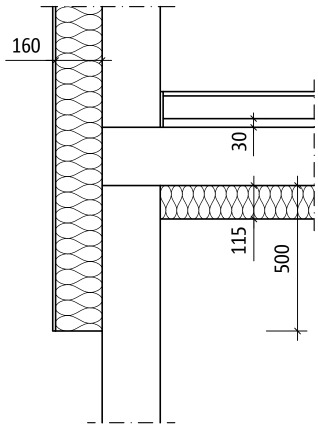
Building-physical properties of a wall connection

- The construction of continuous concrete walls, which penetrate the insulation layer of the floor, leads frequently to structural damage as the heat-side wall surface temperature drops too much, see example on page 32.
- If wall connections are constructed with flank insulation, the situation improves in terms of energy, but structural damage cannot be ruled out.
- Designing with Schöck Sconnex® type W guarantees solutions without structural damage and moreover reduces the energy loss through the thermal bridges considerably. As the type W is installed at a point, the intermediate area is insulated undisturbed. That and the low thermal conductivity of the product components lead to very low energy losses.
- External walls and in particular outer corners are situations where low wall surface temperatures occur on the heat side, especially if there is also an underground garage underneath. In general, the following applies: The greater the temperature difference between the internal and external air, the more critical the situation. A heated room adjacent to a ventilated underground garage is therefore more critical than a room adjacent to a closed basement . However, with basements the case is critical if this borders directly on the ground.
- With an above-slab insulation the condensation water situation can be critical in the component verification. With this the condensation water falls initially between floor slab and the insulation lying above. The situation, however, is massively improved through the arrangement of a vapour barrier under the screed and leads in many cases to a successful component verification. With over-slab only insulation the arrangement of a vapour barrier is strongly recommended.

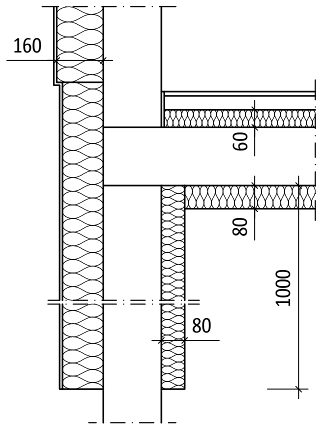
Thermal comparison with Schöck Sconnex® type W

External wall

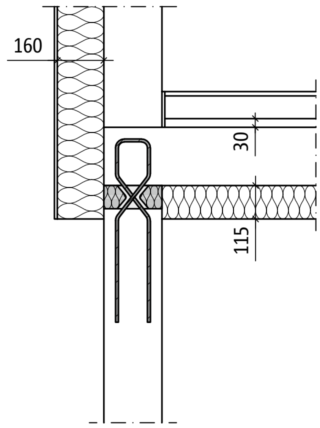
Under-slab insulation



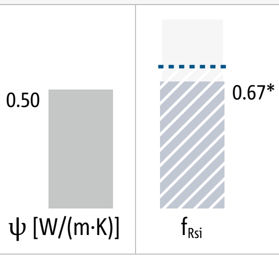
Continuous cast through concrete without flank insulation

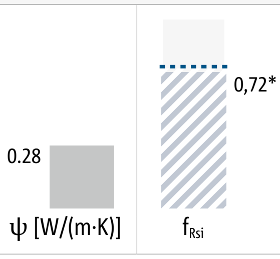


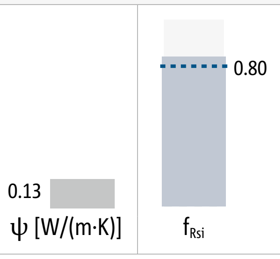
Continuous cast through concrete with flank insulation



Construction with Schöck Sconnex®

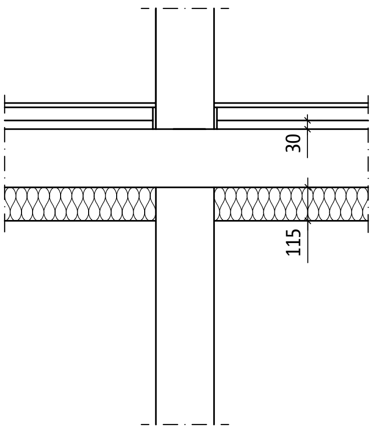




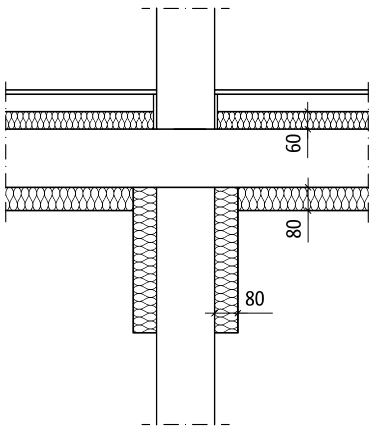


Inside wall

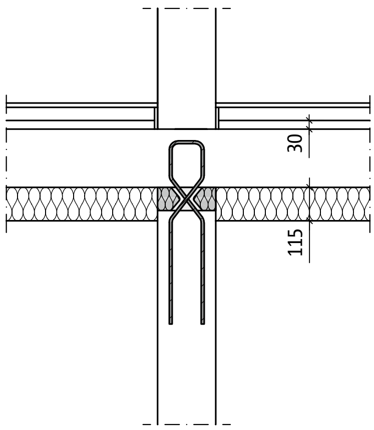
Under-slab insulation



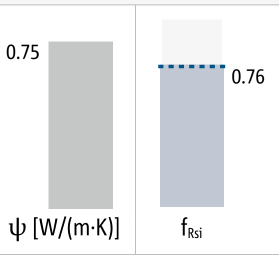
Continuous cast through concrete without flank insulation

