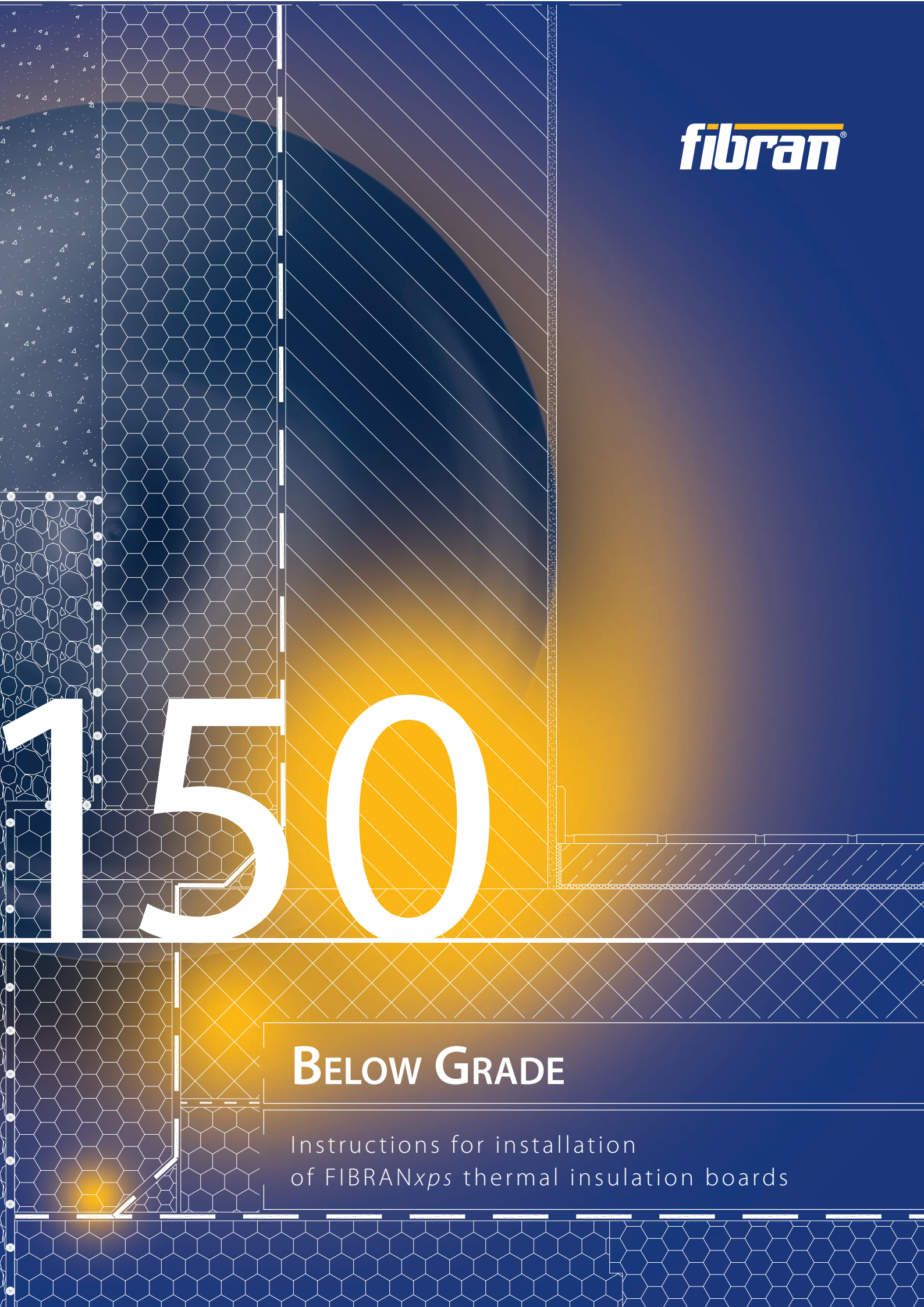
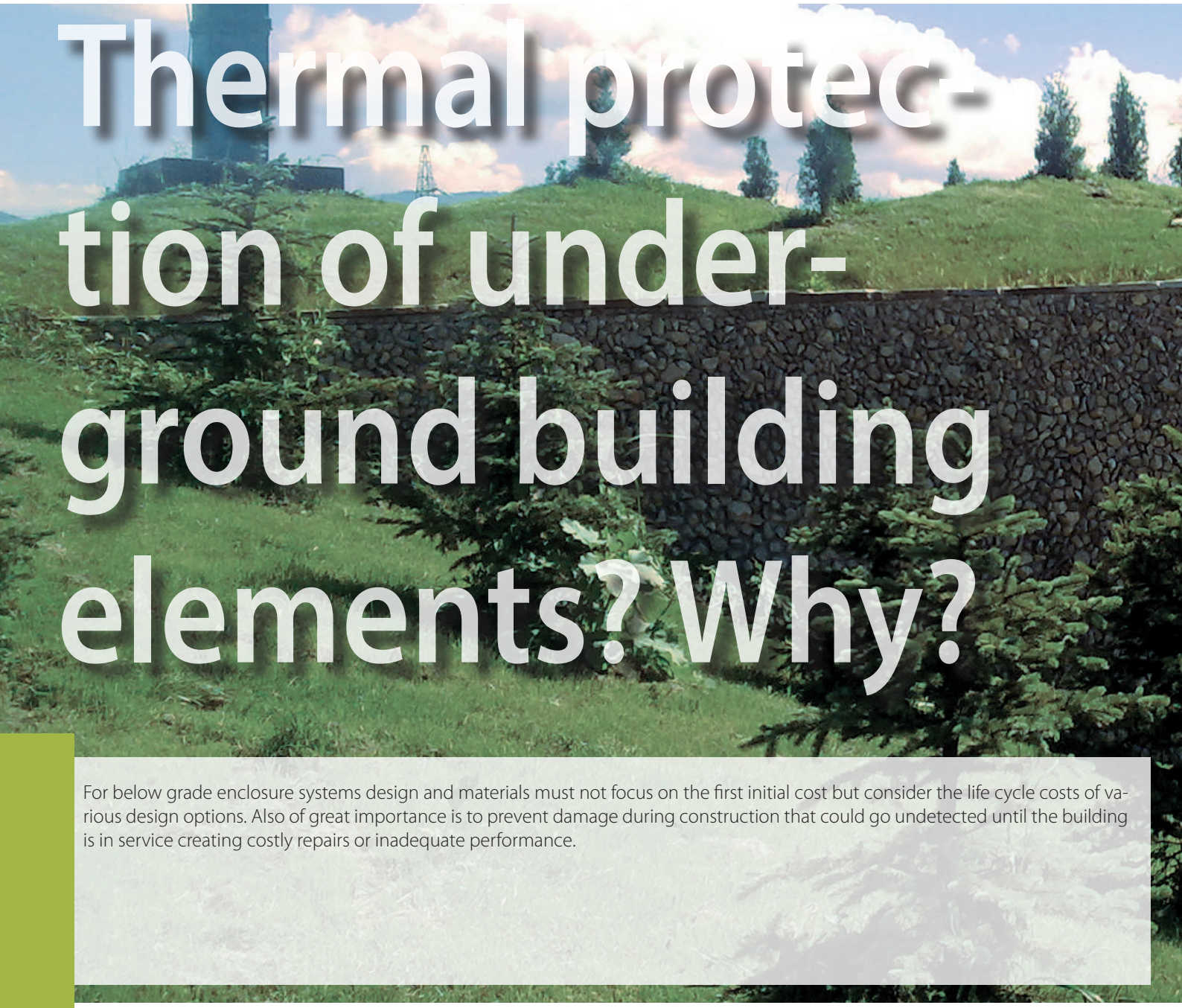


