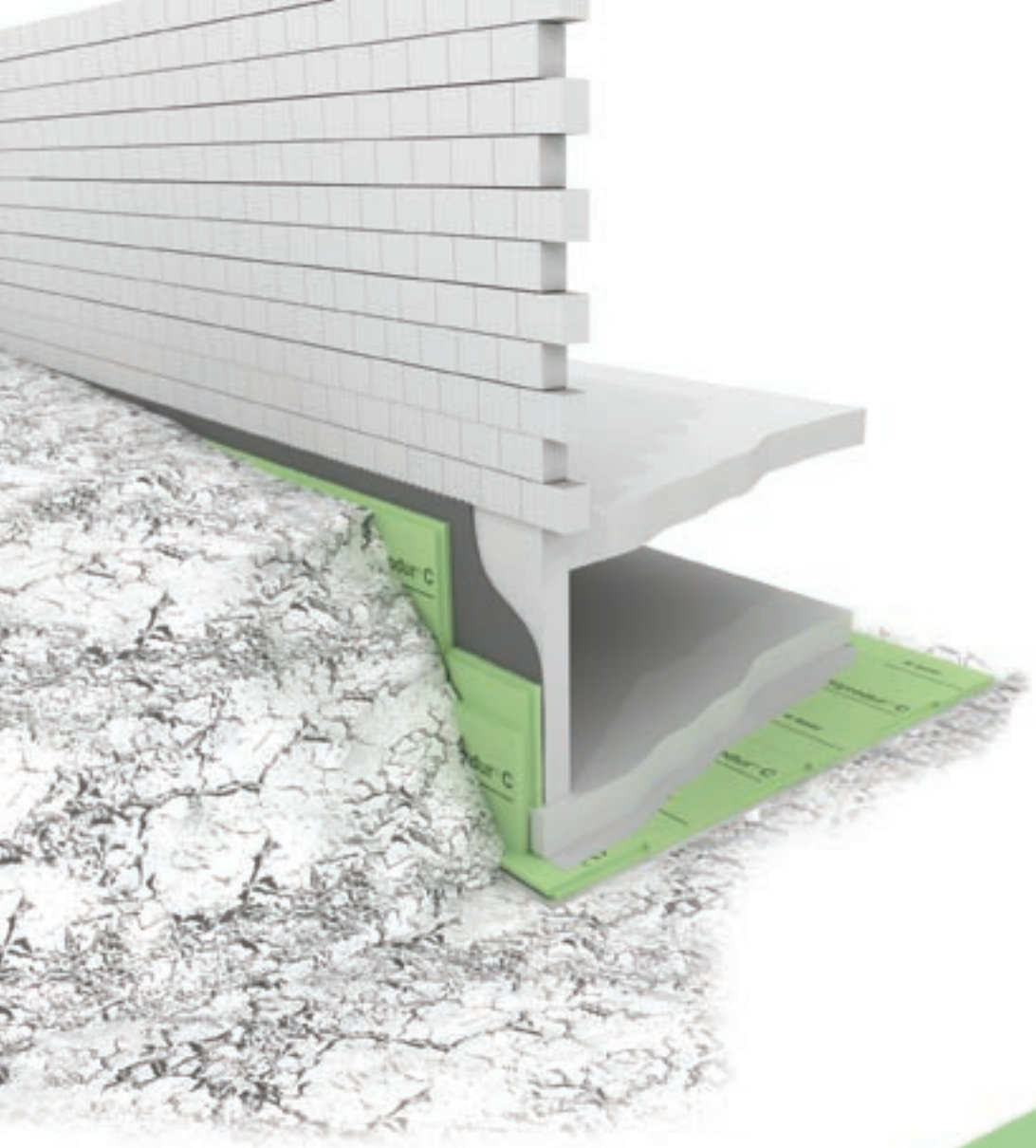


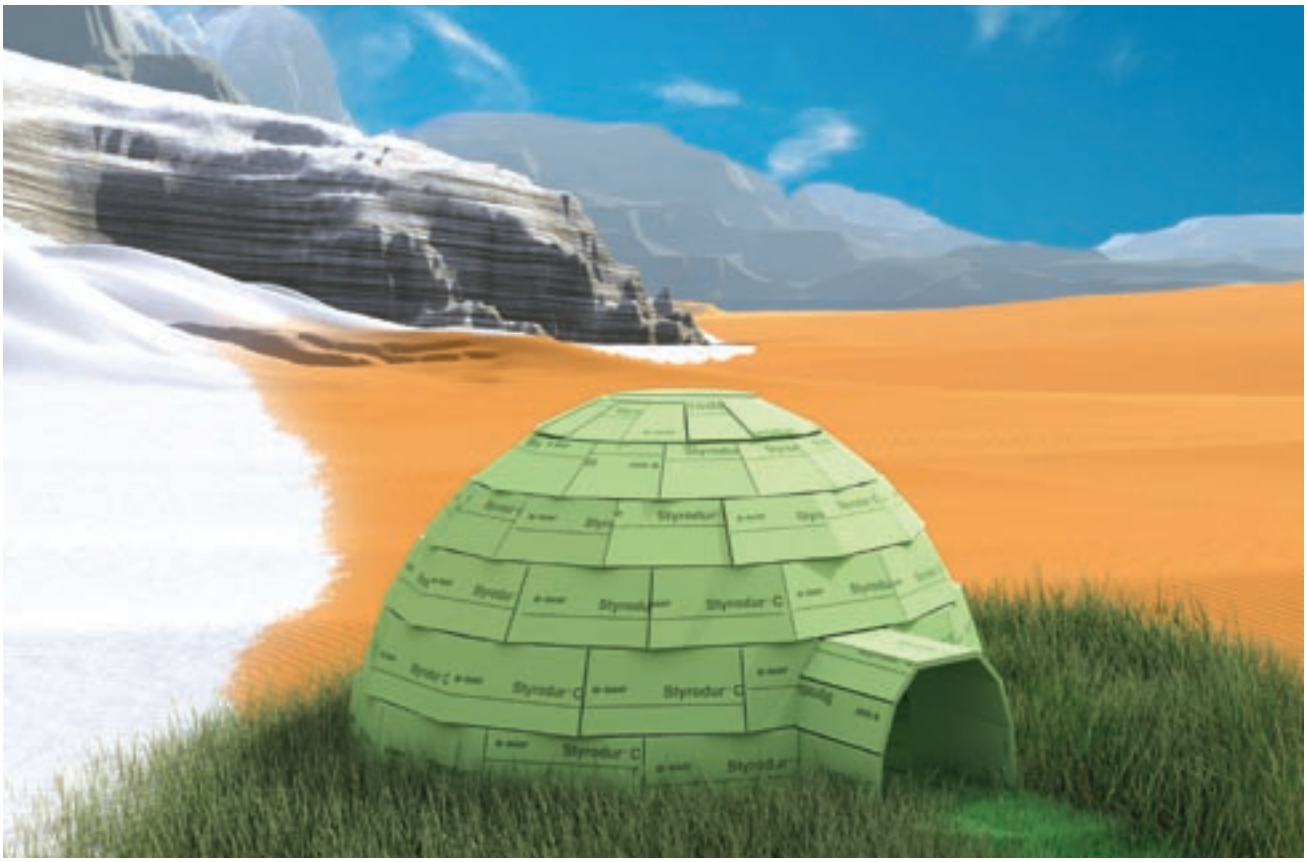
Europe’s green insulation

# Styrodur® C

## Basement Insulation

BASF
The Chemical Company

# Contents Overview



## 1. Styrodur® C Thermal Insulation

Styrodur® C is BASF's environmentally friendly, extruded polystyrene rigid foam. It is free of CFC, HCFC and HFC and makes an important contribution towards reducing emissions of carbon dioxide ($CO_2$).

Due to its high compressive strength, low moisture absorption, long working life and its resistance to decay, Styrodur® C has become synonymous with XPS in Europe. The compressive strength is the main distinction between the various Styrodur® C-types.


Effective thermal insulation with Styrodur® C reduces energy consumption with the result that the investment in thermal insulation can be recouped within a short period of time. It makes for healthy and comfortable living and protects the building from the effects of moisture as well as high and low temperature.

Styrodur® C is manufactured according to the requirements of the European norm DIN EN 13 164 and its reaction to fire has been classified as Euro Class-E according to DIN EN 13501-1. It is subject to extensive assurance tests from "Wärmeschutz e.V." and has been granted the approval no. Z-23.15-1481 from the "DIBt", the Institute of the Federal and Länder Governments for a uniform fulfillment of technical tasks in the field of public law.

## 2. Perimeter Insulation

Perimeter insulation is the outside thermal insulation of construction parts that are in direct contact with the ground e. g. basement walls **(Fig. 1)** or basement floors **(Fig. 2)**.