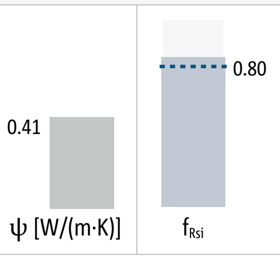


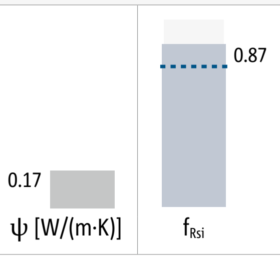
Continuous cast through concrete with flank insulation



Construction with Schöck Sconnex®







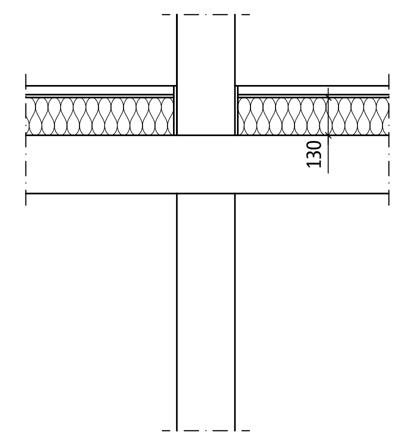
*) Target value $f_{Rsi,min} \geq 0.75$ according to BRE Information Paper IP1/06 not complied with.

Building physics

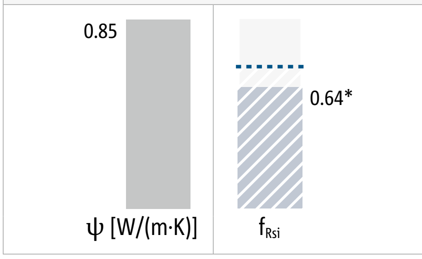
Thermal comparison with Schöck Sconnex® type W

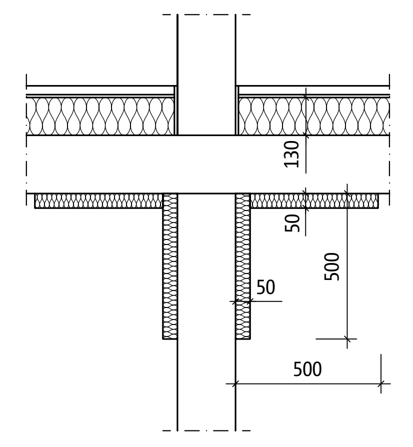
Inside wall

Above-slab insulation

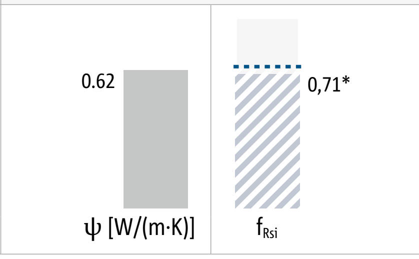


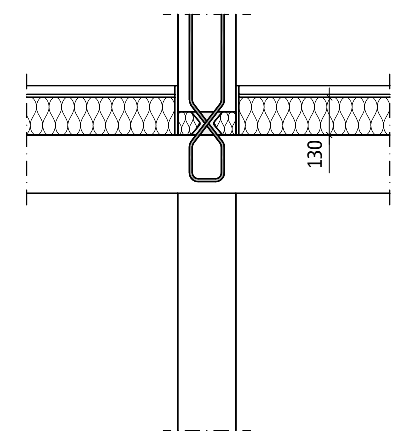
Continuous cast through concrete without flank insulation



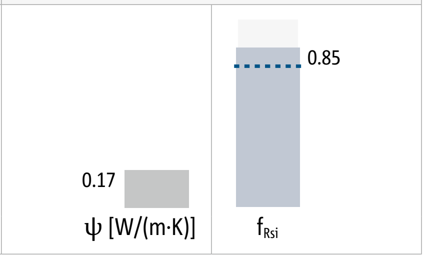


Continuous cast through concrete with flank insulation



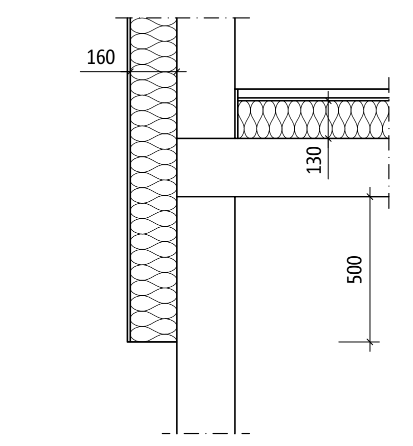


Construction with Schöck Sconnex®

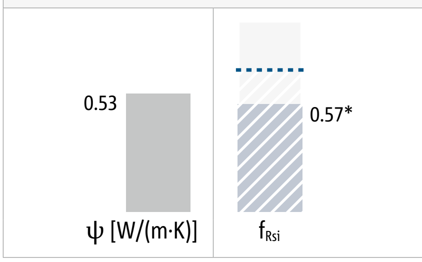


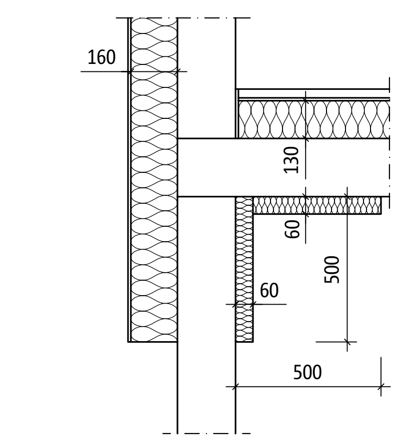
External wall

Above-slab insulation

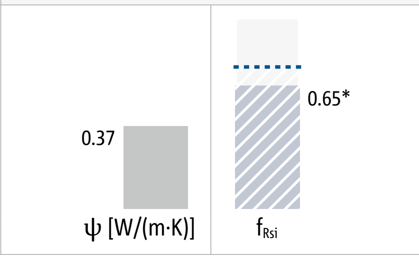


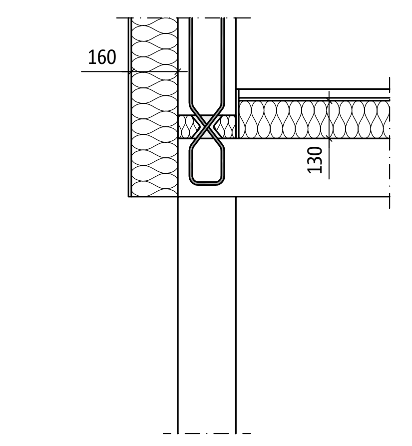
Continuous cast through concrete without flank insulation