fibran®

150

Below Grade

Instructions for installation
of FIBRAN*xps* thermal insulation boards



Thermal protection of underground building elements? Why?

For below grade enclosure systems design and materials must not focus on the first initial cost but consider the life cycle costs of various design options. Also of great importance is to prevent damage during construction that could go undetected until the building is in service creating costly repairs or inadequate performance.

Thermal insulation of underground constructions:

- protects **heated spaces** against heat losses and ensures long-term living comfort;
- reduces temperature fluctuations in **cooled spaces**;
- protects **un-heated parts of buildings** against condensation, and consequently moulds;
- protects **waterproofing** against temperature fluctuations and against mechanical damage, thus ensuring its durability;
- provides **protection against frost** which could lead to swelling and sinking of the ground.

FIBRAN*xps* thermal insulation acts as an efficient ENERGY SHIELD of underground building elements.

FIBRAN*xps* thermal insulation boards are made of extruded polystyrene, with closed-cell structure, which, due to special building and physical characteristics (high compressive strength, excellent thermal insulation capacity and no moisture absorption) provide thermal insulation also in humid environment, where most other thermal insulation materials fail.

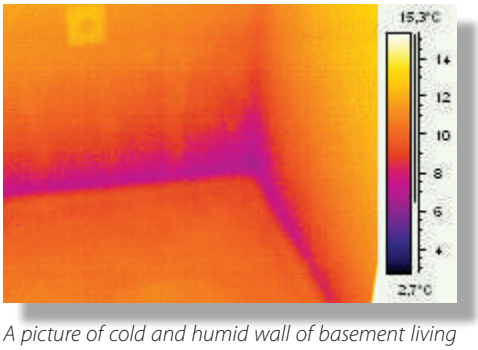
FIBRAN*xps* and waterproofing support each other:

- The building or the object must be protected against water intrusion with waterproofing,
- Waterproofing must be protected against mechanical damage and large temperature differences with solid and durable thermal insulation, which provides a long-lasting protection also in long-term humid environment.

A combination of waterproofing layer and FIBRAN*xps* thermal insulation boards provides durability and maintains thermal stability for constructions such as roofs, facade and basement walls, and the ground.

I. Protection of underground building elements against heat losses and humidification

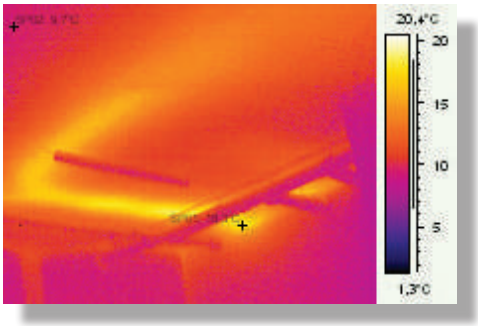
A space under the ground level with low quality waterproofing leads to many problems for builders and occupants. Remedial work, if possible at all, brings with it extremely high costs.



A picture of cold and humid wall of basement living space, taken with infrared camera (picture taken in cold space).

Visible moisture and health damaging mould on the wall.

If the waterproofing of walls is mechanically and thermally protected with water-repellent, solid boards with high thermal insulation performance, made of extruded polystyrene, such as FIBRAN*xps*, the properly installed waterproofing layer remains un-damaged, the basement spaces remain dry, and the thermally insulated wall maintains the temperature of the space, and provides comfortable living.



The picture taken with infrared camera shows thermal bridge on the ceiling and on the wall of the un-heated basement (picture taken in cold space).

Consequence: huge energy loss and non-comfortable living. In heated spaces above the cold basement condensate and mould are visible.

II. Protection of ground against frost

The stability of power-line columns, wind turbine columns and bridge constructions,which, besides being exposed to torsional, axial or bending loads, are also exposed to temperature fluctuations, depends on unchangeable load bearing capacity of foundation ground.

Thermally insulated ground around foundations ensures stability of constructions exposed to temperature fluctuations.

Freezing of marshy ground, soaked with water, causes damage on roads and sewage systems.