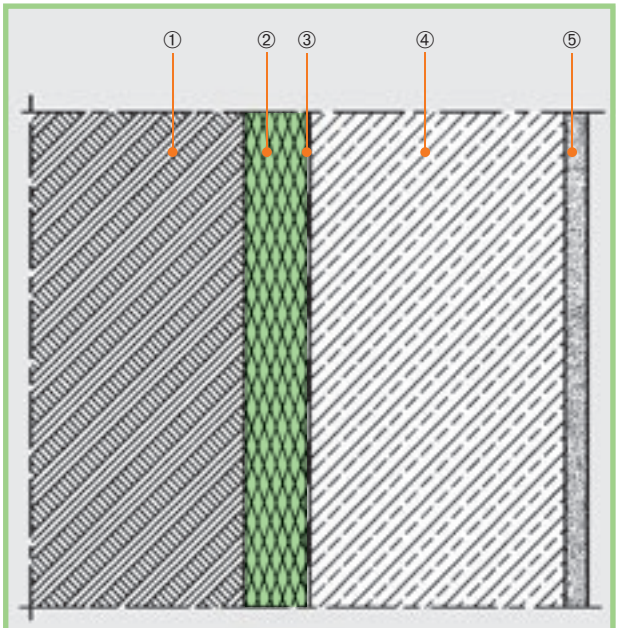



**Fig. 1:** Basement wall with outside insulation layer, bordering the ground.

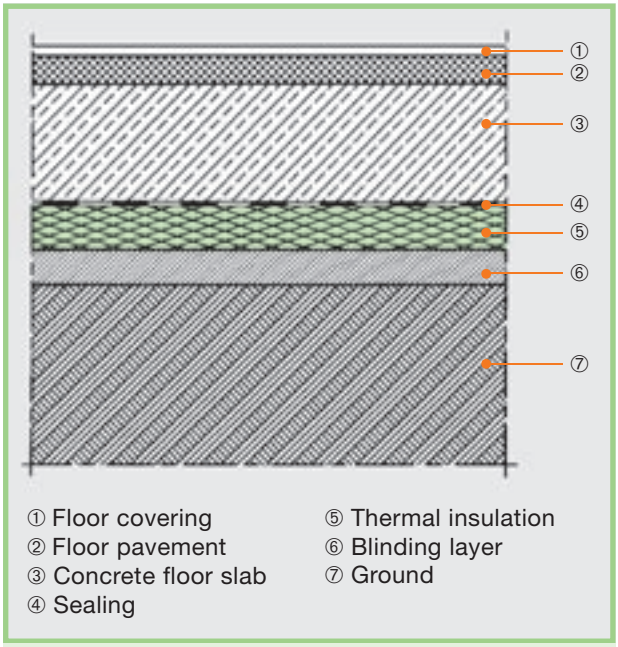



**Fig. 2:** Non-supporting lower brick partition with insulation layer bordering the ground. Example of ground insulation (without temporary or consistent pressing water).

It is typical for any perimeter insulation to install the thermal insulation layer on the outside of the respective construction part and the its sealing.

The insulation material of any perimeter insulation is exposed to high pressures from e. g. the constant contact with the ground, precipitable water, earth thrust and the load of traffic. Therefore high standards are set for the materials used:

- Resistance to moisture
- High compressive strength
- Resistance to decay while providing solid and durable thermal insulation

Styrodur® C comes equipped with all these properties which makes it the perfect choice for perimeter insulations.

### Perimeter Insulation according to the Norm

The German DIN 4108-2 norm defines thermal insulation systems as perimeter insulation if the insulation boards are e. g. from extruded polystyrene according to EN 13 164 and if they not consistently exposed to groundwater. The perimeter insulation with Styrodur® C above the groundwater level therefore constitutes a construction conforming to the standards.

### Perimeter Insulation in Groundwater

For the perimeter insulation in consistent backwater or pressing water, Styrodur® C has been approved by the DIBt under the reference number Z-23.5-233. According to this approval Styrodur® C boards may be installed up to 3.50 m into the groundwater.

### Perimeter Insulation below Foundation Slabs in Groundwater

According to the DIBt's approval number Z-23.34-1325, Styrodur® C may also be installed below load bearing foundation slabs if these are up to 3.50 m into the groundwater.

Perimeter insulation also reduces the heat loss from the building into the ground and makes for a much higher standard of living in your basement areas. Higher temperatures of the inside surfaces help prevent the creation of condensate inside the rooms thus avoiding the rather moldy smell of many basements.

There are even more advantages:

- Rise in temperature and air quality in the basement/ ground floor
- Rise in temperature of the interior surfaces of basement walls
- Prevention of condensate on basement walls and interior surface of basement floor
- More space inside basement area
- Rise in the building's quality
- Thermal insulation reduces energy costs
- Thermal insulation layers can be constructed free of cold bridges
- Protection of sealing

## 3. Advantages of Perimeter Insulation

There are many good reasons for the use of Styrodur® C in perimeter insulation:

- High compressive strength
- No need for an extra insulation layer
- No limitation as to the depth of installation
- No restrictions concerning the minimum distance to passing traffic
- Total thermal transmission coefficient of $< 0.32$ W/(m²·K), with only 12 cm of insulation layer
- No cold bridge addition
- Hardly any absorption of water
- No restriction concerning thermal conductivity due to practically no absorption of water
- Approved for groundwater levels
- Styrodur® C has proven valuable for over 30 years
- Reports about long-term properties are available
- Advantages in the installation process since for base insulation, Styrodur® C does not have to be laid in bitumen and for wall insulation it needs no extra insulation layers
- No need for extra protection measures in areas prone to frost
- No need for drainage in non-cohesive soils
- Simple installation: glue together at six points per slab; only in groundwater will it be necessary to apply glue to whole slab and edges of the slab, as well as to plug up the grooves
- Styrodur® 2800 C with embossed surface can also be used for base insulation
- The embossed surface of Styrodur® 2800 C makes plastering of the base course easy
- According to the DIBt's approval no. Z-23.34-1325, Styrodur® C may also be installed below load bearing foundation slabs even if these are up to 3.50 m into the groundwater

With the following information and suggestions of various installations and applications we want to support you in the process of coordinating and finally installing Styrodur® C.

**Note:**
If Styrodur® C is used below covers e. g. roof membranes, an interlayer, or sheets for the protection of buildings, high temperatures during the summer can cause absorption of solar radiation, which can lead to profuse warming of the material followed by a deformation of the Styrodur® C boards.

## 3.1 Good Reasons for Building a Basement

### Building a House is more Economic with a Basement

Basements cost only 200 Euro per square meter. With intelligent planning, the added floor space of approx. one third can even help you in financing your home, because:

- If parts of the added floor space is considered "living space", government aids can be used to full capacity.
- Large acclivities or elevated basement studios can be used as an extra apartment, adding to the financing of your home.

Applied to your building costs, a basement can improve the financial growth of your house, since the resale value usually rises.

**Fig. 3:** Perimeter insulation with Styrodur® C.

**Fig. 4:** Insulation measures with Styrodur® C.

Many technical reasons speak for building a basement as well. From a construction point of view, there are considerable disadvantages if you build a house with no basement, e. g.:

- Your house connections as well as the maintenance of your fittings will be more expensive.
- The sound insulation of town houses and semi-detached houses is inferior.
- Cohesive soils below the base can dry out and shrink, causing the foundation slab to sink and the walls to rip.
- The utilization of small premises is by far inferior.

### Extra Space in your Home

A cleverly designed basement can offer you:

- A quiet bedroom
- An office space or workshop
- A spacious playroom
- A sauna
- Storage rooms or
- Party room

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

## 4. Applications

During the extrusion process of the Styrodur® C boards, a clean compressed foam membrane emerges on the surface of the board.

The surfaces have to be rough-textured in order to guarantee better adhesive properties of gluing mortar, plaster or other mortars used in e. g. base insulation. Styrodur® 2800 C comes with thermally induced stamping (honeycomb) thus guaranteeing good adhesive properties for all sorts of plaster and concrete.

PRO KELLER

The "Initiative Pro Keller e.V." (Pro-basement Initiative) provides information about the advantages of reconstructing your basements as well as comprehensive information material to download from their website:
**www.prokeller.de**

A professional building insulation is the premise for installing Styrodur® C in perimeter insulation. Depending on the exposure to moisture, basement insulations are categorized according to the German DIN 18195 norm into different loading conditions.

## 4.1 Thermal Insulation Layer

For horizontal as well as vertical surfaces, Styrodur® C boards are slotted tightly in order to guarantee a conjoined installation **(Fig. 5)**. To avoid cold bridges the use of boards with shiplapped edges is especially advisable. The insulation layer provides the necessary heat insulation of the construction and protects the sealing.

**Fig. 5:** Conjoined installation of Styrodur® C boards.

## 4.2 Perimeter Insulation of Walls

Walls that reach into the ground can be made from concrete, waterproof concrete or plastered brickwork. Elements that are permeable to water have to be sealed off with a construction sealing according to the German DIN 18195 norm. The execution of such measures depends on the level of exposure to moisture.

Perimeter insulation cannot replace a solid construction sealing. Walls out of waterproof concrete can be insulated without any prior treatment. Before the covering of the building pit the Styrodur® C boards have to be secured so they will not shift or dislocate, which is usually done by gluing them to the sealed-off walls. Moreover, the insulation boards have to stand on compact ground e. g. the ledge of the foundation **(Fig. 6)**.