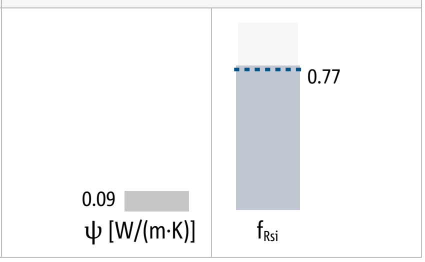


Continuous cast through concrete with flank insulation





Construction with Schöck Sconnex®



*) Target value $f_{Rsi,min}$ ≥ 0.75 according to BRE Information Paper IP1/06 not complied with.

Thermal comparison | Schöck Sconnex® type W product characteristic values

In the overview, it is clear that even solutions with flank insulation, the requirements on the minimum protection against moisture and thus the normal requirements in many cases are not met. Here a particular risk exists for structural damage. f the requirements for moisture protection are met, the energy loss for the cast through solutions is many times higher than that of a solution with Schöck Sconnex®.

i Boundary conditions for the example constructions on page 32 and 33

- Above-slab insulation: λ = 0.035 W/(m·K)
  Under-slab insulation: λ = 0.04 W/(m·K)
- U value of the floor with above-slab insulation: U = 0.25 W/(m²·K)
- U value of the floor with under-slab insulation: U = 0.25 W/(m²·K)
- U value of the external wall: U = 0.21 W/(m²·K)
- Spacing Schöck Sconnex® type W-N1-V1H1: 1 per metre
- Wall thickness: 200 mm
- Building physics boundary conditions: Were selected as per BS EN ISO 6946 and BRE IP 1/06.

Schöck Sconnex® type W product characteristic values

Schöck Sconnex® type W	N1-V1H1	Part Z
Force absorption		
B [mm]	λ_{eq}	λ_{eq}
150	0.573	0.031
180	0.471	0.031
200	0.421	0.031
250	0.336	0.031
300	0.281	0.031

- A type summary with the matching application areas can be found on page 8.
- λ_{eq} Equivalent thermal conductivity in W/(m·K)
- Component height to be applied = 80 mm
- For further information on the determination of the mean thermal conductivity see page 35

Verification procedure thermal insulation

Detailed thermal bridge verification

As described on page 30, a homogeneous block with the equivalent thermal conductivity λ_{eq} for the product can be applied. For this see following diagrams. For a Schöck Sconnex® type W an insulation element with length 300 mm, height 80 mm and the λ_{eq} value of the respective type W is applied in a 3D model. The insulation value of the intermediate insulation is applied for the intermediate area A. With this model, the ψ value of the wall connection can be easily calculated.

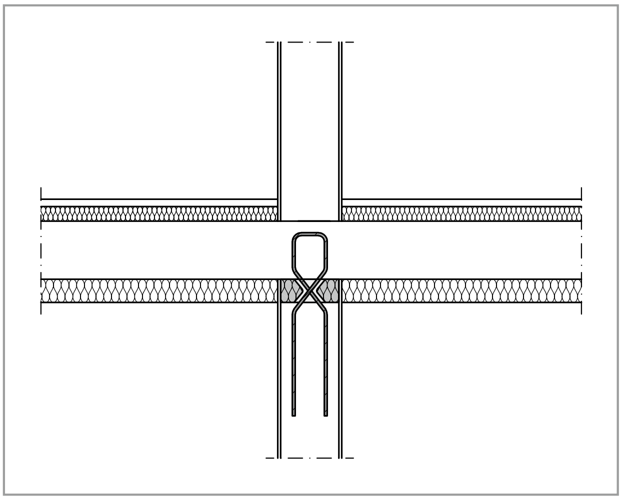


Fig. 43: Representation of a sectional drawing with detailed Schöck Sconnex® model

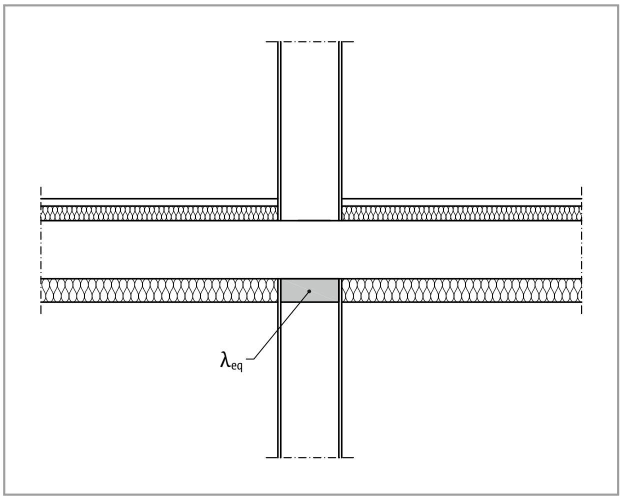


Fig. 44: Representation of a sectional drawing with simplified substitute insulating element

If a two-dimensional calculation for the determination of the ψ value is to be carried out, the thermal conductivity of the Schöck Sconnex® type W and the intermediate insulation can be determined (see following diagram). The mean thermal conductivity $\lambda_{eq,mean}$ can then be applied in a two-dimensional model (see diagrams on page 35).