When frozen, a poorly drained ground increases in volume, and its swelling causes damages on roads, on constructions and decks with shallow foundations, and also threatens the stability of objects.

ENERGY **SHIELD OF UNDERGROUND CONSTRUCTIONS**

Thermal insulation of underground constructions is exposed to very demanding conditions, such as heavy, so-called useful loadings, passive and active earth pressures, constant moisture of the ground, long-term exposure to water and freeze-thaw cycles, and also to mechanical damaging during the building process. Under such conditions, the effective performance of most thermal insulations is reduced, but mostly, their original thermal insulating properties are lost.
XPS insulations are one of rare thermal insulations suitable for use in the ground. Rigid thermal insulation boards, with negligible moisture absorption, are manufactured by a special process of extrusion of foamed polystyrene, and maintain their designed building-physical properties also when utilised in humid ground.

XPS is one of the most economical and efficient thermal insulations in the ground, and that is why it is called ENERGY **SHIELD** of underground constructions.

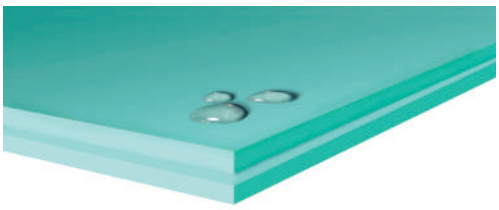
Why is it important to pay so much attention to insulation work of underground parts of objects during each construction phase?

- it is usually difficult to access underground parts of buildings at a later date,
- it is more demanding to correct errors at a later date,
- remedial work is very time consuming,
- remedial work may be a few times more expensive than properly installed insulation…

FIBRAN*xps* - durable efficient thermal insulation of underground constructions

Different types of thermal insulation boards are being manufactured under brand name FIBRAN*xps*, with different building-physical properties, depending on their intended use.

Thermal insulation boards intended for undergroud use and in humid environment have exceptionally high declared compressive strengths (from 300 to 700 kPa). FIBRAN*xps* thermal insulation boards are manufactured in rectangular form, with smooth water-repellent surface, with shiplap edges (L form) to allow a simple and technically adequate installation, to prevent thermal bridges.



Thermal insulation board FIBRAN*xps*.

Insulation boards, like FIBRAN*xps* **300-L**, which are being used for underground protection most frequently, have a smooth surface, with declared compressive strength 300 kPs (more than 30 tons/m^2 at 10% deformation), and with minimum moisture absorption by diffusion WD(V)3, and by total immersion WL(T)0,7.

Technical properties of FIBRAN*xps* products that meet the local as well as European standards, for varied use in underground conditions, are the following:

FIBRAN*xps*	l/b [mm]	d [mm]	CS(10\Y)i [kPa]	min. demand CC(2/1,5/50) σc [kPa]	WD(V)i [vol.%]	max. alowed WD(V)i [vol.%]	FTi	min. demand FTi
300-L	1250/600	30-200	300	90	WD(V)3	WD(V)5	FT2	FT1
400-L	2500/600	80-200	400	-	WD(V)3	WD(V)5	FT2	FT1
500-L	1250/600	50-180	500	150	WD(V)3	WD(V)5	FT2	FT1
700-L	1250/600	60-120	700	200	WD(V)3	WD(V)5	FT2	FT1

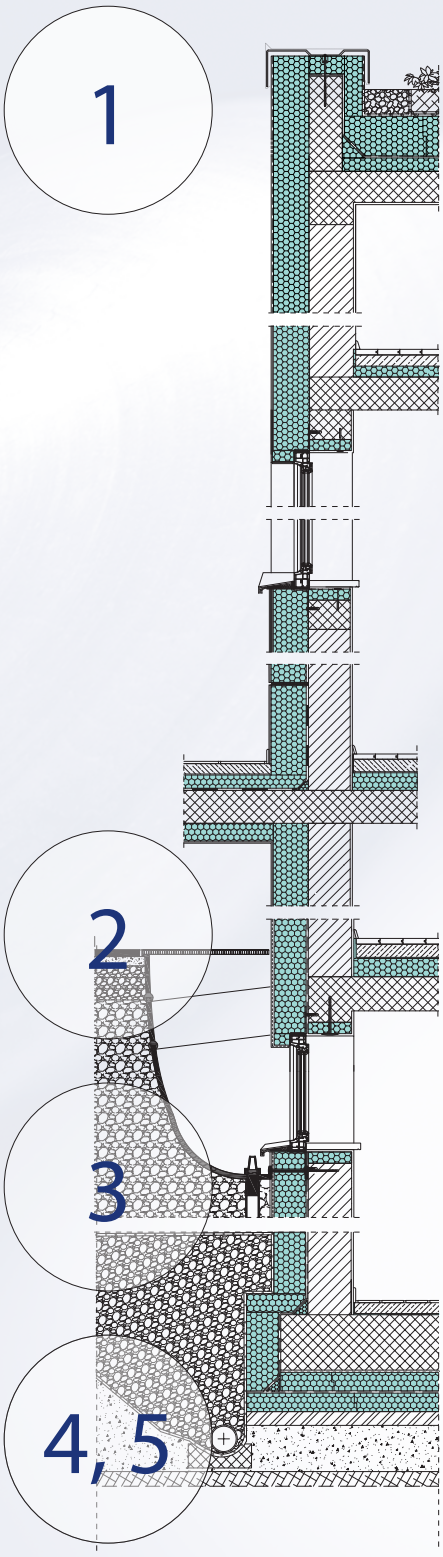
- **CS(10\Y)** compressive strength
- **CC(2/1,5/50)σc** compressive creep
- **WD(V)i** long term water absorption by diffusion
- **FTi** freeze-thaw resistance
- λ_D thermal conductivity

For detailed technical specifications, please see the product catalog FIBRAN*xps*.

