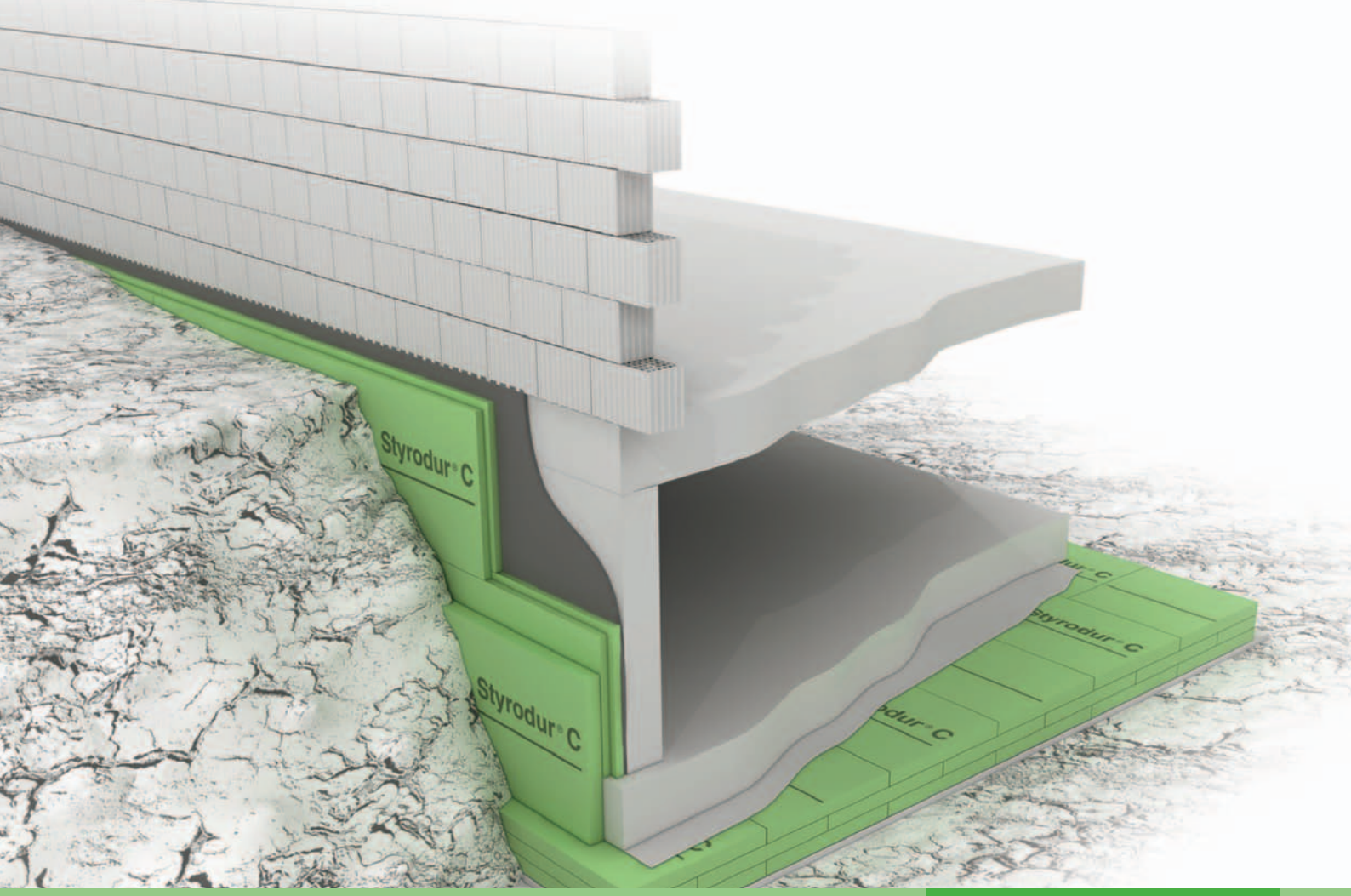
Styrodur® C
Europe's green insulation

Perimeter Insulation

Wall, Floor, Foundation Slab, Groundwater



BASF
The Chemical Company

Contents

1. Long-standing Trust in Styrodur® C

Styrodur® C is the green, extruded rigid polystyrene foam (XPS) developed by BASF more than 45 years ago. Today, Styrodur C is the synonym for XPS in Europe and—as a thermal insulation material—significantly contributes to climate protection by reducing CO_2 emissions.

Styrodur C provides convincing advantages to specialized planners, architects, craftsmen, builders, and building material suppliers.

Environmental advantages:

- Environment-friendly thanks to CO_2-production processes with air as cell gas
- Free of HFC
- Reduction of carbon dioxide emissions (CO_2) due to excellent insulating performance

Quality and safety advantages:

- Safety based on decades of experience
- Protects the building construction from external forces such as heat, cold, and humidity
- Comprehensive production control and quality monitoring, documented by CE marking and Ü-sign
- Long-lasting: if correctly installed, Styrodur C out lasts the life expectancy of the building construction

Structural-physical advantages:

- Excellent insulation properties
- High compressive strength
- Low water absorption
- Resistant to aging and decay
- Fulfills all structural-physical and building construction requirements in Europe´s various climate conditions

Processing advantages:

- Low dead weight
- Simple and practical processing with woodworking tools
- Can be installed in all weather conditions
- No dust hazardous to health during mechanical processing
- Extensive product range
- Most diverse potential applications

Economic advantages:

- Quick amortization of the insulation investment with rising energy costs
- Reduction of energy costs for heating and cooling
- Increases the life span of the building and raises the value of the structure
- Pan-European logistics with professional customer service via local distributors

2. Good Reasons in Favor of Basements

Building with basements is more economic

Compared to a normal floor slab, the average extra cost for an additional basement is between 300–400 euros per square meter. If skillfully designed, the approximately one third larger floor space can even help in financing the home, because:

- if part of the added floor space is considered "living space," government aids can be used to the full.
- large acclivities or elevated basement studios can be used as an extra apartment, contributing to the financing of your home.

In relation to the building costs, a basement can improve the growth of the house value, since the resale value usually increases significantly.

Technical aspects underline the benefit of basements. From a construction standpoint, there are considerable disadvantages if you build a house without basement.

For example:

- House connections and the maintenance of fittings are more expensive.
- Sound insulation of town houses and duplexes is inferior.
- Cohesive soils beneath the foundation can dry out and shrink. The floor slab can sink, causing the walls to fracture.
- Utilization of small lots is vastly inferior.

Additional space in your home

A skillfully designed basement can include:

- Quiet bedrooms
- Office spaces or workshops
- Spacious family rooms
- Saunas
- Storage rooms
- Party rooms

Modern building materials and components make for more comfort due to reliable sealing and solid thermal insulation, as well as plenty of light and air.

3. The Perimeter Insulation

The perimeter insulation comprises the exterior thermal insulation of building elements with ground contact, e.g., exterior basement walls **(Fig. 1)** and basement floors **(Fig. 2)**. The distinguishing feature of perimeter insulation is that the thermal insulation layer is applied on the outside of the building structure and waterproofing.

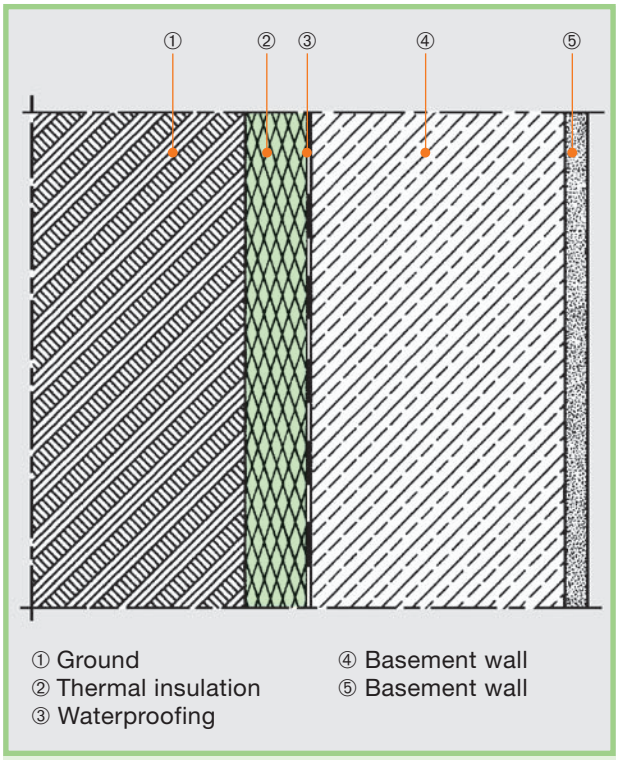


Fig. 1: Basement wall with exterior thermal insulation layer, adjacent to the ground.