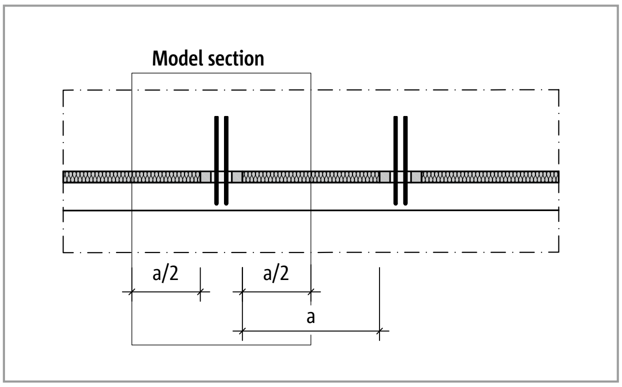


Fig. 45: Representation of a possible model section for a three-dimensional modelling of a wall connection detail with point-sited Schöck Sconnex® type W and insulation in between

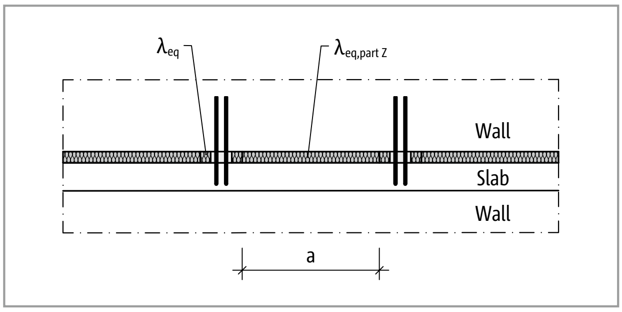


Fig. 46: Representation of two sectional axes for the determination of $\lambda_{eq,mean}$ of a wall connection detail with point-sited Schöck Sconnex® type W and insulation in between

$$\lambda_{eq,Mittel} = \frac{\lambda_{eq} \cdot 0{,}3\ m + \lambda_{eq,Part\ Z} \cdot a}{0{,}3\ m + a}$$

Info

- $\lambda_{eq,mean}$ = mean thermal conductivity of the connection
- λ_{eq} = equivalent thermal conductivity of Schöck Sconnex®
- $\lambda_{eq,part\ Z}$ = thermal conductivity of the intermediate insulation with the employment of Schöck Sconnex® type W part Z: λ_{eq} = 0.031 W/(m·K)
- a = length of the intermediate insulation = element centre distance – 0.3 m
- Product characteristic values λ_{eq} for Schöck Sconnex® type W and type W part Z see page 34.

Thermal insulation using Schöck Sconnex® type P

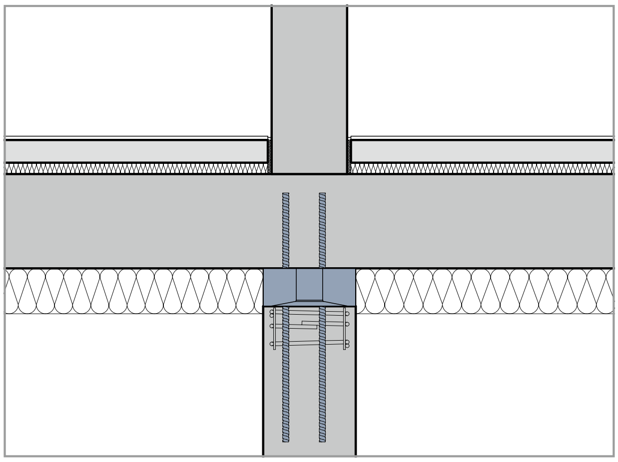


Fig. 47: Schöck Sconnex® type P with internal columns and under-slab insulation

Schöck Sconnex® type P is used in reinforced concrete columns to insulate the thermal bridge at the top of the column. In some cases, employment at the foot of columns is possible with foundation slabs.

Columns have to transfer high loads. Continuous cast through columns due to the high heat transfer are point thermal bridges. Even if a column is designed with flank insulation this energy loss can only be partially reduced. Schöck Sconnex® type P, on the other hand, is specifically installed in the insulation layer.

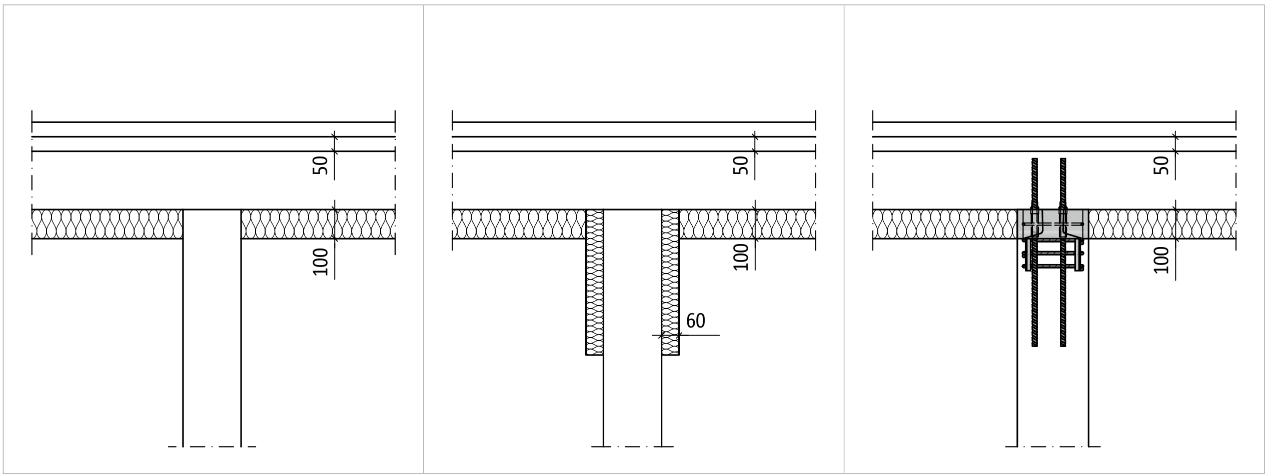
While concrete with a thermal conductivity λ = 1.6 W/(m•K) and reinforcing steel with λ = 50 W/(m•K) penetrate the insulation layer in a continous cast through concrete column, the Schöck Sconnex® type P interrupts the reinforced concrete construction with an equivalent thermal conductivity of λ_{eq} = 0.61 W/(m•K). This low value is achieved due to an energy optimised lightweight concrete and fibreglass reinforcement with λ = 0.9 W/(m•K).