Note:
Technical properties of FIBRAN*xps* thermal insulation boards exceed every requirement stated in the Standards (DIN 4108-10, ÖN B6000…). Considering the required compressive strength the type of the product is selected by the statics engineer.

I. CONSTRUCTION ELEMENTS **IN CONTACT WITH THE GROUND**

1. Green roof
2. Facade plinth
3. Wall in the ground
4. Foundations and ground bearing floor
5. Foundation slab - foundations for low-energy buildings



1. Green roof

The execution of thermal protection of green roofs is described in detail in leaflet No. 0111 – Inverted flat roofs – Building instructions.

Green roofs and inverted green roofs are construction parts that are in direct contact with the ground or with rainwater. All elements that are exposed to water require an especially careful execution, which applies also to green roofs and inverted green roofs. In case of green roof only a part of its construction is in contact with the ground and the water, but in case of inverted green roof the thermal insulation is also exposed to moisture, as the insulation protects the waterproofing layer against high temperature fluctuations and mechanical damages, thus ensuring its durability.

2. Facade plinth

The execution of thermal insulation of facade plinth is described in detail in leaflet No. 0130 – Facades – Building instructioins.

Facade plinth is an element of construction, connecting the facade with the basement wall or with the foundations of the building. In contact with the ground the plinth is exposed to rainwater and ground moisture. As moisture resistance is one of the most important properties of thermal insulation at the foot of the building, thermal insulation made of extruded polystyrene, such as FIBRAN*xps* **ETICS** is regularly used on facade plinths.

Note:
If FIBRAN*xps* **ETICS** thermal insulation of plinth reaches under the ground level, we need to ensure unobstructed water drainage or use, below the ground level, another type of insulation boards, FIBRAN*xps* **300-L** with smooth surface (minimum water absorption) to ensure durable thermal insulation also in humid environment.

3. Wall in the ground

External basement walls, as well as all other building elements that are in contact with the humid ground or are below the underground water level, need to be built in a watertight manner or they should be protected against damaging effects of moisture with waterproofing membranes or coatings at a later date. The waterproofing is exposed to mechanical damaging during the construction phase iself and also later, therefore a layer of solid, water-repellent thermal insulation, made of extruded polystyrene, such as FIBRAN*xps* **300-L**, that meets the requirements for installation below the ground, needs to be added to the waterproofing layer of heated and un-heated basement spaces, to ensure durable mechanical protection and energy performance.

Advantages of thermally insulated walls in the ground:

- ensure temperature stability inside the space,
- prevent forming of dew on internal side of the wall,
- protect waterproofing against mechanical damage,
- protect waterproofing against the effects of temperature, thus preventing faster aging of material.

Thickness of thermal insulation

- HEATED UNDERGROUND SPACES

The minimum thickness of thermal insulation for walls of heated basement spaces is determined according to the Regulations on energy performance of buildings (page 9), but for low-energy houses, and especially for passive houses, the thickness of underground insulation increases considerably, as we need to attain an optimum energy class. These buildings require thicker insulation, but besides this, the perfect installation, without thermal bridges, is of utmost importance.
In case of »nearly-zero energy buildings«, which require thicker thermal insulation, the insulation boards are installed in two layers, which are bonded together.

Determination of thickness of insulation depends on thermal conductivity of the insulation, thermal transmittance of the wall and the desired energy performance of the entire building, calculated with the Archi**MAID** programme. To simplify the use page 9 shows recommended thermal insulation thicknesses.

- NOT HEATED BASEMENT CONSTRUCTIONS

Un-heated basement spaces, where the impact of the change of annual temperature on the temperature deep in the ground is negligible, can be thermally and mechanically protected by minimum thickness of adequate insulation, serving as mechanical protection of waterproofing, and at the same time as minimum thermal protection, thus preventing the formation of dew and mould on walls of basement spaces. Thermally insulated constructions of un-heated spaces are taken into account in the heat balance of the building, and affect the determination of energy class of the building. The calculation method is prescribed in the standard EN 13370, and the entire calculation is carried out with the programme for the calculation of energy efficiency Archi**MAID**.

Selection of thermal insulation

To provide a solid and effective ENERGY **SHIELD** of the wall below ground level it isually enough to select thermal insulation boards FIBRAN*xps* **300-L** with adequate technical properties required by standard DIN 4108-10 and ÖN B6000, which prescribes the minimum required quality of insulation according to its intended purpose.

The installation of basement walls' thermal insulation

Thermally insulated boards should be carefully installed over the entire surface of backfilled wall, including the side parts of the foundation, where usually increased thermal losses occur. Boards are placed over the flat and clean waterproofing layer, in a staggered pattern, with tightly butted joints.

Gluing of FIBRAN*xps* **300-L** *boards with butyl rubber stickers* FIBRAN*stick.*

Fixing of XPS thermal insulation

FIBRAN*xps* boards are fixed onto the waterproofing layer with butyl gum stickers FIBRAN*stick*, or with special polyurethan foam. Under the groundwater level the thermal insulation boards should be glued over the entire surface. In such a case adequate water-resistant adhesive pastes are recommended.

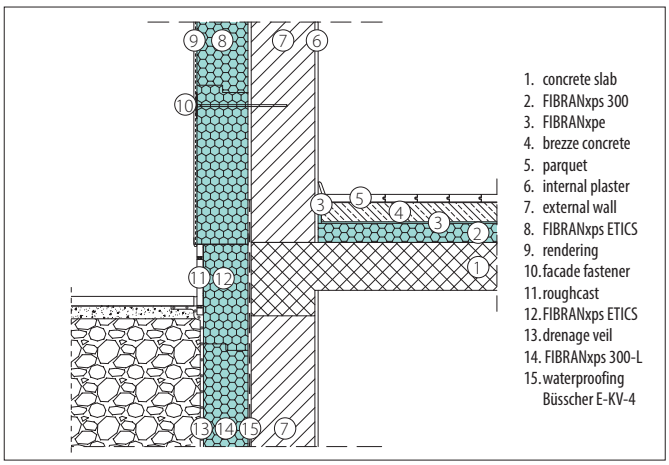
To achieve the desired thermal performance of basement walls, special attention should pe paid to the following:

a.) **joints of insulation boards**, to prevent potential increased heat transmission at junctures,
b.) execution of **links** between insulation of **basement wall and façade plinth**,
c.) execution of **links** between insulation of **foundations of the building and the basement wall**,
d.) for locations with poor ground drainage an adequate **drainage** system must be installed around the thermally insulated object, to allow drainage of rainwater and undergroud water,
e.) **thermal bridges**, such as service penetrations, light shafts, links between the heated and un-heated parts of the building …

a.)