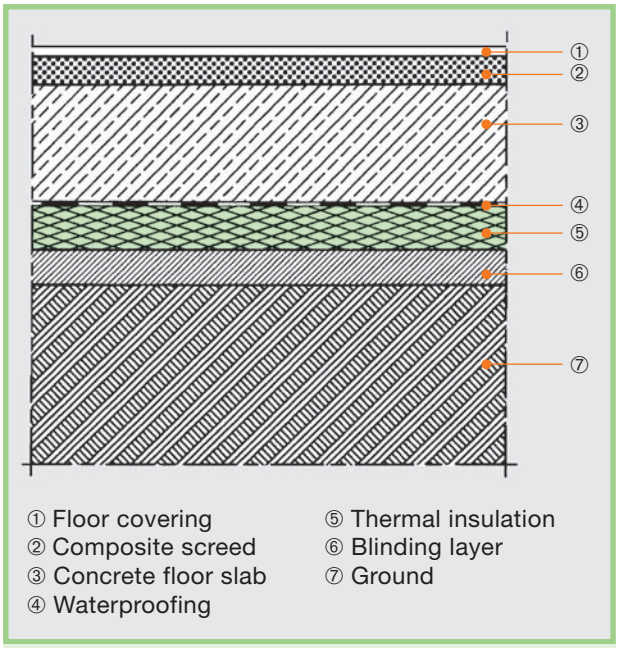


Fig. 2: Lower room barrier with thermal insulation layer against the bottom, adjacent to the ground.

Perimeter insulation in areas with pressing water and standing seepage water (in groundwater) requiring technical approval

Styrodur® C has been approved for many years by the German Institute for Building Technology (DIBt) in Berlin/Germany under approval number Z-23.5-223 for use as perimeter insulation in areas subject to long-term backwater or pressing water. In accordance with this approval, the Styrodur C boards can be laid on basement exterior walls with ground contact as a single or double layer and under static non-load-bearing building elements (basement floor slabs) as a single, double, or triple layers at up to 3.5 m below groundwater level. The structure is waterproofed in accordance with DIN 18 195-6 “Sealing against outside pressing water and standing seepage water.”

Perimeter insulation in areas with soil moisture and non-standing seepage water (above groundwater) according to standard and approval

DIN 4108-2 defines thermal insulation systems as perimeter insulation if the insulation boards are made of extruded polystyrene foam according to EN 13 164, are installed as a single layer and not under building foundations, and if they are not continuously exposed to groundwater. The perimeter insulation with Styrodur C above groundwater level therefore constitutes a construction conforming to the standards.

In accordance with the German Institute for Building Technology (DIBt) approval Z-23.5-223, Styrodur C can be used as perimeter insulation on exterior basement walls in contact with the ground in single or double layers and in static non-load-bearing building elements (basement floor slabs) in single, double, or triple layers.

The structural waterproofing is in accordance with DIN 18195-4 “Waterproofing against soil moisture (capillary water, hard water) and non-standing seepage water on floor slabs and walls, design and execution.”

Perimeter insulation under load-bearing foundation slabs (above groundwater)

Based on DIBt approval Z-23.34-1325, Styrodur C can also be used under load-bearing foundation slabs. The insulation boards may be laid in up to three insulation layers with a total maximum thickness of 300 mm. The structural waterproofing is in accordance with DIN 18195-4 “Waterproofing against soil moisture (capillary water, hard water) and non-standing seepage water on floor slabs and walls.”

Perimeter insulation under load-bearing foundation slabs (in groundwater)

For perimeter insulation in areas with long-term backwater or pressing water (in groundwater), Styrodur C boards may reach up to 3.5 m into the groundwater. The structure is waterproofed in accordance with DIN 18 195-6 “Waterproofing against outside pressing water and standing seepage water.”

Perimeter insulation reduces heat loss at lower building closures and thereby enables a comfortable indoor climate in the basement area. The higher temperatures on the interior surfaces of walls and floors prevent condensation in the interior spaces, which helps to avoid the musty odor frequently encountered in basement areas. For the user, this provides the following advantages:

- The indoor climate in the basement/lower level is improved.
- The temperatures on the inner surface of the base ment walls rise.
- Condensation on the inside of the basement walls and basement floor is prevented.
- The user gains additional interior space.
- The value of the building is increased sustainably.
- The thermal insulation saves energy costs.
- Insulation layers can be applied without thermal bridges.
- The waterproofing is protected.

Since the thermal insulation material of the perimeter insulation is extremely highly stressed by rainwater, earth pressure, and traffic loads, the materials are manufactured to meet the highest demands:

- High compressive strength
- Resistance to moisture
- Low thermal conductivity
- Rot-proof
- Good, durable thermal insulation properties

Styrodur C possesses these properties and is excellently suited for use as an insulation material in perimeter insulation.

4. Thermal Insulation Layer with Styrodur® C

On horizontal and vertical surfaces, Styrodur® C boards are laid in a bond formation, butting tightly against one another **(Fig. 3)**. Boards with an overlap are particularly suited to prevent the formation of thermal bridges. They also protect the structural waterproofing from mechanical stresses.

Installation:

In accordance with DIBt approvals Z-23.5-223 and Z-23.34-1325, Styrodur C boards may be used

- in areas with soil moisture and non-standing seepage water (above groundwater) as well as
- in areas with pressing water and standing seepage water (in groundwater)

and installed in one to three layers:

- on walls, one or two layers
- under basement floors (static non-load-bearing), one, two, or three layers
- under foundation slabs (static load-bearing), two or three layers

The total thickness of the thermal insulation layer may not exceed

- 400 mm on walls
- 400 mm under basement floors (static non-load-bearing)
- 300 mm under foundation slabs (static load-bearing)

The individual insulation boards must have the following thicknesses:

- Styrodur 3035 CS: 40 to 200 mm
- Styrodur 4000 CS: 40 to 160 mm
- Styrodur 5000 CS: 40 to 120 mm

With foundation slabs (static load-bearing) and multiple layering, the single board thickness may be up to a maximum of 120 mm.

Product recommendations:

On walls, under basement floors and foundation slabs:

- Styrodur 3035 CS
- Styrodur 4000 CS
- Styrodur 5000 CS

In the base area:

- Styrodur 2800 C

General application instructions

During the Styrodur C board extrusion process, a smooth compressed foam membrane is formed on the surface of the board.

The surfaces must be rough-textured in order to ensure superior adhesion of adhesive mortar, plaster, or other mortars used in base insulation, for example. The surface of Styrodur 2800 C is thermally embossed (honeycomb), guaranteeing good adhesive properties for plaster and concrete.

The proper execution of the building waterproofing is a prerequisite for the installation of Styrodur C in the perimeter insulation. DIN 18195-4 and -6 identify different load cases for basement waterproofing depending on the moisture stress. The basements known as “white tanks” made from waterproof concrete require no additional waterproofing.

Fig. 3: Securing a two-layer perimeter insulation of Styrodur® C boards until the backfilling of the excavation pit.

Further information:
“Technical data” brochure in the download area under www.styrodur.de

5. Advantages of Styrodur® C in Perimeter Insulation

There are many good reasons to use Styrodur® C in perimeter insulation:

- High compressive strength
- No need for additional protective layers
- Installation depth according to earth pressure, Table 6, Page 21
- No restrictions concerning the minimum distance to passing traffic
- Passive house grade perimeter insulation up to 400 mm
- No deterioration of thermal conductivity since virtually no moisture absorption
- Technical approval for use in groundwater, Z-23.5-223 and Z-23.34-1325
- Styrodur C has proven itself for more than 45 years
- Expert opinions on the long-term behavior are available
- Processing advantages, as Styrodur C does not require the time-consuming floating in bitumen for floor insulation and wall insulation requires no additional protective layers
- No special precautions are needed in frost-prone areas
- Non-cohesive soils do not require drainage
- Easy assembly bonding; full-surface and edge bonding and coating of the board joints is only necessary in groundwater
- The use of Styrodur 2800 C with its textured surface also facilitates base insulation
- The textured surface of Styrodur 2800 C simplifies plastering in the base area
- In accordance with DIBt approval Z-23.34-1325, Styrodur C may also be installed under load-bearing foundation slabs, even if they reach up to 3.5 m into the groundwater

We wish to support you in the planning and use of Styrodur C with the following information, installation suggestions, and design examples.

6. Perimeter Insulation in Areas with Soil Moisture and Non-standing Seepage Water (Above Groundwater)

6.1 Perimeter Insulation in Wall Areas

Waterproofing

Walls reaching into the ground can be made of concrete, waterproof concrete, or plastered brickwork. Building elements permeable to water must be fitted with waterproofing in accordance with DIN 18195 “Structural waterproofing.” The execution of such measures depends on the level of exposure to moisture.

Perimeter insulation does replace a solid structural waterproofing. Walls made of waterproof concrete may be insulated without pretreatment.