Passive House standard using Schöck Sconnex® type P
Due to the very good thermal insulation performance of the Schöck Sconnex® type P, the column connected with the Sconnex® type P is certified as a passive house component by the Passive House Institute (PHI) in Darmstadt. As a result the Schöck Sconnex® type P corresponds to the highest energy requirements.
For the certification the thermal conductivity coefficient χ and the minimum internal surface temperature for a Schöck Sconnex® type P are determined in a Passive House construction. These values must correspond to the quality requirements and the limit values defined by the Passive House Institute.

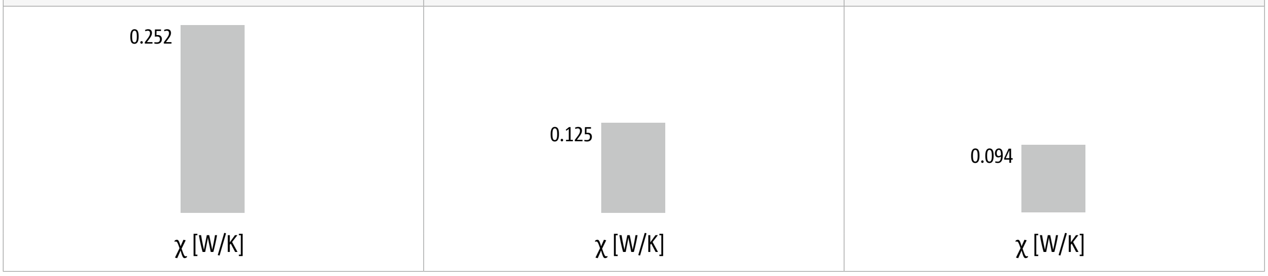
Thermal comparison | Schöck Sconnex® type P product characteristic values

Thermal comparison Schöck Sconnex® type P with constructive insulation

For a typical construction the heat loss through an uninsulated reinforced concrete column is χ = 0.252 W/K. With a column with 50 cm length and 6 cm thick flank insulation the χ-value reduces to χ = 0.125 W/K. With Schöck Sconnex® type P the χ value falls to χ = 0.094 W/K.



Column without insulation | Column with flank insulation | Column with Schöck Sconnex® type P



As a result, the solution using the Schöck Sconnex® type P is about 63% better than the uninsulated thermal bridge, and about 23% better than the configuration with flank insulation.

i Boundary conditions

- λ Insulation: 0.04 W/(m·K)
- U value of the floor: 0.244 W/(m²·K)
- Building physics boundary conditions: Were selected as per BS EN ISO 6946 and BRE IP 1/06.

Schöck Sconnex® type P product characteristic values

Schöck Sconnex® type		P
B [mm]	L [mm]	λ_{eq}
245	245	0.610

- Possible column geometry is 25 x 25 cm.
- λ_{eq} Equivalent thermal conductivity in W/(m·K)
- Component height to be applied = 100 mm

Verification procedure thermal insulation

Detailed thermal bridge verification
A detailed verification according to the following method can be carried out.
Schöck Sconnex® type P is a point connection and a detailed calculation is best carried out three-dimensionally. The model is produced with the product dimensions 245 mm width, 245 mm length and 100 mm height and for that purpose the equivalent thermal conductivity λ_{eq} applied. The heat loss in addition to the U-value of the floor is thus the determined χ-value of the column.