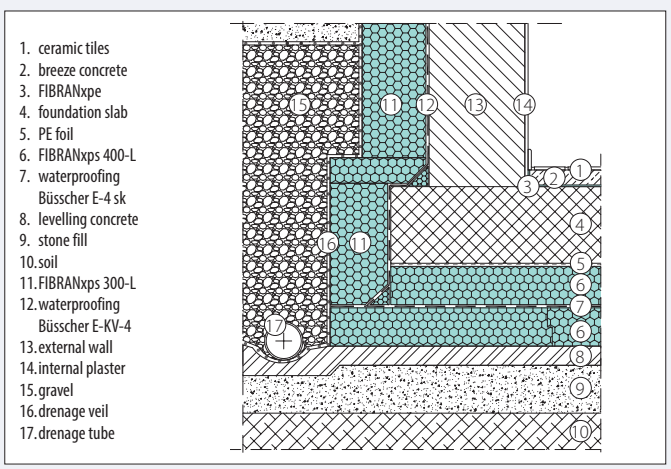
Cross instalation of FIBRAN*xps* **300-L** *boards and fitting of junctures.*

b.)



Detail 1 - Execution at the link between the insulation of basement wall, facade plinth and facade.

c.)



Detail 2 - Execution at the link between the foundation slab insulation and basement wall with drainage.

d.)

To ensure the optimum performance of thermal insulation, it is advisable to install an adequate drainage system around the entire thermally insulated object, to allow drainage of rainwater and undergroud water.

e.) Thermal bridges

Besides increased thermal losses, thermal bridges (increased heat transmissison in comparison with the direct environment) can cause a visible, unpleasant condensation of air moisture on the colder part of wall or ceiling surface, which can consequently lead to the forming of fungi and moulds…

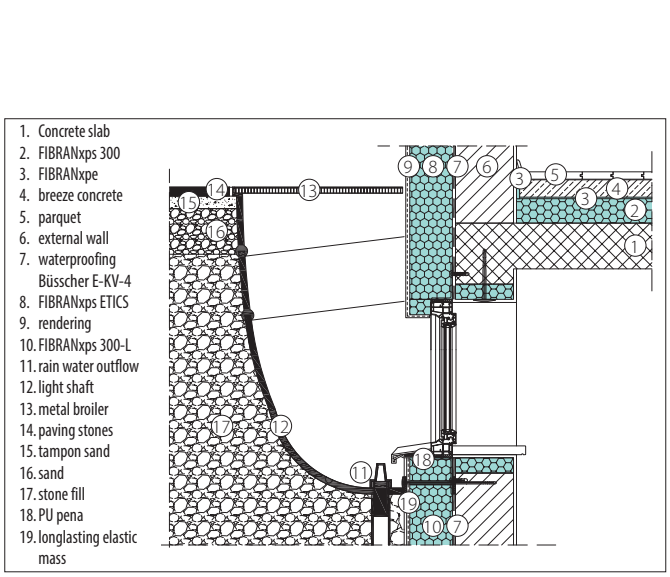
To avoid thermal bridges, we should be careful,

- to prevent penetrations of thermal insulation along the entire envelope of the heated part of the building,
- to execute very carefully the link between the heated and un-heated part of the building, thus ensuring perfect load-bearing capacity and durable thermal insulation performance.

– Light shafts

Construction elements such as light shafts, terraces, cold adjacent spaces or buildings and other individual constructions, need to be separated, or insulated, from the heated part of the building to avoid increased heat transmission and other undesirable consequences of such thermal bridges.

Cold elements that must be linked with the heated part of the building, should be anchored with stainless steel reinforcement into thermal insulation FIBRAN*xps*, or with specially manufactured anchoring.



Detail 3 - Prefabricated elements, such as light shafts are installed according to the manufacturer's instructions. The penetration, caused by anchoring the light shaft, needs to be carefully sealed. The part of the construction should be thermally insulated from cold construction of light shaft.

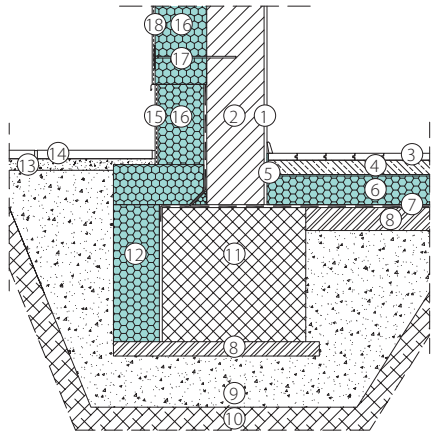
– Cold concrete elements which are made on site, are anchored in steel reinforcement which is already built in the construction. Durable link is executed with stainless steel reinforcement, which is welded for that area into the thermal insulation FIBRAN*xps*.