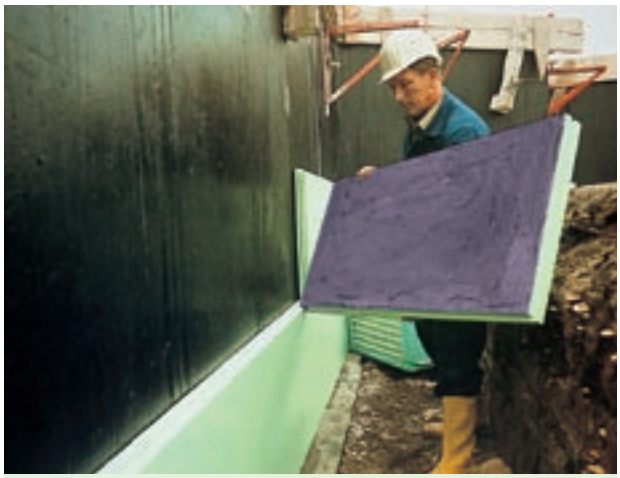


**Fig. 6:** Attaching the Styrodur® C boards to the outside of the basement wall.

Gluing the boards onto the waterproof concrete is a temporary adhesion to keep the insulation boards in position before the covering of the building pit. In order to avoid the impact of shear stress to the construction sealing during the covering, the insulation boards should be glued on extensively. Construction sealing and adhesive products have to harmonize in their chemical and physical characteristics and chosen properly for the particular application.

For bitumen sealing or such using bitumen sheets it is advisable to use e. g. solvent-free two-component adhesives on a bitumen-concrete basis or solvent-free epoxy glue.

You should avoid pressing the insulation boards into the not yet dry bitumen sealing for the following reasons:

- When pressing the boards into the sealing, parts of it could come off and the density of the sealant can no longer be guaranteed.
- Many times solvents on a cold bitumen basis are used which contain components that can damage the insulation material. When working with cold bitumen sealing it is advisable to grant a week of flash-off time before attaching the insulation boards.

For the use of waterproof concrete one could also use construction adhesive on a dispersion basis.

You can get further information about the right adhesive at your local hardware store or directly from the manufacturer.

## 4.3 Attaching and Aligning

On base points **(Fig. 7)** e. g. the bottom of the perimeter insulation, Styrodur® C boards should be attached in a way as to avoid shifts caused by the sinking of the ground.

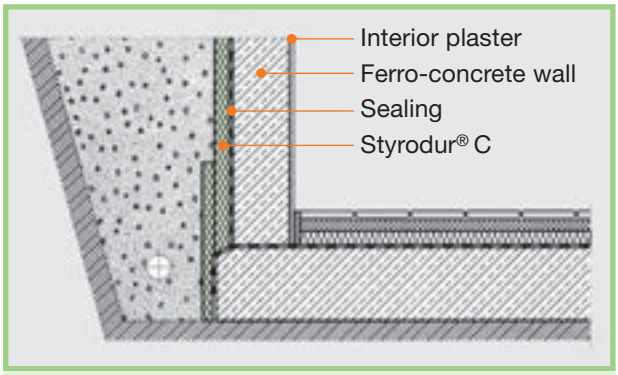



**Fig. 7:** Base point of the perimeter insulation.
The Styrodur® C board is sitting on the foundation.

The insulation should also be free of cold bridges around the window areas **(Fig. 8)**, which is why the lintels and reveals have to be insulated as well. Light wells have to be arranged in a way as to not break into the perimeter insulation and avoid cold bridges.

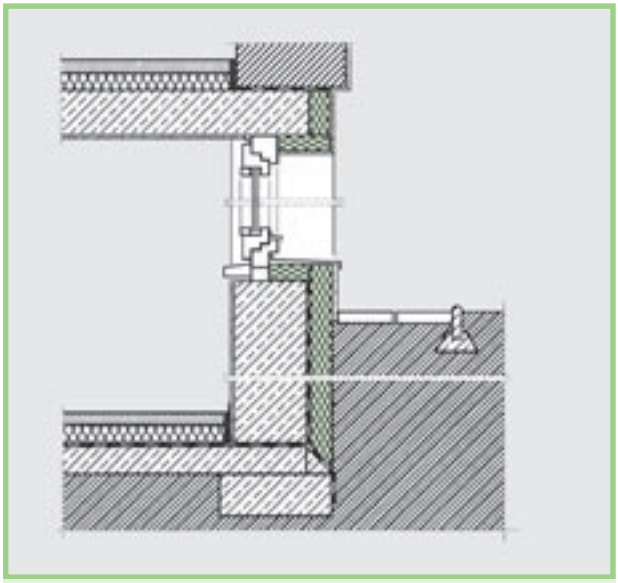


**Fig. 8:** Insulation of window area, free of cold bridges.

Examples of pre-constructed light wells made from concrete or plastic are seen in **Figs. 9** and **10**.

It is advisable to construct the light well separately from the building, that way you can avoid cold bridges and the breadth of the light well is modifiable. This could be done with a light well made from pre-fabricated concrete elements, which are to be laid on a gravel pit, in connection with the perimeter insulation **(Fig. 9)**.

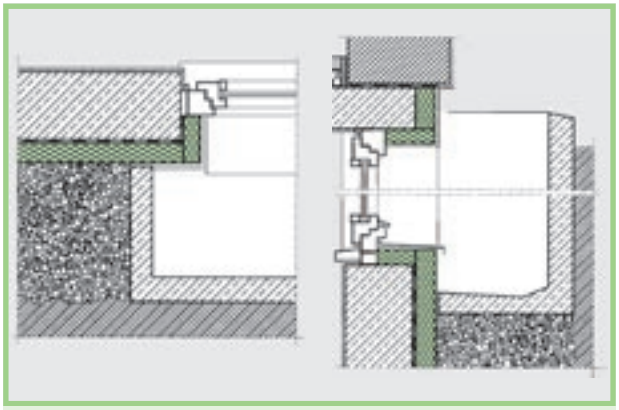


**Fig. 9:** Attachment of a concrete light well, free of cold bridges.

Another valid option is the use of a plastic light well, which is connected with the basement wall by bolts or screws interpenetrating the insulation **(Fig. 10)**.

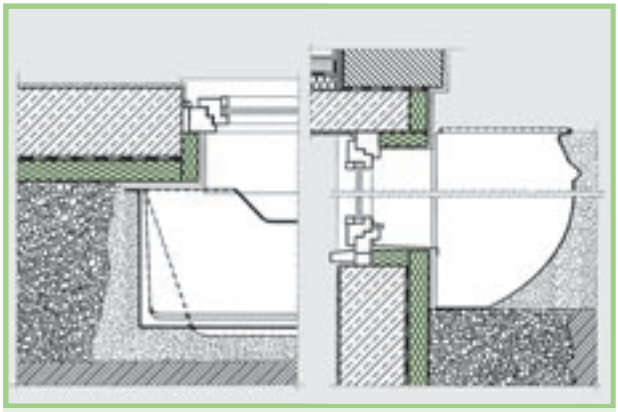


**Fig. 10:** Attachment of a plastic light well, free of cold bridges.

## 4.4 Base Insulation

Insulation is also necessary for the base area of your basement between the upper edge of the ground and the above-grade masonry **(Fig. 11)** or the external thermal insulation composite system **(Fig. 12)**. For applications above the ground it is advisable to use Styrodur® 2800 C boards with honeycomb surface if you plan to plaster the surfaces.

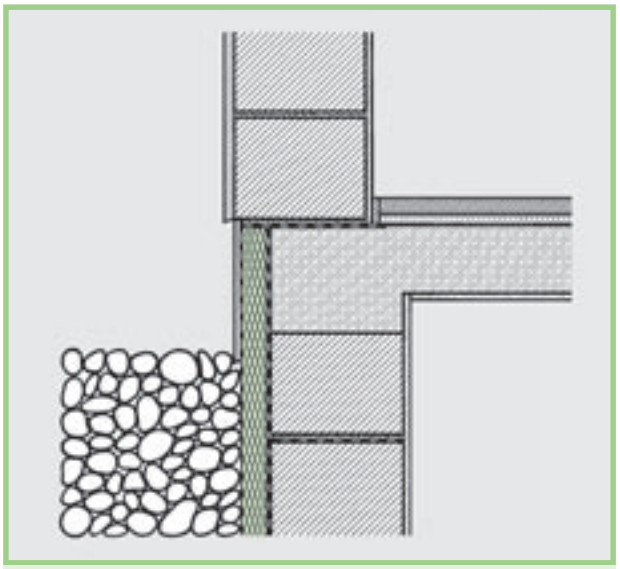


**Fig. 11:** Base course, perimeter insulation with heat insulating above-grade masonry.

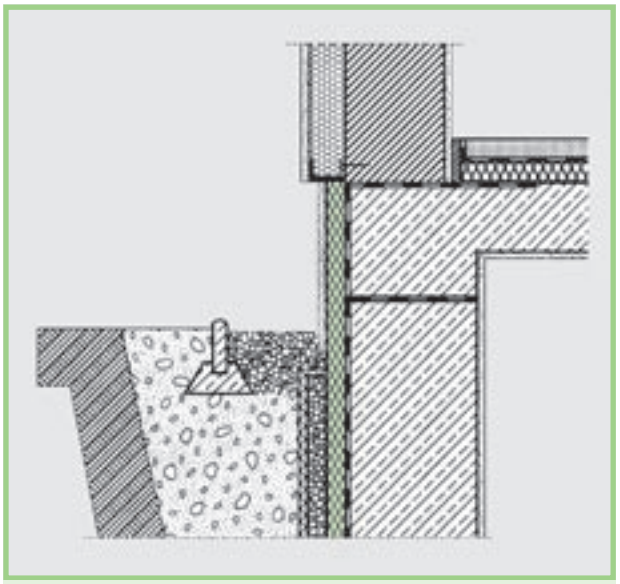


**Fig. 12:** Base course, perimeter insulation with external thermal insulation composite system.

At the base course the boards are to be attached to the external wall with construction adhesive. Once the glue has hardened the boards have to be doweled using four insulation anchors per board **(Fig. 13)**. The diameter of the anchor's heads should be at least 60 mm.