Structural waterproofing and adhesive products have to harmonize with regard to their chemical and physical properties and must be selected to suit the particular application.

For waterproofing with bitumen or when using bitumen sheets, it is recommended to use, amongst others, solvent-free two-component adhesive on bitumen-concrete basis or solvent-free epoxy glue.

The insulation boards should not be pressed into the not-yet-dry bitumen sealing for the following reasons:

- When pressing the boards into the bitumen sealing, parts of it could come off.
  The density of the sealing can thus no longer be guaranteed.
- Sealants on cold-bitumen basis are often used, but can contain solvent components that may damage the insulation material. When applying cold-bitumen waterproofing, it is advisable to grant at least one week of flash-off time before attaching the insulation boards.

Bituminous coatings, putties, waterproof plasters, and sealing slurries that can at least withstand soil moisture and non-pressing water are used.

Structural waterproofing and adhesive products have to harmonize with regard to their chemical and physical properties and must be selected to suit the particular application.

Bonding Styrodur® C boards

Prior to backfilling the excavation pit, the Styrodur® C boards must be secured to prevent any shifting or dislocation. This is usually done by gluing them to the sealed walls. The assembly bonding ensures that the insulation boards stick to the wall until they are subsequently clamped by the ground. It must be ensured that later settling of the backfill soil does not cause harmful shear stresses on the building waterproofing.

In combination with waterproof concrete, dispersion-based construction adhesive can also be used. Further information on the appropriate adhesive can be obtained at your local hardware store or directly from the manufacturer.

Fig. 4: Styrodur® C boards provide perimeter insulation without thermal bridges.

Attaching Styrodur C boards

The insulation boards must be butted tightly to form a bond **(Fig. 4)**. The all-round overlap ensures a joint lock, which prevents the formation of thermal bridges. In addition, the insulation boards must be positioned on a solid supporting surface (e.g., the projecting foundation).

When installed as a double layer, the two board layers are to be joined using point bonding, with the joints being covered and the boards offset to each other **(Fig. 5)**.

Fig. 5: Point bonding the second layer of Styrodur C boards with overlap and offset joints.

6.2 Perimeter Insulation Under Basement Floors (Static Non-load-bearing)

Base

For horizontal perimeter insulation, the base on which the Styrodur® C boards are installed must be even and provide the necessary load bearing capacity for the respective application **(Fig. 6)**. DIN 1054 “Building ground—verification of safety of earthworks and foundations” must be taken into account when assessing the load-bearing capacity of the building ground. This applies for both natural ground and backfill.

Abb. 6: Blinding layer of lean concrete for the installation of floor insulation

The installation surface must also be flat and even if Styrodur C boards are laid on bedrock. A concrete leveling course should be considered for this purpose **(Fig. 7)**. A bedding layer of concrete must be properly leveled.

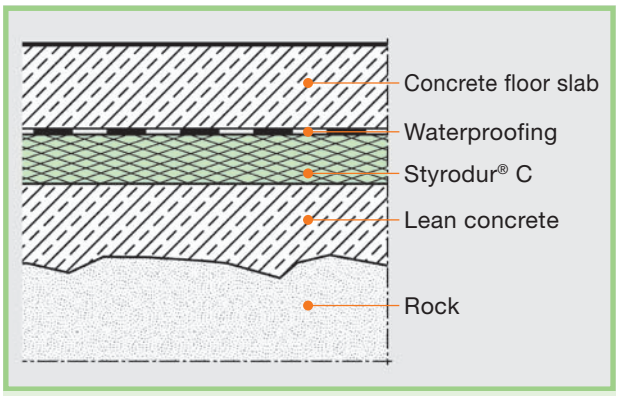


Fig. 7: Leveling course of lean concrete on bedrock.

Waterproofing

When waterproofing, DIN 18 195 “Structural waterproofing” must be taken into account. Bitumen membranes, which require the sheets joints to be glued with hot bitumen, cannot be laid directly onto a layer of Styrodur® C because the hot bitumen will melt the Styrodur C boards.

The use of solvent-containing cold bitumen is not recommended because the solvent partially dissolves Styrodur C. Suitable materials are membranes that can be conjoined either by hot-gas welding or solvent welding. ECB (ethylene copolymer bitumen) membranes are particularly recommended. PVC membranes containing plasticizer cannot be used in combination with Styrodur C.

Laying Styrodur® C boards

When using Styrodur C as thermal insulation **(Fig. 8)** under a non-load-bearing floor slab (no loads on rising structures) in accordance with DIN 4108, the following must be observed:

- Styrodur C can be laid in up to three layers.
- The total thickness of the thermal insulation layer can be up to 400 mm.
- Only extruded foam boards with overlap are permitted (Styrodur 3035 CS, Styrodur 4000 CS, Styrodur 5000 CS).
- Styrodur C is laid in a bond without cross joints.
- The board layers are laid with offset joints.
- A separation layer such as polyethylene sheet is laid between the thermal insulation and the floor slab.
- Styrodur C boards must not be used under static load-bearing single or strip foundations.

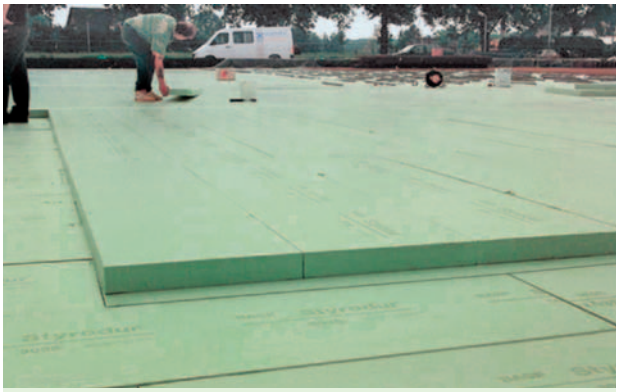


Fig. 8: Multilayer installation of Styrodur® C boards under the floor slab according to DIBt approval Z-23.34-1325.

Reinforcement

Spacers must be used for the support of the separately fitted bottom and top structural steel reinforcement. This can consist of suitably shaped steel mesh fabric, precast concrete or plastic parts **(Fig. 9)**. The reinforcement is placed on the spacers **(Fig. 10)**. There will be no contact with the PE film. The risk of damaging the film is marginal.

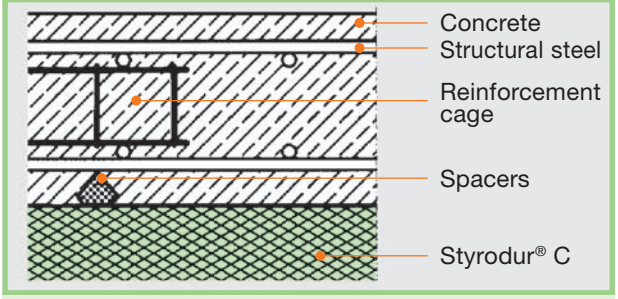


Fig. 9: Walkable spacers made of fiber-reinforced concrete for the bottom reinforcement; reinforcement cage of steel mesh fabric for the top reinforcement of the floor slab.

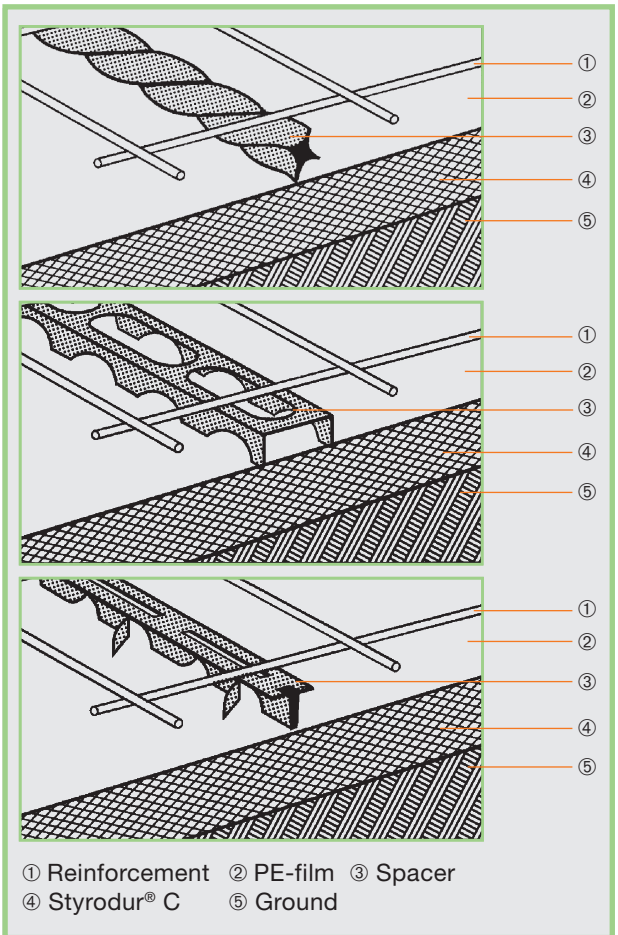


Fig. 10: Walkable plastic spacer for horizontal reinforcement. The height of the concrete cover is predetermined by the profile height.