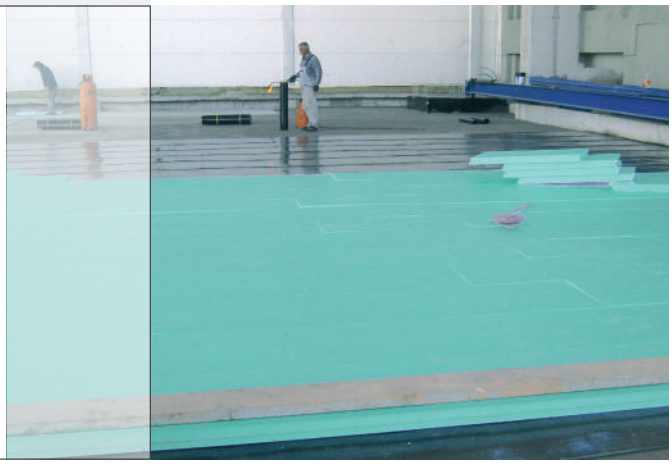
4. Foundations and ground floor

Industrial, workshop and warehouse floors, as well as groundfloors in objects without a basement, and basements are exposed to loading and moisture much more than other floor surfaces, therefore it is necessary to install load-bearing and water-resistant thermal insulation that maintains its energy performance and remains solid also during unforeseen situations, such as floods.

Protection of foundation and floor slab

1. internal plaster
2. external wall
3. parquet
4. breeze concrete
5. FIBRANxpe
6. FIBRANxps 300-L
7. waterproofing Büsscher E-KV-4
8. levelling concrete
9. stone fill
10. soil
11. rainforced concrete
12. FIBRANxps 300-L
13. sand
14. paving
15. rendering
16. FIBRANxps ETICS
17. facade fastener
18. roughcast

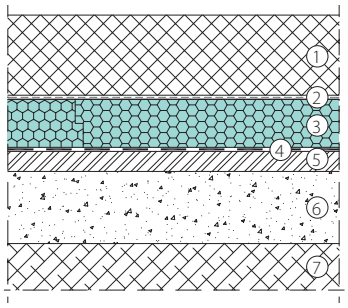


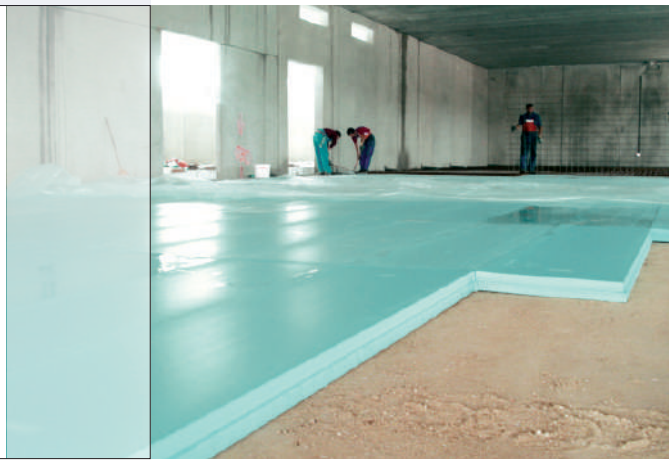


Detail 4 - Protection of foundation and floor slab. Execution of waterproofing before the installation of thermal insulation FIBRAN*xps* **300-L**.

Protection of industrial floor slab

1. Foundation slab
2. PE foil
3. FIBRANxps 500-L
4. waterproofing Büsscher E-KV-4
5. flor slab
6. stone fill
7. soil

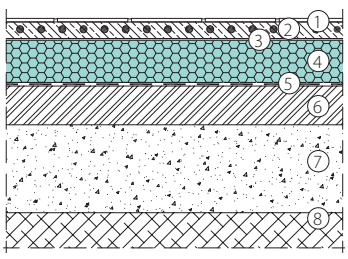


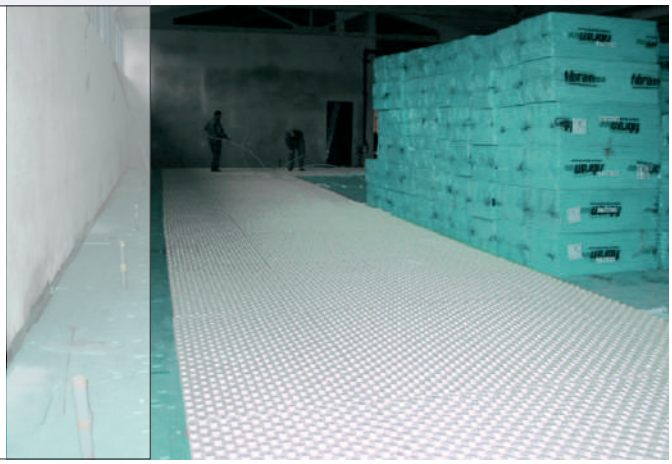


Detail 5 - Thermal protection of industrial floor slab with FIBRAN*xps* **500-L**. *If the surface is uneven, it can be levelled out with thin sand.*

Floor heating in floor constructions on the ground

1. ceramic tiles
2. breeze concrete with flor heating
3. FIBRANxpe sound insulation and tide up foil
4. FIBRANxps 300-L
5. waterproofing Büsscher E-KV-4
6. flor slab
7. stone fill
8. soil





Detail 6 - Installation of floor heating on FIBRAN*xps* **300-L** boards.

The installation of underfloor heating on the solid thermal insulation layer is a reliable and effective solution. The layer of cement screed above the heating system can be kept to a minimum, thus providing a fast acting and efficient heating of the floor. Durable thermal insulation layer of adequate thickness reduces heat losses through the floor. In case of low-energy buildings the heating is effectively applied in the foundation slab, under which thermal insulation of designed thickness is installed.

Recommended thermal insulation thicknesses

Regulaltions in our country are becoming stricter from year to year, as they have to follow the European guidelines. Builders mostly comply with the regulations, not just to reduce the energy use and to lower the costs, but also because of ecological awareness of investors and future occupants, and the desired living comfort. Huge climate changes, which we have been witnessing during the last years, confirm the forecasted changes and legitimate concern for the ENERGY **SHIELD** and thus of buildings' energy independency.