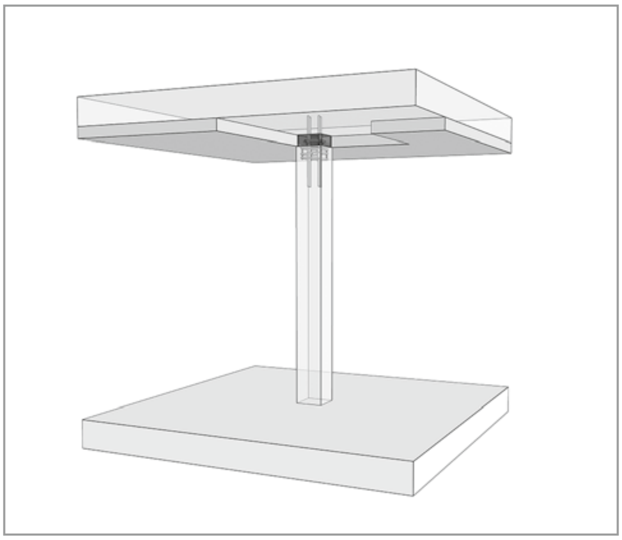


Fig. 48: Connection detail with detailed Schöck Sconnex® model

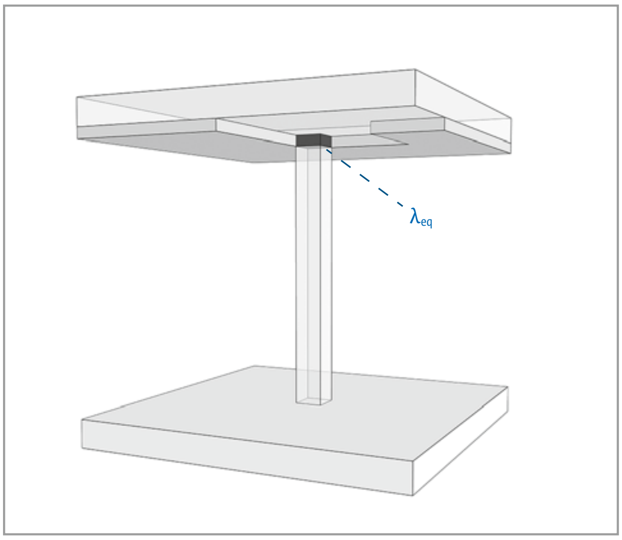


Fig. 49: Connection detail with simplified substitute insulation element

Thermal insulation using Schöck Sconnex® type M

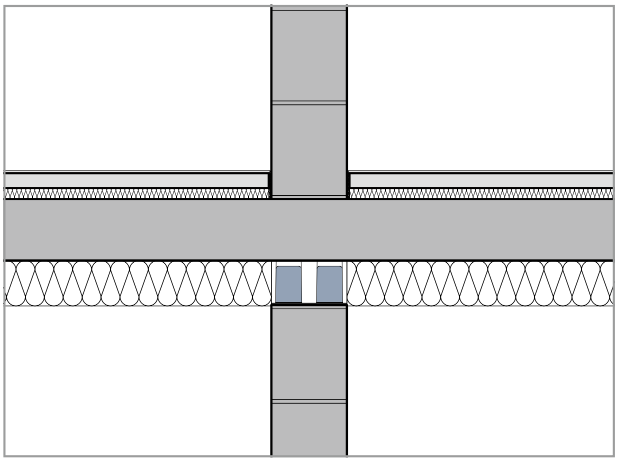


Fig. 50: Schöck Sconnex® type M in masonry with internal walls and under-slab insulation

The Schöck Sconnex® type M is an insulating element for the thermal separation of masonry. The thermal insulation elements are installed mainly as thermal protection and protection against moisture on footings. In accordance with the Approval they serve as first alignment of the masonry above or below the basement floor.

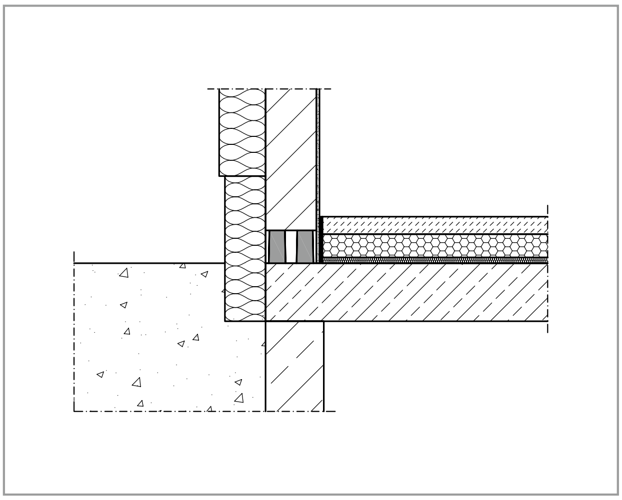


Fig. 51: Efficient thermal insulation using Schöck Sconnex® type M

Protection against moisture at foot of wall

During the construction phase a great deal of water enters the shell at the foot of the wall. In particular the layer of blocks above the basement floor or on the foundation slab is affected with a high moisture load.

Porous insulating materials, which are capillary absorptive, can absorb large amounts of moisture. Due to increased moisture content in the material there is a drastic decrease of the insulating property. The wetter a building material is, the higher the thermal conductivity is and the lower the thermal insulating effect.

The lowest layer of blocks on the floor or foundation slab (calibrating layer), through the increased moisture content over a very long period, displays an increased thermal conductivity. This results in reduced thermal insulating performance at the foot of the wall, which is accompanied with reduced surface temperatures. This leads to problems such as the accumulation of condensation and the formation of mould as well as increased heat loss.

Building physics

Thermal bridge at footing

With the increasing energy efficiency of buildings the minimization of thermal bridges is evermore decisive. With highly thermally insulated buildings (Passive House standard) the share of thermal bridges in the overall transmission heat loss of buildings is currently approx. 15 to 20%, whereby this share is determined mainly through the thermal bridges window flanning (approx. 6%), balcony connections (approx. 3% with projecting balconies) as well as external and internal wall connections (approx. 10%). This shows that the footing, due to its large developed length and the geometric conditions, represents a serious thermal bridge. The controversial combination of statically highly loaded external and internal walls ($\lambda \approx 1.0$- 2.3 W/(m•K)), which through their unavoidable positioning on the basement floor penetrate the thermal insulation envelope of the building ($\lambda \approx 0.04$ (W/(m•K)) (thermal insulation layer on the external wall as well as the thermal insulation layer on the basement or underground garage floor), represent a great challenge on an efficient thermal insulation envelope.

Influencing variables, which affect the energy loss in the footing
By insulating the exterior walls and providing flat insulating materials underneath and/or on top in the area of the ground floor ceiling, the heat transfer through the flat building components is minimised to a large extent.

As a result of these increasing two-dimensional thermal insulation measures the thermal bridges are increasingly gaining in significance.
Through flanking insulation measures of the structurally-conditioned thermal bridges (The pulling down of the perimeter insulation to over the interface wall/floor (50–100 cm from underside of floor)) there is an attempt to mitigate this critical detail.

Implementation using flank insulation, however, involves the risk that here the minimum requirement on $f_{Rsi} > 0.75$ according to BRE Information Paper IP1/06 is no longer met. Therefore, it is always to be noted that the implementation with flank insulation functions.