6.3 Perimeter Insulation Under Foundations and Foundation Slabs (Static Load-bearing)

Lateral thermal insulation of foundations with Styrodur® C

The sides of foundations can be insulated with Styrodur® C boards for thermal insulation and to prevent freezing. This prevents frost penetration even under minimal-depth foundations of heated buildings **(Figs. 11 and 12)**.

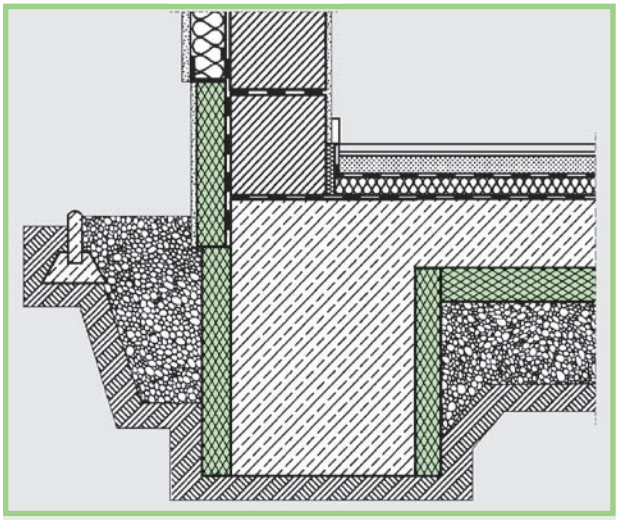


Fig. 11: Insulation of the foundation and connection to the external thermal insulation composite system.

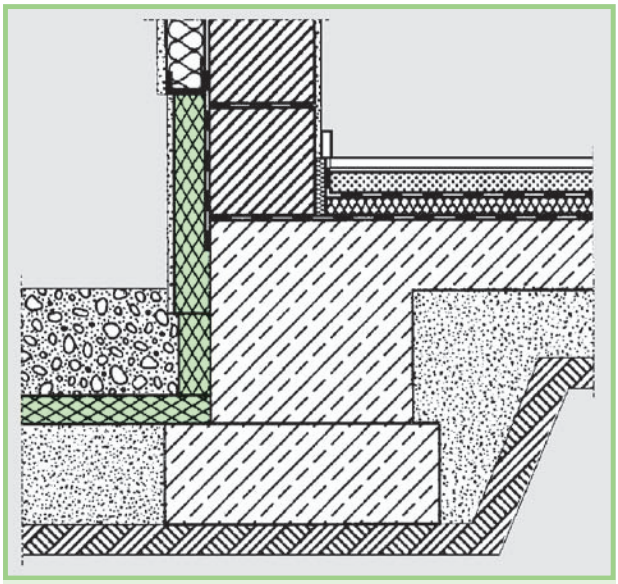


Fig. 12: Possibilities of insulating the foundation against subgrade frost.

Thermal insulation under load-bearing foundation slabs with Styrodur C

In accordance with DIBt approval Z.23.34-1325, Styrodur C can also be used as load-bearing thermal insulation with up to three layers under foundation slabs. This is precisely where Styrodur C meets all of the key requirements of thermal insulation: high compressive strength as well as resistance to decay and low water absorption.

Foundation slabs made of steel-reinforced concrete are becoming ever more common in the construction of homes and office buildings. It is recommended to install Styrodur C boards underneath the entire foundation slab in order to prevent the formation of thermal bridges. The rising basement wall perimeter insulation, which is also free of thermal bridges, is mounted directly on this base. The benefit of this method is that the basement is completely and comprehensively enclosed in insulating material.

Frost protection

For frost protection, the thermal insulation is extended beyond the area of the foundation slab to prevent the formation of frost under the foundation or foundation slab **(Fig. 13)**.

Today an increasing number of buildings without basements are constructed on foundation slabs, without considering the appropriate frost protection of the base. The risk here is that temperatures beneath the foundation may drop below freezing during winter months. Depending on the condition of the soil, this may result in ice lenses and frost heave, potentially causing damage to the building.

The arrangement of the frost protection prevents the penetration of frost under the floor slab **(Fig. 14)**. With this method, horizontal thermal insulation is installed around the entire building at a depth of about 30 cm. If block paving is to be laid above the frost protection, then the depth can be reduced to 20 cm.

Fig. 13: Frost protection by LohrElement

Passive house standard

Climate with period of permanent frost < 40 days:

- Frost protection width = Styrodur® C board length b = 125 cm
- Insulation board thickness d = 8 cm
- Ground cover h = approx. 30 cm

Climate with period of permanent frost < 26 days:

- Frost protection width = Styrodur C board length b = 60 cm
- Insulation board thickness d = 3 cm
- Ground cover h = approx. 30 cm

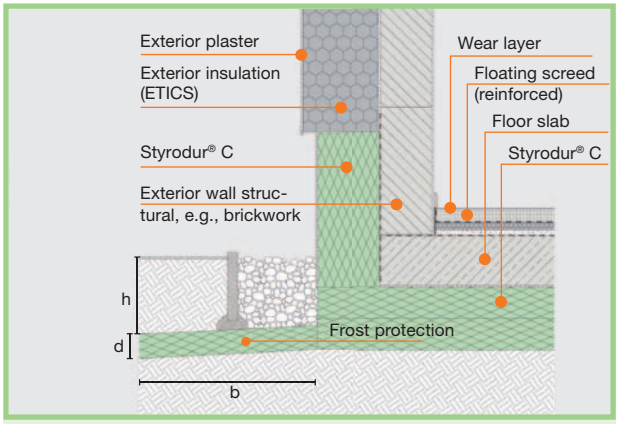


Fig. 14: Information on the design of frost protection.

When using Styrodur C for load-bearing thermal insulation under static load-bearing foundation slabs, the following is to be considered:

- Styrodur C can be laid in up to three layers.
- The total thickness of the thermal insulation layer can be up to 300 mm.
- Only extruded foam boards with overlap are permitted (Styrodur 3035 CS, Styrodur 4000 CS, Styrodur 5000 CS).
- In the case of multiple layering, the stacked board layers may only be comprised of boards of the same type and compressive strength (Styrodur 3035 CS, Styrodur 4000 CS, Styrodur 5000 CS).
- Styrodur C is laid in a bond without cross joints.
- The board layers are laid with offset joints.
- The extruded foam boards are to be laid on a blinding layer, e.g., C8/10 concrete or on a level, densely compacted gravel and sand base. The base must be sufficiently level.
- A single separation layer such as a PE sheet above the insulation layer, or other suitable measures, are to be taken in order to protect the insulation layer during the installation of the foundation slab.

Note:
For single-layer installations, up to 20% of the rated value of the normal stress of the respective load case can be dispersed as horizontal forces via Styrodur C. The installation of a PE film should be omitted.

Static prerequisites

For verification of stability, the rated value of the compressive stress fcd of the extruded foam plates may be used as a maximum.

- Styrodur 3035 CS - single layer fcd = 185 kPa
- Styrodur 3035 CS - multiple layer fcd = 140 kPa
- Styrodur 4000 CS - fcd = 255 kPa
- Styrodur 5000 CS - fcd = 355 kPa

Settlement calculations

In accordance with DIBt approval Z-23.34-1325, the settlement for a thermal insulation layer thickness of 120 mm must be considered for two borderline cases:

- Calculation for the intended building ground without consideration of the thermal insulation layer
- Calculation for the intended building ground and the thermal insulation layer using the modulus of elasti city of the compressed extruded foam board after 50 years (taking into account the long-term creep deformation of the insulation material):
- Styrodur 3035 CS - E50 = 5.000 kPa
- Styrodur 4000 CS - E50 = 10.000 kPa
- Styrodur 5000 CS - E50 = 14.000 kPa

From the standpoint of building physics and depending on the intended indoor climate, it may be necessary to install a vapor barrier on the warm side, or the top surface of the Styrodur C layer. It interrupts the water diffusion flow from the interior of the building toward the ground, which prevents condensation in the insulation material.

7. Perimeter Insulation in Areas with Pressing Water and Standing Seepage Water (In Groundwater)

In accordance with DIBt approvals Z-23.5-223 and Z-23.34-1325, Styrodur® C boards may additionally be used in an areas with permanent or long-term pressing water (in groundwater) in up to three layers, whereby the Styrodur C insulation can be immersed in groundwater to a maximum of 3.5 m.

7.1 Perimeter Insulation in Wall Areas

Waterproofing

The structural waterproofing must not be impaired in its function by the insulation layer in any way. The structure is waterproofed in accordance with DIN 18195-6 “Waterproofing against outside pressing water and standing seepage water, design and execution” **(Fig. 15)**.