According to European guidelines for construction of buildings (Energy Performance of Building Directive - EPBD), the nearly-zero energy buildings will be obligatory for all public buildings after the year 2018, and for all other buildings by the end of the year 2020, which means that energy performance of buildings will increase considerably.

The certified energy class of a building will also affect its sale value. In order to maintain the determined level of value of buildings which are being built at present, also after 2018 or 2020, the real estate experts recommend the installation of more efficient or thicker thermal insulation, resulting in lower values of heat transmission (U-value) than is prescribed in current regulations. Already by 2015 the Slovene regulations will become more strict once again, to avoid the too big gap in implementing new building regulations for nearly zero-energy buildings in 2018.

Orientation thermal insulation thicknesses, with thermal conductivity λ_D= 0,035 W/mK, are given as simplification. If thermal conductivity is higher, a thicker thermal insulation is required.

Thermal insulation thicknesses of massively built buildings:

Designed thermal insulation thickness depends on:

- desired level* of thermal protection,
- construction elements or their thermal transmittance U
- desired level of comfort living
- desired energy performance of the entire building or energy use for heating or cooling, calculated with Archi**MAID** programme,
- climatic conditions.

The minimum orientation thicknesses according to current regulation:**

• roofs	20 cm	Umax < 0,20 W/m^{2}K
• façade and façade plinths	12 cm	Umax < 0,28 W/m^{2}K
• below grade external walls	10 cm	Umax < 0,35 W/m^{2}K
• ground floor	12 cm	Umax < 0,30 W/m^{2}K
• foundation slab	12 cm	Umax < 0,30 W/m^{2}K

Minimum recommended thicknesses:

• roofs	30 cm
• façade and façade plinths	20 cm
• below grade external walls	18 cm
• foundation slab	20 cm

Thicknesses of nearly zero energy houses:

• roofs	from 30 cm to 45 cm
• façade and façade plinths	from 20 cm to 30 cm
• below grade external walls	from 18 cm to 30 cm
• foundation slab	from 20 cm to 30 cm

Low-energy buildings require the use of foundation slab. >>>>>>>>>>>>>>>>>>>

If FIBRAN*xps* thermal insulation serves only as protection of the waterproofing layer of un-heated spaces and as prevention of condensation, then insulation boards of lower thickness are installed. However, as mostly in family houses, the basement spaces may be upgraded to living spaces at a later date, it is recommended to install thermal insulation also in un-heated basements, in thicknesses prescribedby the Regulations**.

** Thickness of thermal insulation material λ_D= 0,035 W/mK, respectively the maximum thermal transmittance according to the regulations is given for.*

*** Regulations- Local Regulations on Energy Performance of Buildings*

NEARLY-ZERO ENERGY BUILDING

Low-energy buildings, but mostly „nearly-zero" energy buildings are subject to strict building requirements, such as minimum heat losses and maximum heat gains efficiency, affected by:

- thickness of adequate thermal insulation,
- precisely designed constructional elements, including all the details and execution instructions,
- precise execution of thermal protection of the entire building envelope, without thermal bridges,
- architectural design of the building and its orientation,
- airtightness of the building,
- ventilation by heat recovery (air recuperation).

Besides precise execution of installation, the crucial factor in providing effective protection is of course the thickness of the adequate and precisely installed thermal insulation. Due to the fact that all the building's construction elements (the building envelope and inner constructions) have an effect on **heat balance** (besides conditions given in the first paragraph), the insulation thicknesses for constructional elements can vary for different buildings. Thermal insulation thickness is selected according to the desired energy performance of the building. Orientation values for the most part of Slovenia are given on page 9.

heat balance of the building = heat losses– heat gains

The building of low-energy houses, which has been increasing intensively throughout Europe, for new and also for refurbished buildings, is heading towards "nearly-zero" buildings. What used to be the domain of individual enthusiasts is now turning into reality

When designing a building with a very low energy use, the key requirement is to diminish heat losses:
Due to heat losses through concrete mass it is practically impossible to build a "nearly-zero" energy building on grade beam footings, and therefore the designers of low-energy buildings throughout Europe are choosing foundation slabs, which is a new building practice in Slovenia.

5. Thermal insulation underneath the foundation slab

Design guidelines

A continuous thermal envelope of quality executed low-energy (passive, nearly-zero) buildings, without thermal bridges, is guaranteed only by installing thermal insulation also underneath the building's foundations, which can be achieved by building the foundation with foundation slabs. This solution provides the lowest possible heat losses through constructions in the ground, therefore the building of foundations in this manner is probably the only adequate choice for "nearly zero-energy" houses.

Advantages of such protection:

- fast and optimum cost effective execution
- Durable thermal protection with no thermal bridges
- The accumulation of heat within the concrete mass of the foundation slab
- Stronger earthquake protection.

At a first glance, building the foundation with foundation slabs could seem an unusual solution for the statics engineer, and also for the investor. But when an analysis is carried out, assessing the quantity of demanding work, material and time, the depth of excavation, the surface of formworks, and the energy efficiency, the financial results support building the foundation with foundation slabs.

Building the foundation of a low-energy building

A. Building and installation works

Vertical service installation, compacting and levelling out of the ground, on which the first layer of FIBRAN*xps* **400 - L** *insulation will be placed.*

Installation of services into previously cut out channels of FIBRAN*xps thermal insulation boards.*

If the design of the foundation slab allows for a slight movement in case of seismic activity, this can cause damages on service channels. For such cases earthquake protection construction of service channels (flexible pipes, curved pipes, double pipes…) is planned. All the penetrations for service channels that reduce the thermal envelope performance (thermal bridge) need to be thermally insulated with great precision.

B. Thermal insulation of the foundation slab

To guarantee the stability of the building and an effective thermal protection underneath the foundation slab, an adequate type of thermal insulation should be determined, with the following combination of technical and physical properties:

- the lowest possible thermal conductivity of the material, and adequate thickness of thermal insulation,
- the required compressive strength for long-term loadings,
- the lowest class of long-term water absorption by diffusion, and by immersion,
- guaranted frost resistance,
- adequate permission for installation, i.e. underneath the foundation slab.