This problem is additionally amplified through the material-induced moisture affinity of the wall materials. In particular during the period of building construction, these are exposed to an impact of moisture coming from outside. The high capillary absorption capacity of porous structural elements leads to a moisture penetration and thus to the loss of thermal insulation effect.
A significant drop of the thermal insulation effect is the result, which due to a general “wrapping” of the first layer of blocks using insulation material, flooring installation, plastering etc., leads to a protracted continuous drying out of the wall materials over several years. During this period the wall material has a drastically reduced thermal insulation property, which lies far below the applied mathematical one. Moreover, this moisture can escape on the inside surfaces – thus the risk of mould formation increases.

Thermal comparison Schöck Sconnex® type M with load-bearing insulation

Uninsulated footing

With an uninsulated footing the rising masonry interrupts the thermal insulating envelope of the building between the external wall insulation and the insulation above the basement floor. Through this, together with the high thermal conductivity of the masonry blocks (λ ≈ 1.0 W/(m•K)), a massive thermal bridge is formed at the footing.
This means:

- Increased heat loss and through this increased heating costs
- Reduction of the room-side surface temperature
- Danger of occurrence of condensation and mould formation

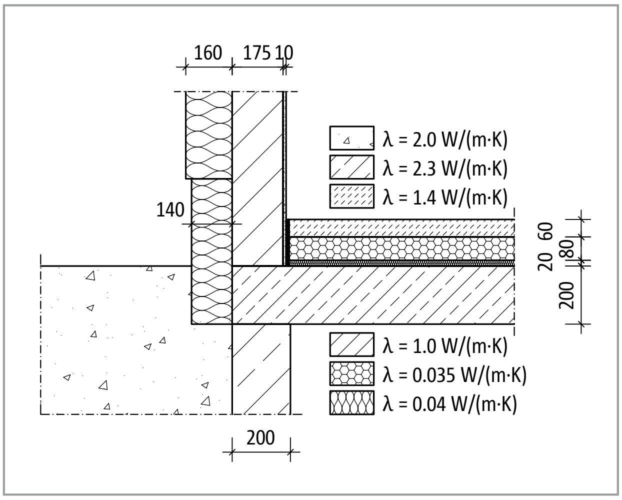


Fig. 52: Structural layout with uninsulated footing

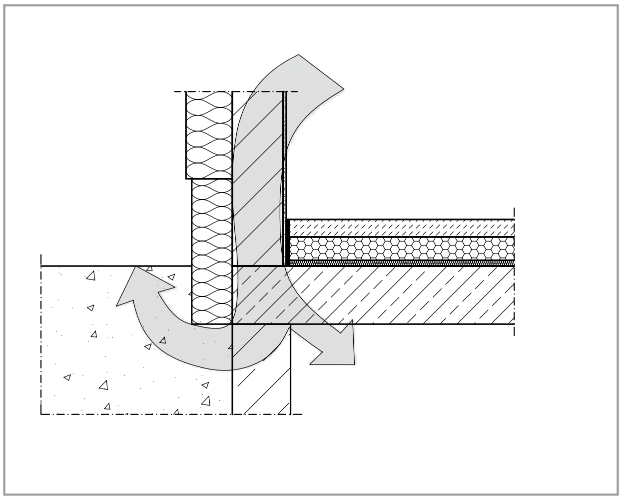


Fig. 53: Structural layout with uninsulated footing

Load-bearing insulation measures

For the reduction of the thermal bridge at the footing, the external wall insulation, in the form of a perimeter insulation, is frequently continued into the ground (see following diagram). In addition to the considerable costs of this measure, the insulation effect that can be achieved with it is also unsatisfactory. In particular, from a depth h of approx. 0.5 m, no increase of the insulation effect through further pulling down of the perimeter insulation is longer detectable.

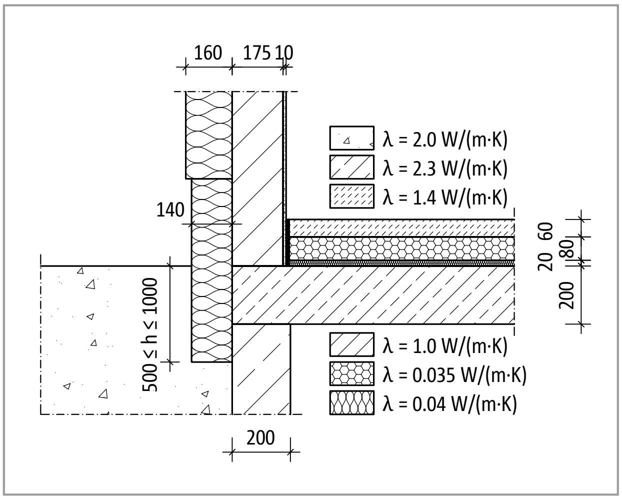


Fig. 54: Load-bearing insulation measures

Overall, through this structural measure – independent of the depth – the thermal insulation effect can be improved only by approx. 50%.

Building physics

Thermal comparison | Schöck Sconnex® type M product characteristic values

Insulation using Schöck Sconnex® type M

The load-bearing Schöck Sconnex® type M thermal insulating element closes the gap in the thermal insulation between the external wall insulation and the insulation above the basement floor. Through this, there results a continuous, very efficient thermal insulation.