Commonly used are bitumen membranes and bulk bitumen, plastic and elastomer sealing sheets, metal bands, polymer-modified bitumen coatings, and waterproof concrete in the form of a “white tank.”

Fig. 15: Waterproofing the basement walls against pressing water.

Bonding Styrodur® C boards

When applying the adhesive, spread the mixed insulation board adhesive over the entire surface of the wall and the insulation board by means of a notched trowel with about 10 mm teeth **(Fig. 16)**. The insulation board adhesive is applied to the mating edges of the boards already glued to the wall.

This process is repeated for double-layer insulation. The joints of the second board layer are to be overlapped and offset.

The adhesive manufacturer’s instructions for use must be observed.

Fig. 16: Full-surface bonding of the insulation boards in areas with pressing water.

Attaching the Styrodur C boards and spackling the joints

Position the boards with a gap of 2 to 3 cm and push together to closely butt the joints. When creating the bond, avoid any cross joints. The all-round overlap ensures a joint lock, which prevents the formation of thermal bridges. Styrodur C boards are to be attached sufficiently tight to the exterior wall so that it is not possible for water to run down the rear side of the thermal insulation. The boards are bonded to the base by means of a suitable adhesive (see Adhesive selection). The side edges of the Styrodur C boards are to be spackled all round with adhesive or an appropriate bituminous sealant for protection against water penetration **(Fig. 17)**.

The boards can reach up to 3.5 m into the groundwater and must be permanently secured against uplift.

Fig. 17: Attaching the Styrodur® C boards and sealing the joints against pressing water.

Adhesive selection

Special adhesives must be used for the full-surface bonding of the insulation boards outside the structural waterproofing in areas subject to permanent or long-term pressing water. The two-component adhesive PCI Pecimor DK on bitumen emulsion base with a binder is particularly suited to this application and guarantees fast and dependable adhesive curing under the bonded insulation boards.

Securing against uplift

The verification of security against uplift is given if one of the following points is complied with:

- The Styrodur® C boards have a full-surface bond with the structure. There must be no shear forces acting across the bituminous waterproofing.
- With a maximum insulation board thickness of 120 mm, the maximum groundwater level must be no higher than 1 m below ground level.
- With a maximum insulation board thickness of 80 mm, the groundwater level must be no higher than 0.5 m below ground level.
- The construction must include measures to secure against uplift.

No additional measures against uplift are necessary with the “white tank” (waterproof concrete) construction method. The groundwater level may rise up to ground level. In well-drained soil, Styrodur C can be installed in the groundwater area without additional special drainage boards. Full-surface bonding is required in groundwater.

7.2 Perimeter Insulation Under Basement Floors (Static Non-load-bearing) and Under Foundations and Foundation Slabs (Static Load-bearing)

The same information and instructions apply as described in this brochure under 5.2 and 5.3. In accordance with DIBt approvals Z-23.5-223 and Z-23.34-1325, Styrodur® C boards may also be installed in areas of permanent or long-term pressing water (in groundwater) with up to three layers. The Styrodur C insulation may reach up to 3.5 m into the groundwater.

8. Attaching and Aligning

At the base points **(Fig. 18)**, for example the lower starting point of the perimeter insulation, the Styrodur® C boards must be positioned such that slipping off due to settlement over time is prevented.

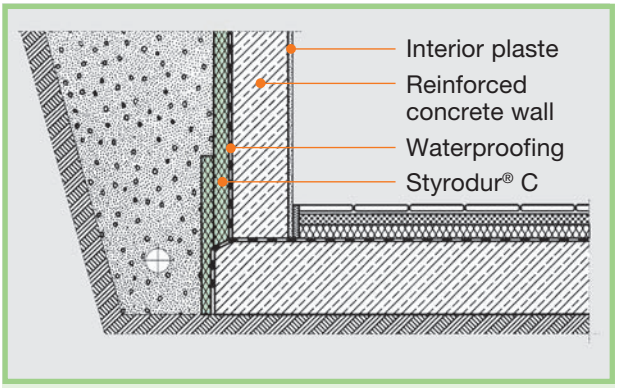


Fig. 18: Base point of the perimeter insulation. The Styrodur® C board rests on top of the foundation.

Near windows, lintels, and window frames, the thermal insulation is to be free of thermal bridges **(Fig. 19)**. Lightwells are to be fitted such that the perimeter insulation is not interrupted and there are no thermal bridges.

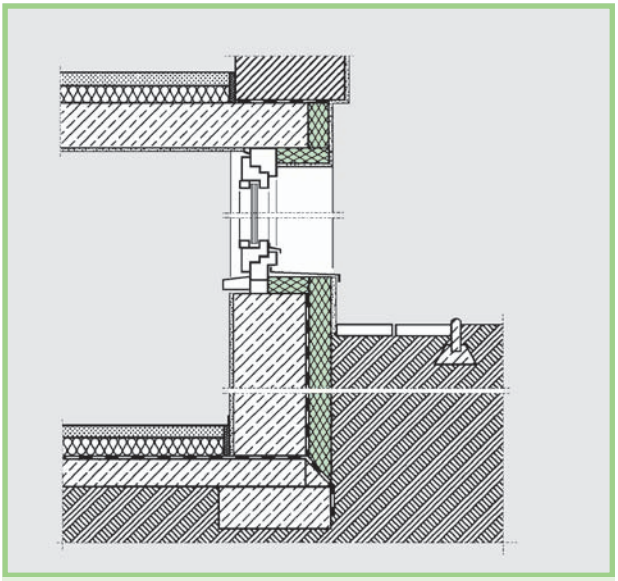


Fig. 19: Insulation in the window area free of thermal bridges.

8.1 Lightwells

In order to avoid thermal bridges, lightwells should be thermally separated from the building. This may mean that the width of the lightwell varies. One example are lightwells made of precast concrete parts **(Fig. 20)** that are set onto a bed of gravel and leaning on the perimeter insulation.

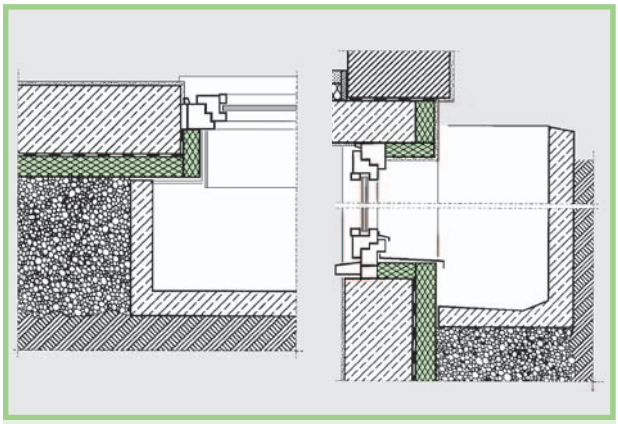


Fig. 20: Attachment of a precast concrete lightwell.

Plastic lightwells also represent a good solution and are attached to the basement wall with screws penetrating the insulation **(Figs. 21 and 22)**.

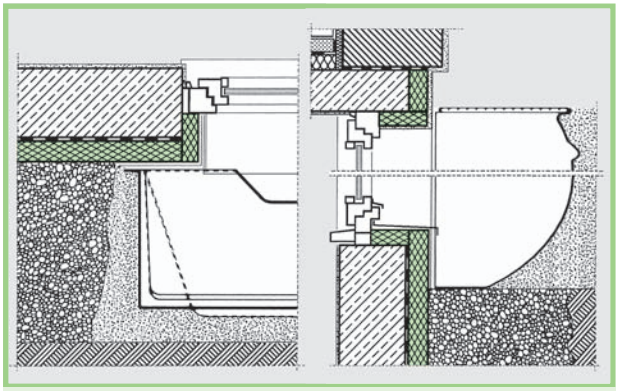


Fig. 21: Attachment of a plastic lightwell free of thermal bridges.

Fig. 22: Lightwell assembly with perimeter insulation.

9. Base Insulation

Insulation is also necessary in the base area of the basement between the surface of the ground and the rising, thermally insulated brickwork or the external thermal insulation composite system **(Fig. 23)**. Above ground level, Styrodur® 2800 C with its thermally structured surface is used if the surface is to be plastered.