Styrodur® C types with foam membrane are not suitable for plastering.

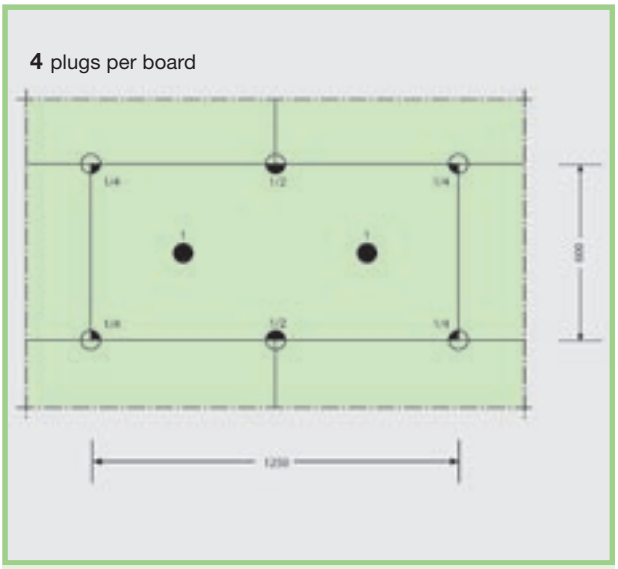



**Fig. 13:** Alignment and number of wall plugs (four per board) for a subsequent base installation of Styrodur® C boards (units in mm).

## 4.5 Installation into Formwork

When constructing a basement with waterproof concrete, the perimeter insulation can also be fitted directly into the formwork and than be covered with concrete from both sides. This is not possible when using standard concrete, because the required sealing cannot be guaranteed. To cover the insulation with concrete only Styrodur® 2800 C boards with thermal stamping are suitable **(Fig. 14)** since their surface provides the perfect adhesion for the concrete.

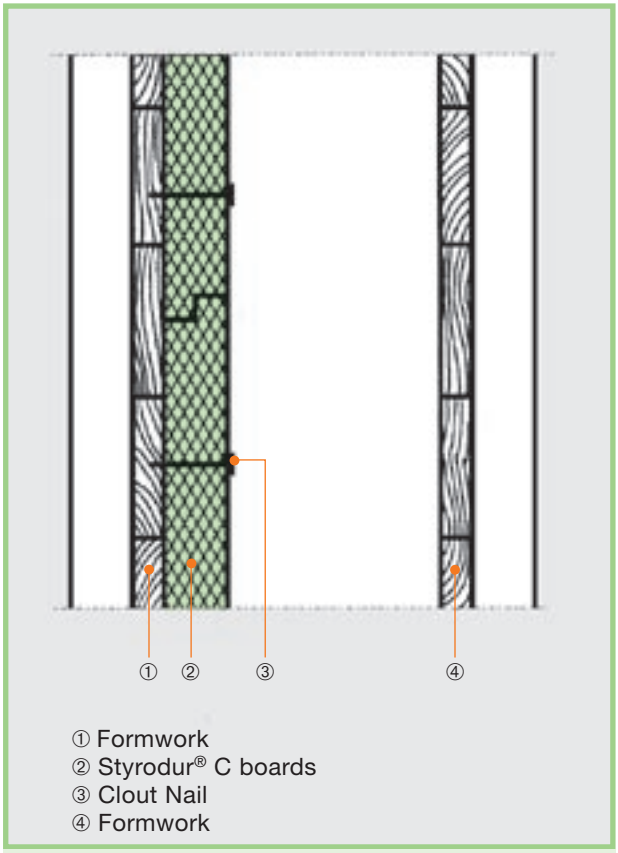



**Fig. 14:** Installation into formwork and fixation of the Styrodur® 2800 C boards with clout nails.

The boards are fitted directly into the formwork. In wooden formwork the Styrodur® 2800 C boards can be fixed with clout nails. In case of a steel formwork other suitable measures for fixation have to be found to make sure that the boards do not shift or come loose during the filling of the concrete or during the compressing process. For sealing, fitting and stripping the forms of the concrete one has to consider the German DIN 1045-3 norm.

For the construction of strip foundations Styrodur® C boards can also be used as stay-in-place formwork. If the foundation is reinforced spacers should be used between the reinforcement and the insulation.

**Fig. 15:** Formwork with Styrodur® C.

**Fig. 16:** Styrodur® C boards installed into formwork.

## 4.6 Perimeter Insulation against the Ground

For horizontal perimeter insulation, the ground on which the Styrodur® C boards are to be laid has to be even and provide the necessary bearing capacity. Regarding the admissible load of the ground one has to take into account the German DIN 1054 norm. This goes for natural ground as well as for backfill. And even on a rock soil the surfaces on which the Styrodur® C boards are laid have to be formed in a way that allows the boards to lay flat and even. Allow for a concrete leveling course **(Fig. 17)**.

The concrete bedding has to be even. Take into account the German DIN 18 195 norm when planning the waterproofing. When installing the waterproofing **(Fig. 17)** consider the following: a bitumen membrane whose slabs need to be glued with hot bitumen cannot be laid directly onto the Styrodur® C layer, since it causes the Styrodur® C to melt.

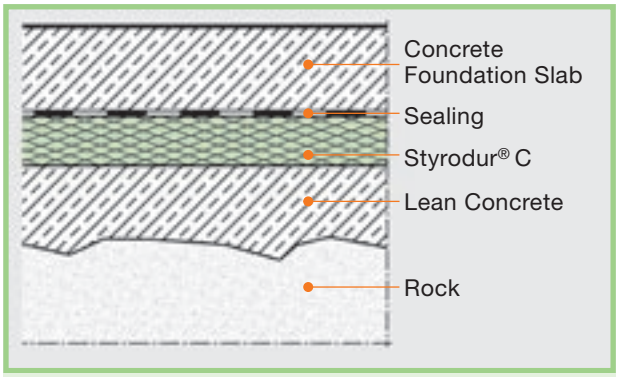



**Fig. 17:** Leveling course made from lean concrete on a rock ground.

**Fig. 18:** Blinding layer made from lean concrete for the installation of ground insulation.

Using solvent-containing cold bitumen is not advisable since the solvent will destroy the Styrodur® C. Suitable materials would be membranes, which can be connected either by gas welding or solution welding. We especially recommend ECB membranes (Ethylene Copolymer Bitumen). PVC membranes containing plasticizer cannot be used with Styrodur® C.

Consider the following when installing the waterproofing above the concrete foundation slab: lay a polyethylene sheet between the Styrodur® C and the concrete foundation slab in order to avoid the grout seeping into the grooves of the Styrodur® C boards.

In order to secure the structural steel reinforcements, which are installed separately on the top and bottom side, spacers need to be used. Those spacers can be made from structural steel or from prefabricated concrete- or plastic units. The reinforcement is applied upon the spacers **(Figs. 19 and 20)**. There is no contact with the polyethylene sheet and only little danger of the sheet being perforated.

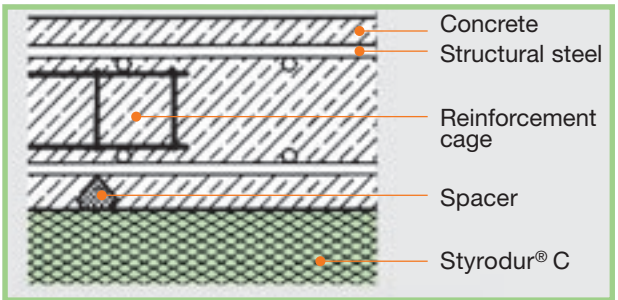



**Fig. 19:** Accessible spacer made from fiber reinforced concrete for the bottom reinforcement, and reinforcement cage made from wire fabric for the upper reinforcement of the foundation slab.