This means:

- Minimized heat loss and through this savings in heating costs
- Increasing the surface temperature inside the room considerably above the critical mould temperature
- No danger of mould formation and condensation
- Healthy indoor climate

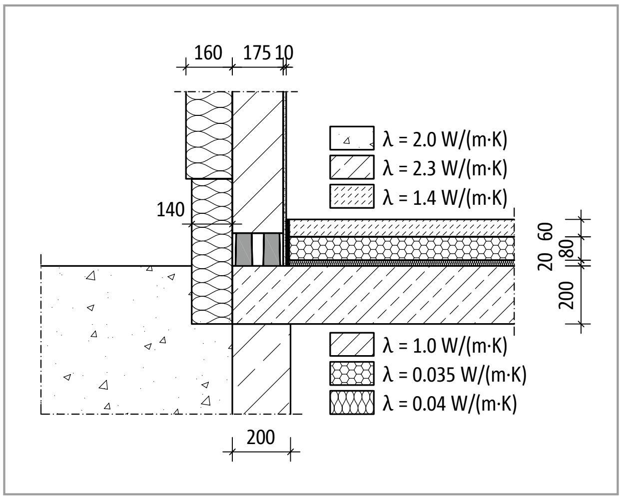


Fig. 55: Efficient thermal insulation using Schöck Sconnex® type M

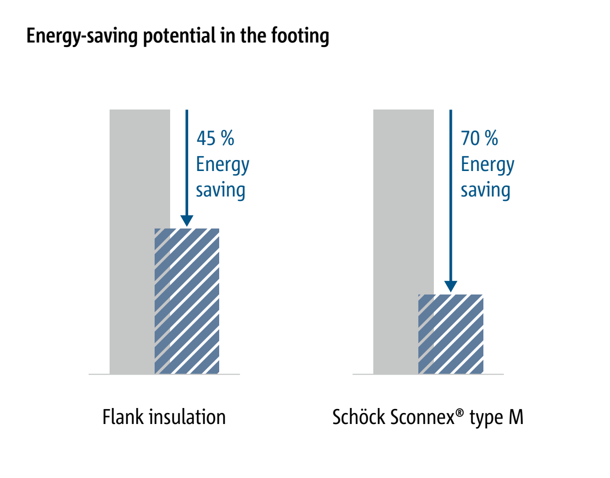


Fig. 56: Energy saving potential of possible insulation measures in comparison with uninsulated footing

In comparison to the theoretically ideally insulated footing it is clear that the Schöck Sconnex® type M displays the best thermal insulation effect of the alternatives shown here. Through a constructive insulation measure only less than half of the ideally insulated footing can be obtained, whereas the employment of Schöck Sconnex® type M a 70% insulation effect is achieved. Moreover, Schöck Sconnex® type M, through the water repellent properties of its materials, in the construction phase takes only a negligible amount of water. Through this the high thermal insulation effect exists from the outset.

Schöck Sconnex® type M product characteristic values

Schöck Sconnex® type M	N1	N2
B [mm]	λ_{eq}	λ_{eq}
115	0.182	0.248
150		
175		
200		
240		

- λ_{eq} Equivalent thermal conductivity in W/(m·K)

This value can be used to determine in suitable software the insulation resistance (ψ-value) for a construction.

Verification procedure thermal insulation | Sound insulation

Detailed thermal bridge verification

The detailed thermal bridge verification is carried out as presented on page 30 .
As a result the Schöck Sconnex® type M can be modified simply as in the following diagram and the λ_{eq} values from page 42 can be applied.

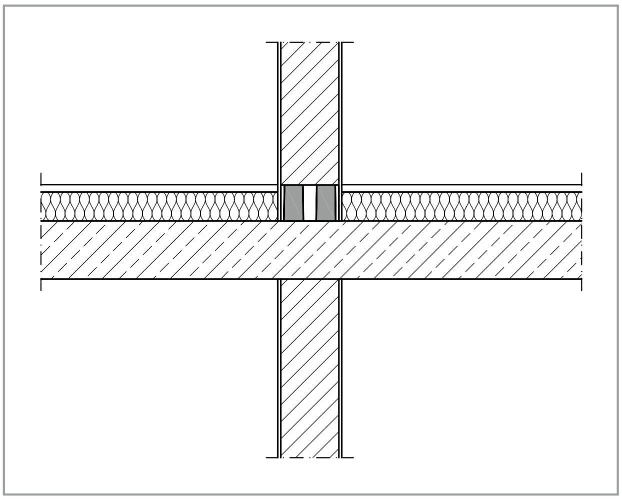


Fig. 57: Representation of a sectional drawing with detailed Schöck Sconnex® model

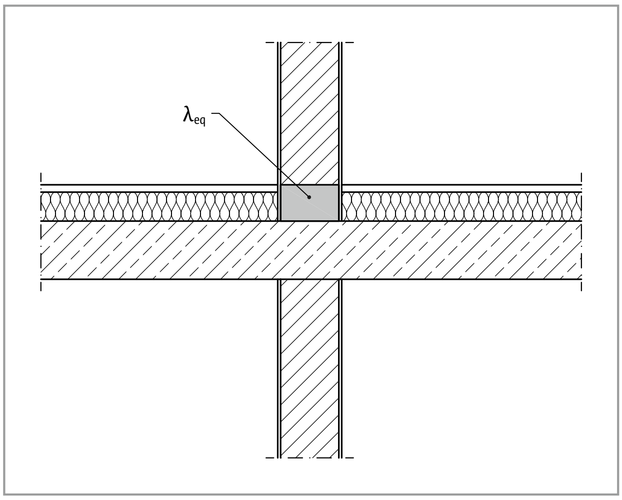


Fig. 58: Representation of a sectional drawing with simplified substitute insulating element

Sound insulation

According to the result of the sonic measurements in the test rig, the airborne sound insulation behaviour of a wall with integrated Schöck Sconnex® type M is not impaired (see Test Report No.: L 97.94 – P 18 and Supplement P 225/02 dated 29/07/2002, ITA (Engineering Society for technical acoustics), Wiesbaden).

With this it is to be noted that, for example, due to the complete (a least on one side) rendering of the wall, no “airborne sound bridges” occur through leakages in the wall (e.g. leaking junctions).