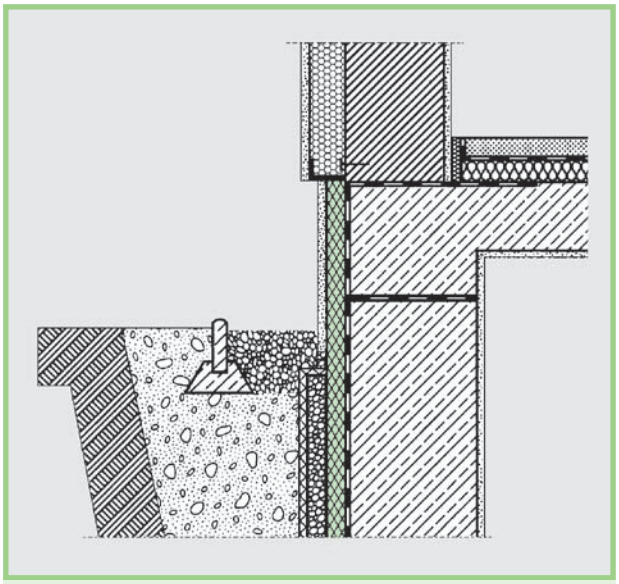


Fig. 23: Base area, perimeter insulation with external thermal insulation composite system.

In the base area, the boards are bonded to the exterior wall with a construction adhesive using the dot-bead method. Once the adhesive has cured, the Styrodur 2800 C boards are doweled with four plate anchors per board **(Fig. 24)**. The head diameter of the plate anchor must measure at least 60 mm. Styrodur C boards without a thermally structured surface are not suitable for plastering.

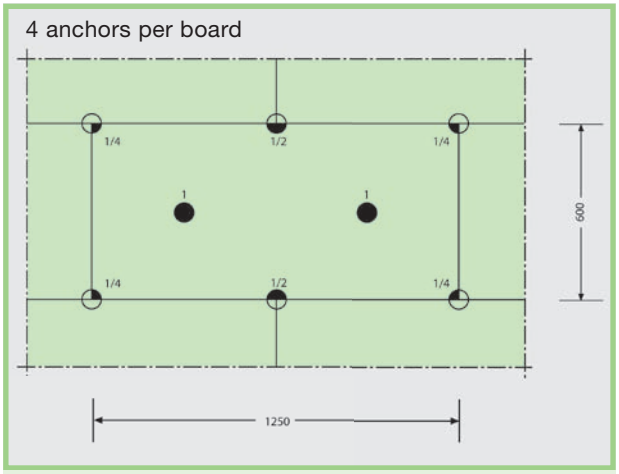


Fig. 24: Positioning and number of anchors (4 anchors per board) for subsequent attachment of Styrodur® C boards in the base area (dimensions in mm).

10. Insulation of Strip Foundations

When constructing insulated strip foundations, Styrodur® C boards can be positioned directly in the formwork and cast in concrete or used as permanent formwork **(Fig. 25)**.

For reinforced foundations, flat spacers are to be used between the insulation and the reinforcement. All types of Styrodur C boards are suitable for concrete pouring. With timber formwork, the Styrodur C boards can be secured to the formwork elements with clout nails **(Fig. 26)**.

For steel or prefabricated formwork, it must be ensured while using appropriate fastening methods that the insulation boards do not come loose or shift during pouring or compacting of the concrete. DIN 1045-3 must be taken into account concerning the post-treatment, outfitting, and stripping of the concrete.

Fig. 25: Formwork with Styrodur® C.

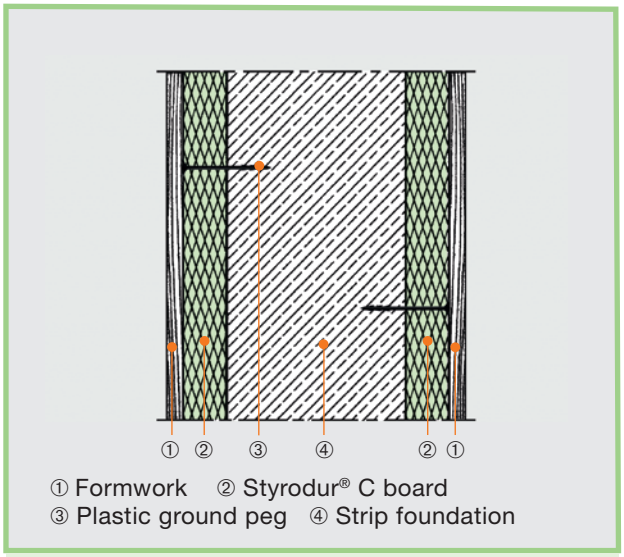


Fig. 26: Installation into formwork and securing of Styrodur 3035 CS boards with plastic ground pegs.

11. Drainage

Drainage is usually not necessary to protect the perimeter insulation. In special soil conditions such as a water-impermeable soil zone, or specific building locations such as on a slope, drainage measures to remove surface and seepage water are required. In these cases, an overall drainage concept in accordance with DIN 4095 “Drainage systems for the protection of structures” must be put into place **(Fig. 31)**. It consists of the surface drainage of the wall, drainage pipes, a gravel pack, filter fleece, inspection chambers, and a connection to the drains or a discharge system. The mere installation of insulating drainage boards is not sufficient.

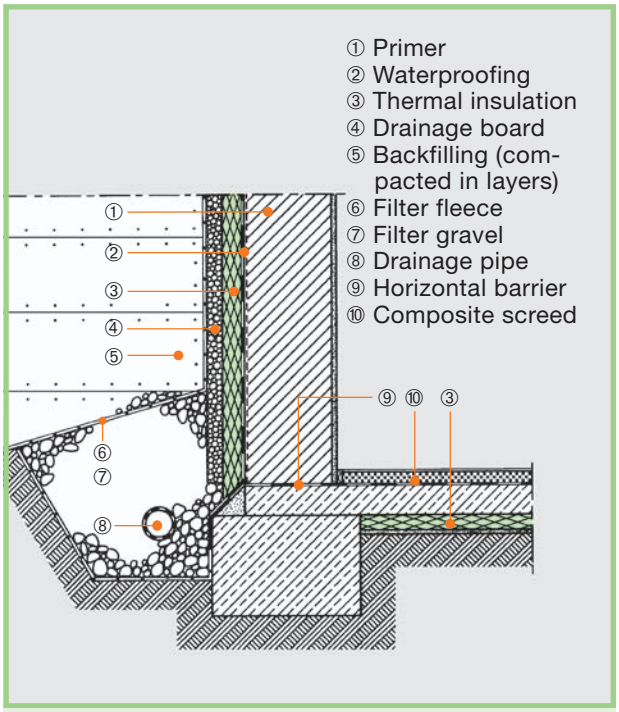


Fig. 27: Arrangement of perimeter insulation combined with drainage system.

12. Backfilling of Excavation Pits

With proper backfilling of the excavation pit, the Styrodur® C boards require no additional protective layers. Minor damage to the surface of the boards will not affect the efficiency of the perimeter insulation. Care must be taken when backfilling to ensure that earth movement or settling do not cause harmful shear stress to the building waterproofing (full-surface bonding of the insulation boards, solid resting area at the base, glide coatings, etc.). The backfilling of the excavation pit **(Fig. 28)** is carried out in layers of about 40 cm, which are subsequently compacted **(Fig. 29)**.

Fig. 28: Layered backfilling of the excavation pit and mechanical compacting.

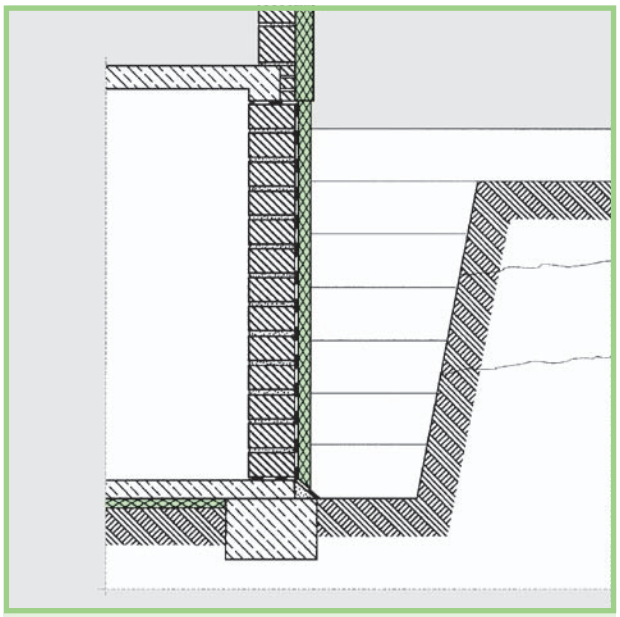


Fig. 29: Layered backfilling of the excavation pit.

13. Perimeter Insulation of Passive Houses with Styrodur® C

In accordance with DIBt approvals Z-23.34-1325 and Z-23.5-223, Styrodur® C boards can be installed in one to three layers. This enables forward-looking and energy-efficient thermal insulation, which has been state of the art in passive houses for many years.

The ingress of water between the individual board layers and shifting of individual board layers is prevented by the load exerted by the foundation slab and the building. The extruded foam plates may only be stressed perpendicular to the plane of the boards. Shear loads are not permitted.