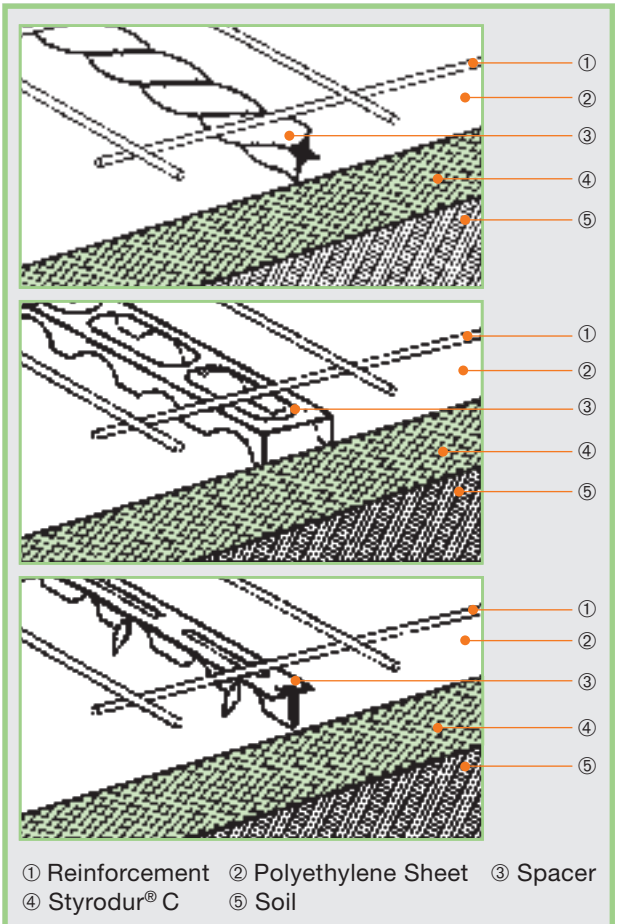



**Fig. 20:** Accessible plastic spacer for horizontal reinforcement. The height of the concrete cover is predetermined by the height of the profile.

## 4.7 Perimeter Insulation of Structural Supporting Components

Foundations can be fitted with Styrodur® C boards to provide heat insulation and protect against frost thus avoiding the penetration of frost below the foundation slabs even for shallow foundations of heated buildings **(Figs. 21, 22 and 23)**.

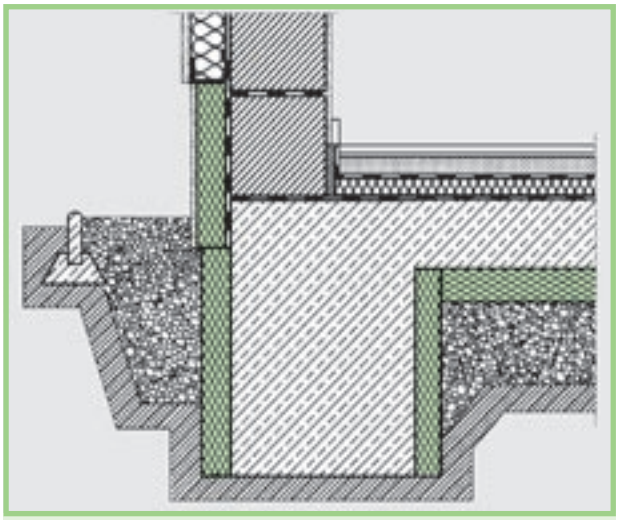


**Fig. 21:** Insulation of the foundation connected to the external thermal insulation composite system.

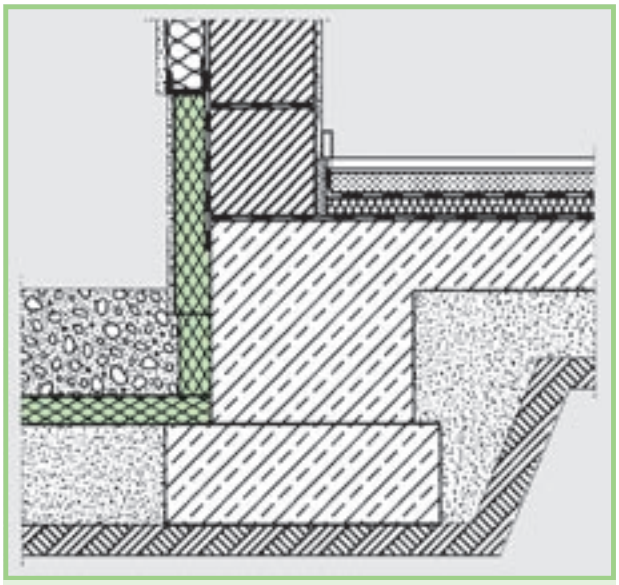


**Fig. 22:** Possibilities of insulating the foundation against subgrade frost.

Styrodur® C can also be used as a load bearing thermal insulation below foundation slabs, where it meets every requirement of thermal insulation: high compressive strength as well as resistance to decay and moisture.

Styrodur® C is used as thermal insulation below load bearing foundation slabs according to Approval number Z-23.34-1325 and constitutes state of the art technology. When dimensioning and implementing thermal insulation in order to protect the foundation against frost heaves, consider the DIN EN ISO 13 793 norm.

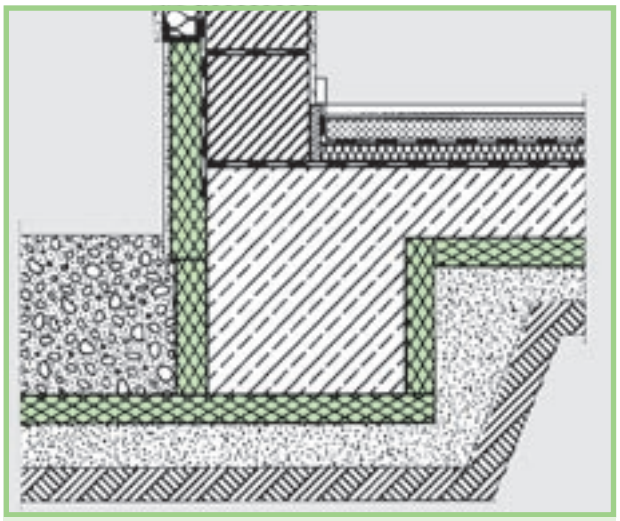


**Fig. 23:** Even the use of Styrodur® C boards below load bearing construction parts is state of the art.

Foundation slabs made from steel concrete become more and more popular when it comes to the construction of homes and office buildings. In order to avoid cold bridges it is advisable to lay Styrodur® C boards under the whole area of the foundation slab.

The above-grade perimeter insulation of the basement wall is directly attached to it – also free of cold bridges. That gives you the extra advantage of the basement and foundation slab being completely i. e. all the way round, covered with insulation. Consider the following points when using Styrodur® C as load bearing thermal insulation below foundation slabs:

- Styrodur® C is to be installed as a single layer
- Styrodur® C boards are to be conjoined avoiding cross joints
- Styrodur® C can be laid up to 3.5 m into the groundwater

Styrodur® C is to be laid onto a blinding layer (e. g. B5 concrete) or a compressed and even layer of gravel sand. The ground has to be even in order to guarantee the contact of the boards over the entire surface. A protection layer e. g. a polyethylene sheet is to be laid on top of the Styrodur® C thermal insulation in order to keep the grout from seeping into the grooves of the Styrodur® C boards.

Lohr Elemente E. Schneider GmbH from Gemünden (Germany) offers prefabricated elements of Styrodur® C for the production of round formwork for foundation slabs and anti frost heave constructions. For such an application the thermal insulation is extended into the ground beyond the foundation slab to prevent frost heaves below the foundation.

www.lohrelement.de

## Static Requirements

Any static load may only be applied vertically onto the Styrodur® C boards. Shear stress is to be avoided. The approved compressive strengths are as follows:

- Styrodur® 3035 CS - $\sigma$ appr. = 0.13 N/mm²
- Styrodur® 4000 CS - $\sigma$ appr. = 0.18 N/mm²
- Styrodur® 5000 CS - $\sigma$ appr. = 0.25 N/mm²

Considering the construction physics, one has to consider installing a vapor barrier onto the warm side i. e. the top side of the Styrodur® C board depending on the intended room temperature. The vapor barrier will stop the diffusion current of the vapor going from the inside of the building into the ground thus avoiding condensate on the insulation material.

**Index 1:** Required compressive strengths of the thermal insulation for load bearing construction elements.

| | Properties | | Unit | Styrodur® 3035 CS | Styrodur® 4000 CS | Styrodur® 5000 CS |
|---|---|---|---|---|---|---|
| $\sigma_D$ | Compressive strength or compressive stress at 10 % deformation, DIN EN 826 | | kPa | 300 | 500 | 700 |
| $\sigma_K$ | Short-term modulus of elasticity, DIN EN 826 | | N/mm² | 20 | 30 | 40 |
| $\sigma_{D,50}$ | Permitted long-term compressive creep (compression < 2 %, 50 years), DIN EN 1606 | | kPa | 130 | 180 | 250 |
| $\sigma_L$ | Long-term modulus of elasticity (50 years), DIN EN 1606 | | N/mm² | 6.5 | 9 | 12.5 |
| $K_L$ | Long-term modulus of elasticity (50 years), DIN EN 1606 | 50 mm | N/mm³ | 0.13 | 0.18 | 0.25 |
| | | 60 mm | | 0.11 | 0.15 | 0.21 |
| | | 80 mm | | 0.08 | 0.11 | 0.16 |
| | | 100 mm | | 0.07 | 0.09 | 0.13 |
| | | 120 mm | | 0.05 | 0.08 | – |
| $\sigma_{zult}$ | Permitted long-term compressive creep for applications below load bearing foundation slabs[1] | | kPa | 130 | 180 | 250 |
| $C_{dyn}$ | Dynamic stiffness depending on thickness of board, DIN EN 29 052: | 50 mm | MN/m³ | 320 | 340 | 360 |
| | | 60 mm | | 260 | 280 | 300 |
| | | 80 mm | | 190 | 210 | 230 |
| | | 100 mm | | 150 | 170 | 190 |
| | | 120 mm | | 130 | 150 | – |

[1] Approval number Z-23.34-1325 DIBt

## 4.8 Drainage

There is no need for a drainage system in order to protect the perimeter insulation. Only in exceptional cases e. g. a waterproof soil horizon or the building being situated on a slope is it advisable to install a drainage system in addition to the thermal insulation in order to drain surface- and seepage water. In such cases, according to German DIN 4095 norm, it is necessary to install a complete drainage system consisting of a wall drainage system, drainage pipes, a gravel bed, geotextile, inspection shafts and a connection to the sewage system or a receiving water course. The installation of insulating drainage slabs alone will not suffice.

**Fig. 24** shows the construction of such a drainage system.

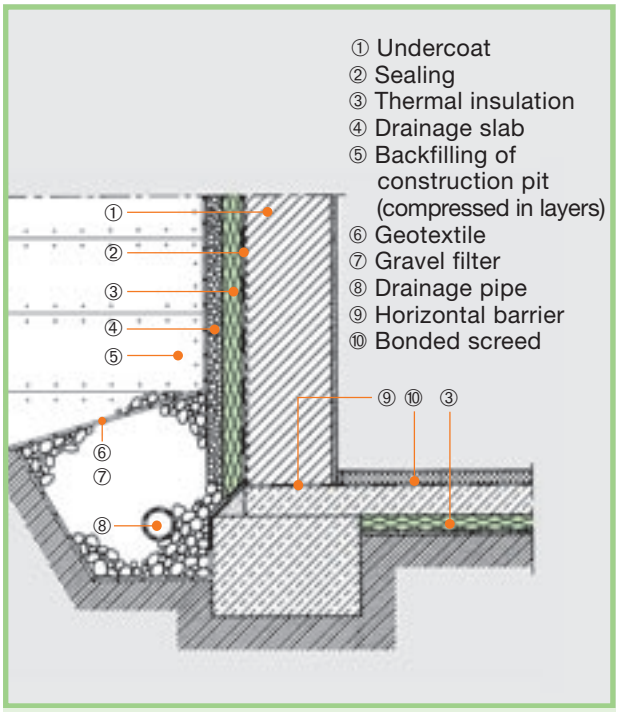



**Fig. 24:** Structure of perimeter insulation in combination with drainage.

## 4.9 Perimeter Insulation against Pressing Water

According the DIBt's Approval number Z-23.5-223, Styrodur® C boards can also be used in cases of consistent or long time exposure to pressing water (groundwater) with the installation of the boards being permitted up to 3.5 m into the ground. However, the building's sealing must not be limited in its functionality due to the insulation layer. The building's sealing is to be installed according to Part 6 of the German DIN 18195 norm.

The Styrodur® C boards have to be slotted tightly in order to secure a conjoined installation i. e. the whole surface of the boards as well as the edges have to be covered with adhesive **(Fig. 25)**. Make sure to use adhesives suitable for applications in pressing water. After the installation of the Styrodur® C boards, the grooves have to be additionally plastered in order to keep the groundwater from seeping in. To make sure the anti-buoyancy measures you have taken are sufficient check the following factors:

- When installing the Styrodur® C boards, the whole surface is covered with adhesive.
- For boards of a maximum thickness of 120 mm, the highest level of the groundwater below the top ground surface is 1 m.
- For boards of a maximum thickness of 80 mm, the highest level of the groundwater below the top ground surface is 0.5 m.
- You have taken up constructive anti-buoyancy measures e. g. base insulation measures in **Figs. 11** and **12**.

There is no need for any extra anti-buoyancy measures in constructions with "white" i. e. impermeable concrete. The groundwater can come all the way up to the top ground surface. Styrodur® C can be installed in grounds permeable to water as well as in groundwater areas with no extra drainage slabs. For installations in groundwater it will be necessary to glue the insulation boards over their entire surface.


**Fig. 25:** Adhesion of Styrodur® C boards (full surface & edges) and plastering of the grooves for boards installed in groundwater.

## 4.10 Backfilling of Construction Pit

Styrodur® C boards need no additional protective coating for the professional backfilling of a construction pit. Sporadic minor damages to the boards' surface do not interfere with the functionality of the perimeter insulation. Make sure, that deformations of the ground caused by the backfill as well as a possible ground subsidence do not cause any damaging shear stress to the buildings sealing (glue entire surface of thermal insulation board, care for solid ground at the base point, blinding layer etc.).

**Fig. 26:** Backfilling of construction pit in layers and mechanical sealing.

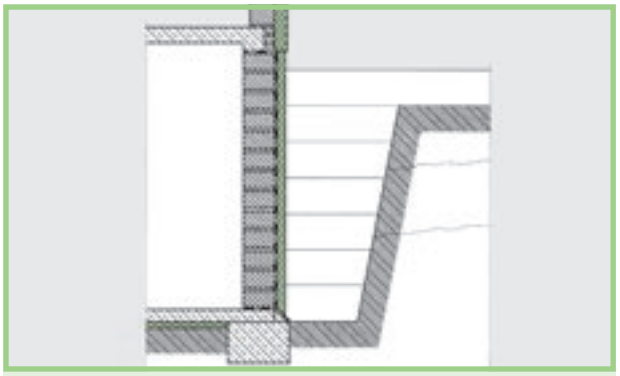


**Fig. 27:** Backfilling of construction pit in layers.

## 4.11 Energetic Perimeter Reconstruction: Frost Protection

Nowadays, a growing number of buildings without basements are built on raft foundations rather than strip foundations without considering the appropriate frost protection of the base. During the winter, temperatures beneath the foundation can drop below zero, creating ice lenses and frost heaves depending on the condition of the soil. Those can cause severe damages to the construction. The penetration of the frost into the floor slab can be avoided with the subsequent installation of a so-called "frost-protection layer" i. e. the laying of a horizontal thermal insulation surrounding the complete building, approx. 30 cm below the ground. If the ground is covered with a set paving, 20 cm below the ground should suffice.

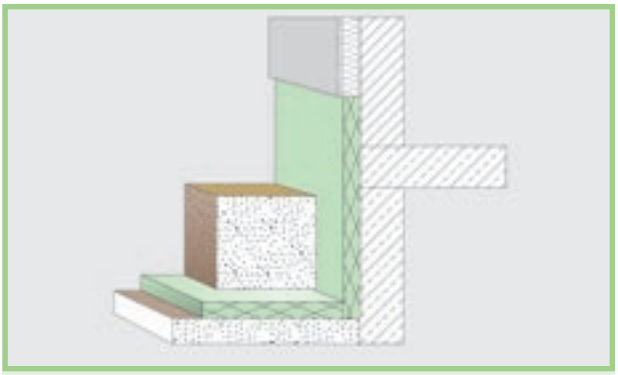


**Fig. 28:** The frost protection layer is put into the ground below the frost line.

## 4.12 The Passive House

According to DIBt's Approval number Z-23.34-1325, extruded foam insulation boards are to be installed in one layer limited to a thickness of 120 mm. For a more trendsetting and energy-saving heat insulation as is state of the art e. g. in passive houses, thicker insulation boards are needed. For load bearing thermal insulation systems, it is just as state of the art and has been approved by numerous County Building Authorities to install Styrodur® C boards in two layers given that the boards are installed on a solid blinding layer e. g. B5 concrete. Any shifting movements of the boards as well as the possibility of water leaking in between them will be avoided by the load of the building's foundation slab. However, the extruded foam insulation boards may only be stressed vertically against the foundation. Any shear pressure is prohibited. Avoid butt joints when installing the thermal insulation boards and install a protective layer e. g. a polyethylene sheet between the top insulation layer and the foundation slab.

**Fig. 29:** Installation of Styrodur® C boards during the construction of a passive house.

## 5. Construction Aids

### 5.1 Dimensioning: Temperature Dependence

Requirements regarding the heat insulation of heated living areas whose construction parts are in direct contact with the ground are very high (see **Index 2**). According to Part 2 of the German DIN 4108 norm (issue 3/01), the required minimum heat insulation for exterior walls adjacent to the ground constitutes a surface coefficient (R-value) of 1.2 $m^2$·K/W which equals a thermal transmission coefficient (U-value) of 0.75 W/($m^2$·K). For the bottom floor of living areas without basement i. e. adjacent to the ground, a minimum surface coefficient of 0.9 $m^2$·K/W is required which equals a U-value of 0.93 W/($m^2$·K). If the building's thermal insulation is calculated according to specifications of the German Energy Savings Ordinance (EnEV) those values are not to be exceeded. Those requirements are fully met by the example structures shown in **Index 3**.