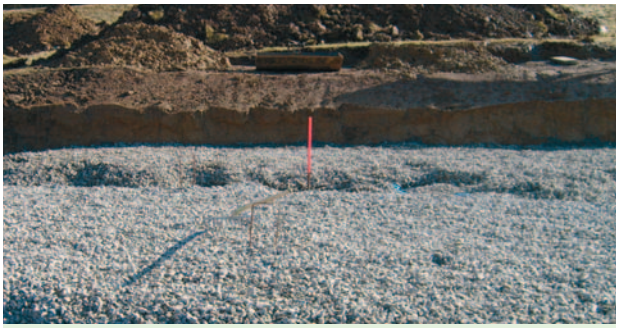
When installing the insulation boards, cross joints must be prevented. A protective layer such as a PE film must be placed between the uppermost insulation layer and the foundation slab.

13.1 Case Study: Triple-layer Installation of Styrodur® C Under the Foundation Slab of Passive House

In February 2008, the formwork and insulation specialist LohrElement constructed their largest foundation slab to date to the passive house standard at 570 m². The construction was extremely challenging as the design incorporated a curved section and numerous corners and offsets. Planning and construction management was headed by the architectural firm Sägezahn in Deggenhausertal. The foundation slab project in Vöhringen was managed by the construction company Bau Steeb from Sulz.

The company LohrElement E. Schneider GmbH from Gemünden offers prefabricated Styrodur® C elements for the formation of edge formwork for foundation slabs and frost heave protection constructions (www.lohr-element.de).

Preparation of the foundation slab



A gravel bed as a blinding layer and leveling plane makes for a flat base. This base course is prepared according to the requirements of the building ground and the instructions of the structural engineer.

Stopend formwork

The arrangement and installation of linear edge elements is performed on the flat base to the respective building installation plan.

Horizontal ground insulation/frost protection

Frost protection in accordance with EN ISO 13793 is necessary to avoid an expensive foundation extending down to the frost depth. It is added to the edge element in the factory and deployed as part of the horizontal ground insulation.

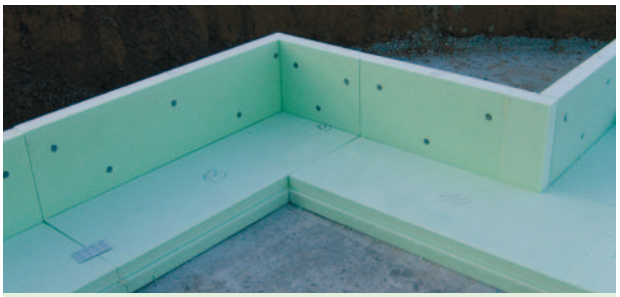
Curved sections

The factory-made, curved edge elements are aligned and installed according to the design radii. This method makes it possible to accurately and precisely construct curved foundation slabs.

First layer

The Styrodur® C boards with all-round overlap are laid in a loose bond in the first insulating layer. The point at which the installation begins and the laying direction is planned for the individual building and crafted to the assembly plans.

Corners



The pre-made and numbered corner elements kit ensures that the edge elements are laid with millimeter accuracy even with structured building footprints. This eliminates the time-consuming measuring and setting of the floor slab.

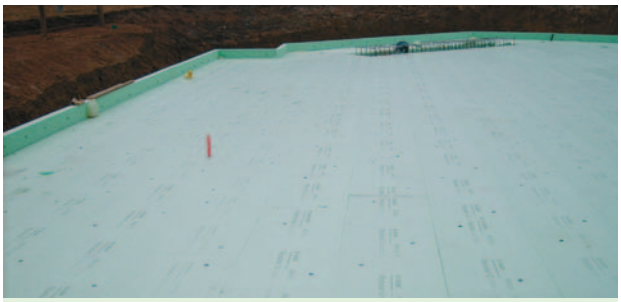
Second layer

The second insulating layer, likewise Styrodur C boards with all-round overlap, is laid with the joints offset to the first layer of boards and also in a loose bond.

Third layer

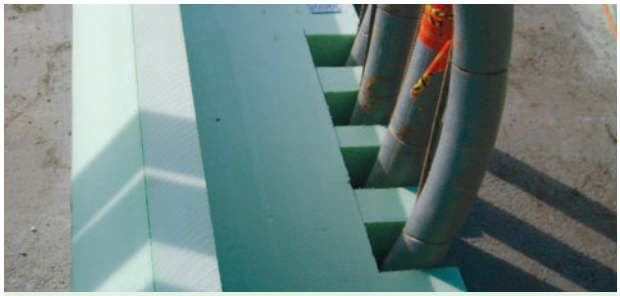
The third insulating layer is installed in the same way as the first layer. The surface elements of the third layer are bonded at the end to the edge elements with a special adhesive, which improves the overall stability of the system.

Accurate floor slab



Two major factors are important for a floor slab that is accurate and free of thermal bridges: the technically approved triple-layer Styrodur® C insulation and professional work preparation with straightforward assembly and installation plans.

Cutouts



Cutouts or penetrations are cut according to structural requirements and local conditions. Any remaining voids are sealed with special PU foam.

Comfortable and convenient floor slab

The thermally active floor slab serves as a large-scale heat accumulator and yields energy savings of up to 30 percent. The reduction in the height of the floor structure provides additional room height.

Securing the insulation boards

Insulation anchor pins are used to secure the adhesion of the individual insulating layers to one another. This results in a joint-free and stable base.

14. Construction Aids

14.1 Thermotechnical Dimensioning

Great demands are placed on the thermal insulation of building elements with ground contact of heated habitable rooms (see Table 1). In accordance with DIN 4108-2, for minimum thermal protection of exterior walls with ground contact a thermal resistance (R value) of 1.2 (m^2·K)/W is stipulated. This corresponds to a heat transfer coefficient (U value) of 0.75 W/(m^2·K). For the lower building closure of habitable rooms in a building without basement that is immediately adjacent to the ground, a minimum thermal resistance (R value) of 0.90 (m^2·K)/W is required.

This corresponds to a heat transfer coefficient (U value) of 0.93 W/(m^2·K). These maximum heat transfer coefficients must not be exceeded when the structural thermal insulation is calculated according to the energy balance method of the German Energy Saving Ordinance (EnEV). The requirements are met for the structures given as example in Table 2.

Table 1: Minimum thermal insulation according to DIN 4108-2 – Requirements –

Building element adjacent to the ground	Thermal resistance [m^2·K/W] R	Heat transfer coefficient [W/(m^2·K)] U-value
Wall	1.20	0.75
Floor	0.90	0.93

Table 2: Minimum thermal insulation according to DIN 4108-2 – Examples –

Example	Construction		U value [W/(m^2·K)]		Insulation layer thickness [mm]	
	thickness [mm]	Building material	Non-insulated	Insulated	λ = 0,035 [W/(m·K)]	λ = 0,040 [W/(m·K)]
1	300	Concrete wall	3.7	< 0.75	40	50
2	20	Exterior plaster	1.8	< 0.75	30	40
	365	Sand-lime brick KSL-12-1,8-12 DF				
	15	Interior plaster				
3	20	Exterior plaster	1.8	< 0.75	30	40
	300	Solid brick Mz-12-1, 8-5 DF				
	15	Interior plaster				
4	20	Exterior plaster	2.0	< 0.75	30	40
	300	Concrete block Hbn-12-1, 8-20 DF				
	15	Interior plaster				
5	120	Concrete floor	4.4	< 0.93	30	40

Table 3: Thermal insulation recommendation according to EnEV 2009

Building element	Thermal resistance* [m^2·K/W] R	Heat transfer coefficient [W/(m^2·K)] U-Value
Ceilings above unheated basements	≥ 2.52	≤ 0.35
Wall adjacent to ground	≥ 2.73	≤ 0.35
Floor adjacent to ground	≥ 2.69	≤ 0.35

* Since the resistance to heat transfer may vary, different minimum thermal resistance coefficients may arise for the same thermal transmission coefficient.

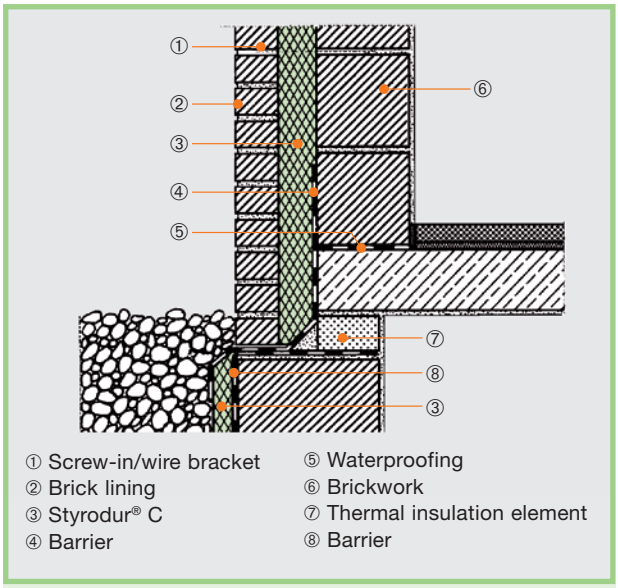


Fig. 30: Connection of the perimeter insulation to brickwork with core insulation.