**Index 2:** Minimum thermal insulation according to Article 2, DIN 4108, issue 3/01 – Requirements –

| Construction elements bordering the ground | Surface coefficient [$m^2$·K/W] R | Thermal transmission coefficient [W/($m^2$·K)]U-value |
|---|---|---|
| Wall | 1.20 | 0.75 |
| Floor | 0.90 | 0.93 |

**Index 3:** Minimum thermal insulation according to Article 2, DIN 4108, issue 3/01 – Examples –

| Construction | | U-value [W/($m^2$·K)] | | Thickness of insulation layer [mm] | |
|---|---|---|---|---|---|
| Thickness [mm] | Material | Whithout insulation | Whith insulation | $\lambda$ = 0.035 [W/(m·K)] | $\lambda$ = 0.040 [W/(m·K)] |
| 300 | Concrete wall | 3.7 | < 0.75 | 40 | 50 |
| 20 | Exterior plaster | 1.8 | < 0.75 | 30 | 40 |
| 365 | Sand-lime brick KSL-12-1, 8-12 DF | | | | |
| 15 | Interior plaster | | | | |
| 20 | Exterior plaster | 1.8 | < 0.75 | 30 | 40 |
| 300 | Solid brick Mz-12-1, 8-5 DF | | | | |
| 15 | Interior plaster | | | | |
| 20 | Exterior plaster | 2.0 | < 0.75 | 30 | 40 |
| 300 | Concrete block Hbn-12-1, 8-20 DF | | | | |
| 15 | Interior plaster | | | | |
| 120 | Concrete floor | 4.4 | < 0.93 | 30 | 40 |

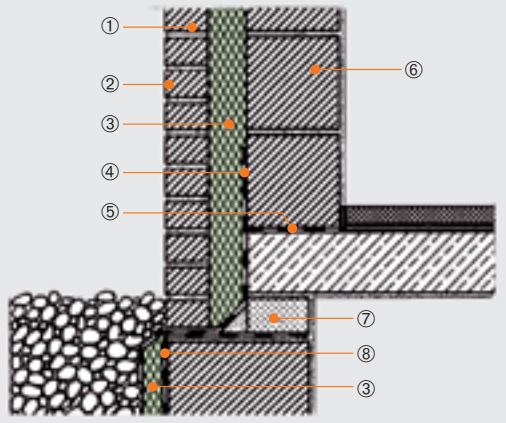



**Fig. 30:** Perimeter insulation connected to brickwork with cavity wall insulation.

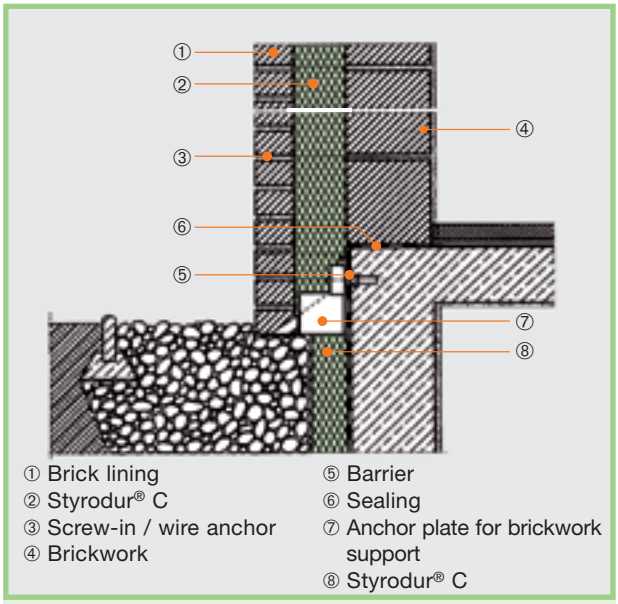



**Fig. 31:** Perimeter insulation connected to brickwork with cavity wall insulation and anchor plate for brickwork support.

With the "Thermal Insulation Ordinance" of 1994 a simplified verification procedure for buildings with up to two floors and no more than three apartments came into effect. The new Ordinance requires a U-value of at least 0.35 W/(m²·K) for all basement floors and walls as well for any basement ceiling that is insulated against the unheated basement. **Index 4** indicates the values as Surface coefficient (R-value) and thermal transmission coefficient (U-value). Those requirements are met by the constructions shown in **Index 5**. The main objective of the EnEV is to reduce energy consumption by 30 % compared to the 3rd "Thermal Insulation Ordinance". Therefore, we recommend a U-value of ≤ 0.3 W/(m²·K) for all basement walls bordering the ground. One should also consider perimeter insulation for unheated basements.

Subsequent exterior basement insulation requires an immense amount of time and work, which leaves us with interior insulation as the only choice. In rooms with exterior walls bordering the ground, ventilation of cold basements with humid and warm summer air bears the dangers of condensate on the inside surfaces of exterior walls. The dew-point temperature of the warm and humid summer air might be higher than the temperature of the basement wall's inside surface, which can lead to the formation of condensate on the inside surface of the exterior wall and consequently to the formation of mildew and a generally moldy scent. A solid thermal insulation of the wall also provides for improvements concerning the building's protection against moisture.

**Index 4:** Minimum thermal insulation according to the 3rd Thermal Insulation Ordinance of August 1994
– Requirements –

| Construction elements bordering the ground | Surface coefficient* [m²·K/W] R | Thermal transmission coefficient [W/(m²·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 surface coefficients may come up for the same thermal transmission coefficient.

**Index 5:** Minimum thermal insulation according to the 3rd Thermal Insulation Ordinance of August 1994
– Examples –

| Construction | | U-value [W/(m²·K)] | | Thickness of insulation layer | |
|---|---|---|---|---|---|
| Thickness [mm] | Material | Without insulatin | With insulation | λ = 0.035 [W/(m·K)] | λ = 0.040 [W/(m·K)] |
| 300 | Concrete wall | 3.7 | < 0.35 | 90 | 110 |
| | | | < 0.3[1)] | 110[1)] | 130[1)] |
| 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 | | | | |
| 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 | | | | |
| 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 | | | | |
| 120 | Concrete floor | 4.4 | < 0.35 | 100 | 110 |
| | | | < 0.3[1)] | 110[1)] | 130[1)] |

[1)] Recommendation for EnEV

## 5.2 Dimensioning: Dependence of Moisture

In perimeter insulation, the exterior thermal insulation of Styrodur® C basically works as a vapor barrier against vapor diffusion because the resistance to water vapor diffusion of the respective layers decreases from the inside towards the outside layer. The surface coefficient however, increases from the inside towards the outside layer. The exterior thermal insulation layer proves also advantageous regarding the protection against condensate because the temperature of the wall's interior surface rises as opposed to the non-insulated construction elements.

The danger of condensate forming on the wall's interior surface is very small. Indexes 5 and 6 show that in buildings with perimeter insulation with a U-value of ≤ 0.35 W/(m²·K), condensate will not form until a relative humidity of over 90 % is reached.

**Index 6:** Avoiding condensate on basement walls with room temperatures of 20 °C.

| Relative humidity [%] | Recommended board thickness [mm] for outside temperatures of | |
|---|---|---|
| | – 10 °C | – 15 °C |
| 60 | 20 | 30 |
| 70 | 30 | 40 |
| **80** | **50** | 60 |
| **90** | **100** | 120 |

## 5.3 Choice of Type according to Mounting Depth

The deeper the thermal insulation boards are installed the higher the compressive stress. Styrodur® C boards have been approved for such high long-term compressive stress that there are no limits as to the maximum mounting depth. However, for higher mounting depths, we do recommend the use of those Styrodur® C types with higher compressive strength. Index 7 shows the approved mounting depths of the various Styrodur® C types for the most unfavorable case "soil pressure with silt sand".

**Index 7:** Long-term compressive strength and maximum mounting depth of various Styrodur® C types

| Styrodur® C type | 3035 CS | 4000 CS | 5000 CS |
|---|---|---|---|
| Permitted long-term compressive stress 50 years/ 23 °C, kPa deformation ≤ 2% | 130 | 180 | 250 |
| **Maximum mounting depth [m]** | **12** | **17** | **24** |

**Note:**
The information submitted in this publication is based on our current knowledge and experience and is referring only to our product and its properties at the time of going into print. It does not imply any warranty or any legally binding assurance about the condition of our product. Attention must be paid to the demand of specific applications, especially the physical and technological aspects of construction and building regulations. All mechanical drawings are basic outlines and have to be adapted to each application.

## 6. Technical Data Styrodur® C

| Property | Unit[1] | Code according to DIN EN 13164 | 2500 C | | 2800 C | | 3035 CS | | 3035 CN | | 4000 CS | | 5000 CS | | Standard |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Edge profile | | |  | |  | |  | |  | |  | |  | | |
| Surface | | | skin | | embossed | | skin | | skin | | skin | | skin | | |
| Length x width | mm | | 1250 x 600 | | 1250 x 600 | | 1265 x 615 | | 2515 x 615[4] | | 1265 x 615 | | 1265 x 615 | | |
| Density | kg/m³ | | 28 | | 30 | | 33 | | 30 | | 35 | | 45 | | DIN EN 1602 |
| Thermal conductivity<br>Thermal resistance | $\lambda_D$ [W/(m·K)]<br>$R_D$ [m²·K/W] | | $\lambda_D$ | $R_D$ | $\lambda_D$ | $R_D$ | $\lambda_D$ | $R_D$ | $\lambda_D$ | $R_D$ | $\lambda_D$ | $R_D$ | $\lambda_D$ | $R_D$ | DIN EN 13164 |
| Thickness | 20 mm | – | 0.032 | 0.65 | 0.032 | 0.65 | – | – | – | – | – | – | – | – | |
| | 30 mm | – | 0.032 | 0.95 | 0.032 | 0.95 | 0.032 | 0.95 | 0.032 | 0.95 | 0.032 | 0.95 | – | – | |
| | 40 mm | – | 0.034 | 1.25 | 0.034 | 1.25 | 0.034 | 1.25 | 0.034 | 1.25 | 0.034 | 1.25 | 0.034 | 1.25 | |
| | 50 mm | – | 0.034 | 1.50 | 0.034 | 1.50 | 0.034 | 1.50 | 0.034 | 1.50 | 0.034 | 1.50 | 0.034 | 1.50 | |
| | 60 mm | – | 0.034 | 1.80 | 0.034 | 1.80 | 0.034 | 1.80 | 0.034 | 1.80 | 0.034 | 1.80 | 0.034 | 1.80 | |
| | 80 mm | – | – | – | 0.036 | 2.30 | 0.036 | 2.30 | 0.036 | 2.30 | 0.036 | 2.30 | 0.036 | 2.30 | |
| | 100 mm | – | – | – | 0.038 | 2.80 | 0.038 | 2.80 | – | – | 0.038 | 2.80 | 0.038 | 2.80 | |
| | 120 mm | – | – | – | 0.038 | 3.20 | 0.038 | 3.20 | – | – | 0.038 | 3.20 | – | – | |
| | 140 mm | – | – | – | – | – | 0.038 | 3.65 | – | – | – | – | – | – | |
| | 160 mm | – | – | – | – | – | 0.038 | 4.20 | – | – | – | – | – | – | |
| | 180 mm | – | – | – | – | – | 0.040 | 4.45 | – | – | – | – | – | – | |
| Compressive stress or compressive strength at 10 % deformation | kPa | CS(10\Y) | 150 – 200[2] | | 200 – 300[3] | | 300 | | 250 | | 500 | | 700 | | DIN EN 826 |
| Compressive creep over 50 years at < 2 % deformation | kPa | CC(2/1,5/50) | 60 – 80[2] | | 80 – 100[3] | | 130 | | – | | 180 | | 250 | | DIN EN 1606 |
| Certificated compressive stress under load bearing loor slabsDIBT | kPa | – | – | | – | | 130 | | – | | 180 | | 250 | | DIBT Z-23.34-1325 |
| Adhesive strength on concrete | kPa | TR 200 | – | | > 200 | | – | | – | | – | | – | | DIN EN 1607 |
| Shear strength | kPa | SS | > 300 | | > 300 | | > 300 | | > 300 | | > 300 | | > 300 | | DIN EN 12090 |
| Compressive modulus of elasticity | kPa | CM | 10,000 | | 15,000 | | 20,000 | | 15,000 | | 30,000 | | 40,000 | | DIN EN 826 |
| Dimensional stability 70 °C; 90 % r. h. | % | DS(TH) | ≤ 5 % | | ≤ 5 % | | ≤ 5 % | | ≤ 5 % | | ≤ 5 % | | ≤ 5 % | | DIN EN 1604 |
| Deformation behaviour: load 20 kPa; 80 °C | % | DLT(1)5 | ≤ 5 % | | ≤ 5 % | | ≤ 5 % | | ≤ 5 % | | ≤ 5 % | | ≤ 5 % | | DIN EN 1605 |
| Deformation behaviour: load 40 kPa; 70 °C | % | DLT(2)5 | ≤ 5 % | | ≤ 5 % | | ≤ 5 % | | ≤ 5 % | | ≤ 5 % | | ≤ 5 % | | DIN EN 1605 |
| Linear coefficient of thermal expansion<br>Longitudinal<br>Transverse | mm/(m·K) | –<br>– | 0.08<br>0.06 | | 0.08<br>0.06 | | 0.08<br>0.06 | | 0.08<br>0.06 | | 0.08<br>0.06 | | 0.08<br>0.06 | | DIN 53752 |
| Reaction to fire | Class | – | E | | E | | E | | E | | E | | E | | DIN EN 13501-1 |
| Long term water absorption by immersion | % v/v | WL(T)0.7 | 0.2 | | 0.3 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | | DIN EN 12087 |
| Long term water absorption by diffusion² | % v/v | WD(V)3 | 2 – 4 | | – | | 2 – 4 | | 2 – 4 | | 2 – 4 | | 2 – 4 | | DIN EN 12088 |
| Water vapour transmission[2] | | MU | 150 – 50 | | 200 – 80 | | 150 – 50 | | 150 – 100 | | 150 – 80 | | 150 – 100 | | DIN EN 12086 |
| Freeze-thaw-resistance | % v/v | FT2 | ≤ 1 | | ≤ 1 | | ≤ 1 | | ≤ 1 | | ≤ 1 | | ≤ 1 | | DIN EN 12091 |
| Maximum service temperature | °C | – | 75 | | 75 | | 75 | | 75 | | 75 | | 75 | | – |

[1] N/mm² = 1 MPa = 1.000 kPa [2] Dependes on thickness [3] Thickness ≤ 30 mm [4] Thickness 30 and 40 mm: 2510 x 610 mm

KTFS 0804 BE - ENGLISH VERSION - February 2008

# Information about Styrodur® C

- **Product brochure: Europe's green insulation**

- **Applications**

  **Basement Insulation**

  Load Bearing and Floor Insulation

  Wall Insulation

  Roof Insulation

  Ceiling Insulation

  Reconstruction and Refurbishment

- **Technical Data**

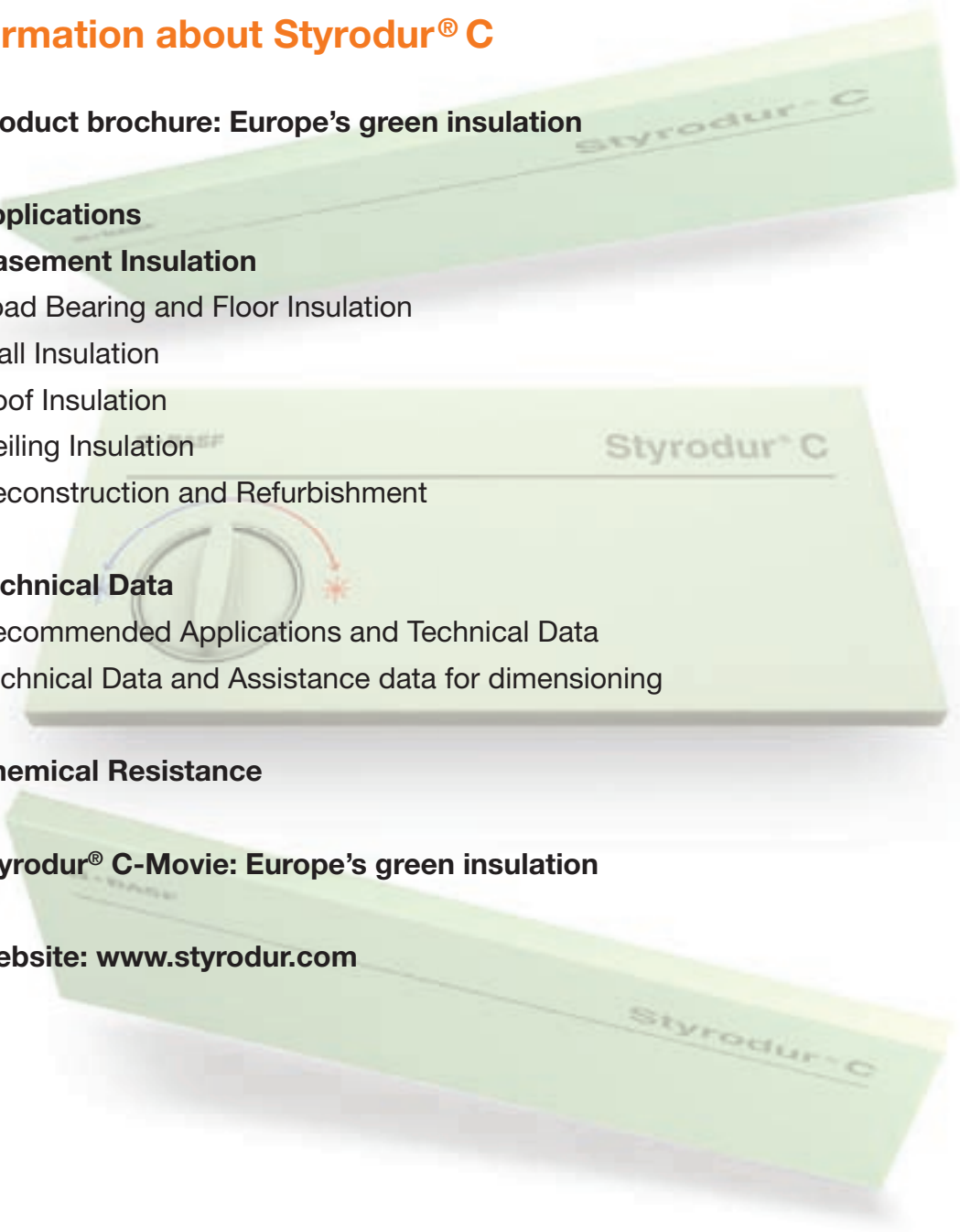
  Recommended Applications and Technical Data

  Technical Data and Assistance data for dimensioning

- **Chemical Resistance**

- **Styrodur® C-Movie: Europe's green insulation**

- **Website: www.styrodur.com**

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