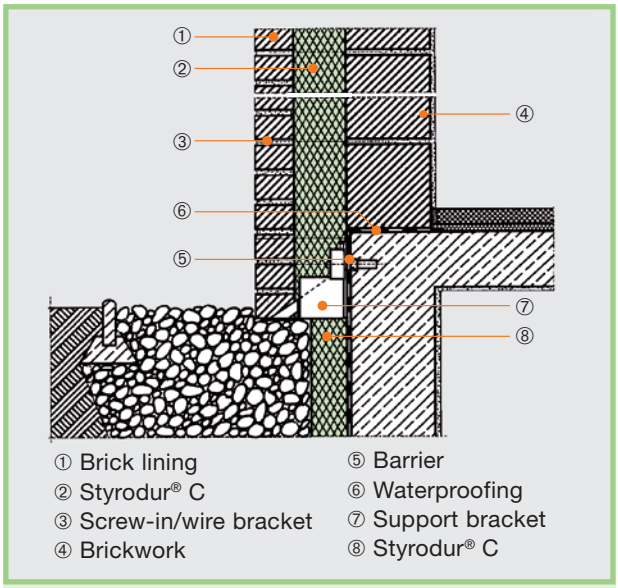


Fig. 31: Connection of the perimeter insulation to brickwork with core insulation with support brackets.

On October 1, 2009, the Energy Saving Ordinance (EnEV) came into force in Germany. After the EnEV, the annual primary energy demand of heated buildings is limited. Which individual method is employed to limit the annual primary energy demand of the building is left to the planners. Only recommendations can be made in regard to insulating measures for building elements in contact with the ground. We suggest that basement walls with ground contact should be dimensioned such that they exhibit a U value of ≤ 0.3 W/(m²·K). Perimeter insulation is advisable even for non-heated lower levels.

If the use of the basement is subsequently changed, retrofitting exterior insulation is extremely complex and expensive. The only true option under such circumstances is interior insulation. In the summer, when the outside air is warm and damp, rooms with exterior walls in contact with the ground run the risk of condensation on the inner surface of the exterior walls. The dew point temperature of the warm, damp summer air can be higher than the inner surface temperature of the basement walls. In this case, condensation forms on the inner surface of the exterior walls, which can lead to mold growth and an unpleasant musty odor. Good thermal insulation also contributes to improved hygrothermal performance.

Table 4: Thermal insulation – Examples –

Example	Construction		U value [W/(m²·K)]		Insulation layer thickness [mm]	
	Thickness [mm]	Building material	Non-insulated	Insulated	λ = 0.035 [W/(m·K)]	λ = 0.040 [W/(m·K)]
1	300	Concrete wall	3.7	< 0.35	90	110
				< 0.3[1)]	110[1)]	130[1)]
2	20	Exterior plaster	1.8	< 0.35	80	100
	365	Sand-lime brick KSL-12-1, 8-12 DF		< 0.3[1)]	100[1)]	120[1)]
	15	Interior plaster				
3	20	Exterior plaster	1.8	< 0.35	80	100
	300	Sand-lime brick Mz-12-1, 8-5 DF		< 0.3[1)]	100[1)]	120[1)]
	15	Interior plaster				
4	20	Exterior plaster	2.0	< 0.35	90	110
	300	Sand-lime brick Hbn-12-1, 8-20 DF		< 0.3[1)]	100[1)]	120[1)]
	15	Interior plaster				
5	120	Concrete floor	4.4	< 0.35	100	110
				< 0.3[1)]	110[1)]	130[1)]

[1)] Recommendation for EnEV 2009

14.2 Hygrothermal Dimensioning

The exterior Styrodur® C thermal insulation when used for perimeter insulation is a functional design based on water vapor diffusion technology, as the water vapor diffusion resistance of the individual layers decreases toward the exterior. The thermal resistance of the individual layers increases from the interior to the exterior. An exterior thermal insulation layer is also advantageous when it comes to protecting the external building elements of the basement from condensation. The insulated wall interior exhibits an increased surface temperature compared to a non-insulated building element, which contributes to comfortable living conditions. The risk of condensation forming on the interior wall surface is low. Tables 5 and 6 indicate that with perimeter insulation with an overall U value of ≤ 0.35 W/(m²·K) on an undisturbed wall area, condensate water first appears at relative humidity above 90%.

14.3 Type Selection According to Installation Depth

The earth pressure on the thermal insulation boards rises with increasing installation depth. Thanks to the high permissible compressive load properties of Styrodur® C, the technical approval does not restrict the depth of installation. For greater installation depths, however, the Styrodur C types with higher compressive strength are recommended. Table 7 shows the different types of Styrodur C and their approved installation depths. They refer to the worst-case load scenario "earth pressure at rest from silty sand."

Table 5: Prevention of condensate water on basement walls at a room temperature of 20°C

Relative humidity of the air [%]	Recommended insulation layer thickness [mm] dimensioned for ambient temperatures of	
	– 10°C	– 15°C
60	20	30
70	30	40
80	50	60
90	100	120

Table 6: Permanent compressive strength and maximum installation depth of the various Styrodur® C types

Styrodur® C-Type	3035 CS	4000 CS	5000 CS
Permissible permanent pressure 50 years at 23°C, kPa Compression ≤ 2%	130	180	250
Maximum installation depth [m]	**12**	**17**	**24**

15. Information and General Processing Instructions

- Styrodur® C should not be exposed to sunlight for long periods, particularly in summer months.
- If Styrodur C is used under covers such as roofing sheets, films, or building protection mats, it is possible that excessive heating could occur during summer due to the absorption of sunlight, which could cause deformation of the Styrodur C boards. Therefore, it is essential to immediately apply the appropriate protective layer in accordance with the flat roof guidelines.
- Styrodur C insulation boards must be permanently protected from UV radiation.
- Styrodur C is not resistant to all substances (see brochure “Chemical Resistance” in the download area of www.styrodur.de). The instructions of the adhesive manufacturer must be observed for the adhesive selected.

16. Application Recommendations for Styrodur® C

Styrodur® C	2500 C	2800 C	3035 CS	3035 CN	4000 CS	5000 CS
Perimeter [1] floor slabs			■		■	■
Perimeter [1] basement walls			■		■	■
Perimeter [1] load-bearing floor slabs			■		■	■
Perimeter [1] / subsoil water areas			■		■	■
Domestic floor	■	■	■			
Industrial and refrigerated warehouse floors	■	■	■		■	■
Cavity walls	■		■	■		
Internal walls		■				
Lost formwork		■				
Cold bridges		■				
Exterior basement wall insulation		■				
Plaster base		■				
Inverted flat roofs			■		■	■
Duo roofs / Plus roofs			■		■	■
Promenade roofs			■		■	■
Roof gardens			■		■	■
Parking decks					■ [2]	■
Conventional flat roofs [3]	■		■		■	■
Parapet walls	■	■	■			
Basement ceiling / Underground garage ceiling		■				
Attic ceiling			■			
Pitched roofs	■	■		■		
Ceilings	■			■		
Drywall composite board		■				
Sandwich panels	■	■				
Warehouses	■		■	■	■	■
Ice rinks			■		■	■
Road transport infrastructure / Rail construction			■		■	■

Styrodur® C: Product approval: DIBt Z-23.15-1481,
extruded polystyrene foam in accordance with EN 13164;
Free of HFC

[1] Insulation in direct contact with the ground
[2] Not for installation under concrete paving stones
[3] With protective layer over the sealing

Styrodur® C—A Strong Product Line

With the Styrodur® C product line, BASF offers the ideal insulation solution for almost every application.

Styrodur 2500 C
- The light thermal insulation board with smooth surface and smooth edges for applications with normal compressive strength requirements.

Styrodur 2800 C
- The thermal insulation board with embossed honeycomb pattern and smooth edges for application in combination with concrete, plaster, and other covering layers.

Styrodur 3035 CS
- The all-round thermal insulation board with smooth surface and overlap is suitable for almost all applications in structural and civil engineering.

Styrodur 3035 CN
- The long thermal insulation board with smooth surface and groove and tongue for quick, thermal bridge-free installation.

Styrodur 4000/5000 CS
- The extremely compression-proof thermal insulation board with smooth surface and overlap for applications with highest compressive strength requirement

Styrodur HT
- The light green, high temperature-resistant thermal insulation board for all areas of application with thermal loads of up to 105 °C. Further information: www.styrodur.com

Styrodur NEO
- The silver-gray thermal insulation board with an up to 20% better insulating performance thanks to the use of graphite as an infrared absorber, as patented by BASF. Further information: www.styrodur.com

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