Thermal insulation boards FIBRAN*xps* **300-L**, FIBRAN*xps* **400-L**, FIBRAN*xps* **500-L**, FIBRAN*xps* **700-L** meet the above stated requirements.

In Slovenia where seismic activity is possible on most locations, and for this reason the eartquake protection is necessary, the installation of boards with compressive strength of **at least 400 kPa**, is allowed, due to excessive loading of the ground during an earthquake. This has been confirmed with the research SECURITY OF PASSIVE HOUSES DURING AN EARTHQUAKE. FIBRAN*xps* **400-L** is a thermal insulation board that can bear the load of residential houses up to three stories high, or of objects with larger surface area, such as kindergartens, schools, sports halls… For more massive or higher buildings with unfavourable building dimensions, a more solid XPS insulation is used, such as FIBRAN*xps* **500-L** or FIBRAN*xps* **700-L**. An adequate solution is determined by experts for earthquake security, based on the analysis of building dimensions and building mass. Information: fibran@fibran.si

C. Waterproofing layer

The quality of waterproofing and precision of its installation under the ground are of extreme importance, as remedial work is almost impossible or it brings with it extremely high costs. Ad equate water proofing is selected according to its intended use and depending on climate conditions.

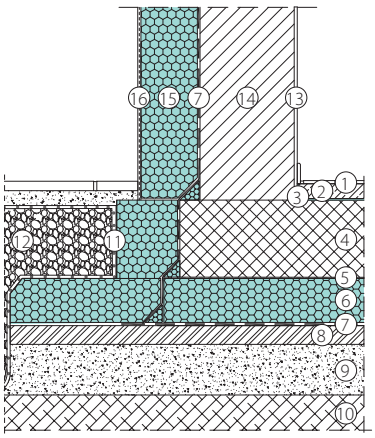
Options for combining thermal insulation and waterproofing layers:

a.) waterproofing underneath thermal insulation
b.) waterproofing above thermal insulation
c.) waterproofing between two layers of thermal insulation
d.) waterproofing on the foundation slab.

Laying of self-adhesive waterproofing on thermal insulation boards FIBRAN*xps* **400-L**.

a.) Waterproofing underneath thermal insulation

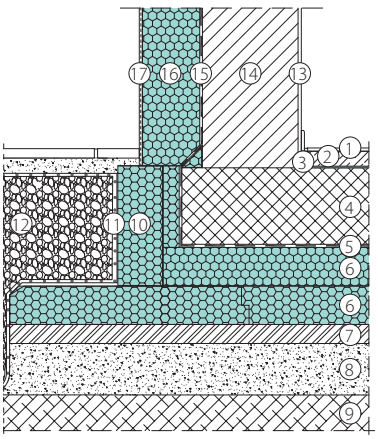
1. ceramic tiles
2. breeze concrete
3. FIBRANxpe sound insulation and tide up foil
4. foundation slab
5. PE foil
6. FIBRANxps 400-L
7. waterproofing Büsscher E-KV-4
8. levelling concrete
9. stone fill
10. soil
11. drenage veil
12. gravel
13. internal plaster
14. external wall
15. FIBRANxps ETICS
16. rendering



Detail 7 - Because of the »load dispersion rule is chosen, as shown in the detail. Preparation of thermal insulation base of a residential building.

b.) Waterproofing above thermal insulation of the foundation slab

1. ceramic tiles
2. breeze concrete
3. FIBRANxpe sound insulation and tide up foil
4. foundation slab
5. waterproofing bentonit
6. FIBRANxps 400-L
7. levelling concrete
8. stone fill
9. soil
10. FIBRANxps 300-L
11. drenage veil
12. gravel
13. internal plaster
14. external wall
15. waterproofing Büsscher E-KV-4
16. FIBRANxps ETICS
17. rendering



Detail 8 - Ecological bentonite waterproofing placed on FIBRAN*xps* **400-L** *before building the foundation slab of a school building.*

D. Formwork of foundation slab

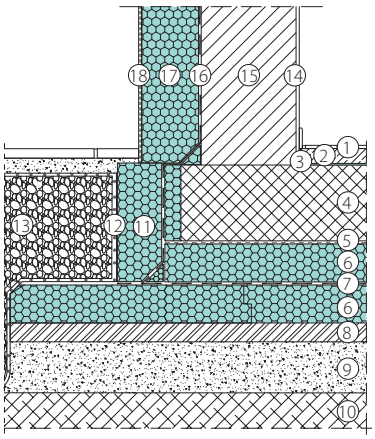
Horizontal and vertical waterproofing can also be applied after the formwork has been made, and is temporarily fixed to the formwork of the slab, before casting the concrete. If thermal insulation is installed in two layers, the second layer of FIBRAN*xps* may be placed in the formwork (detail page 13).

E. Installation of sealing membrane

Sealing membrane (PE foil) prevents leaking of cement milk from concrete mixture. If the boards are laid with precision, or if bentonite waterproofing is used, the installation of sealing membrane is not necessary (detail 8).

c.) Waterproofing underneath the foundation slab, between two layers of thermal insulation

1. ceramic tiles
2. breeze concrete
3. FIBRANxpe sound insulation and tide up foil
4. foundation slab
5. PE foil
6. FIBRANxps 400-L
7. waterproofing Büsscher E-4 sk
8. levelling concrete
9. stone fill
10. soil
11. FIBRANxps 300-L
12. drenage veil
13. gravel
14. internal plaster
15. external wall
16. waterproofing Büsscher E-KV-4
17. FIBRANxps ETICS
18. rendering



Detail 9 - Waterproofing between two layers of FIBRAN*xps* **400-L** *insulation boards. Application of an angle fillet to smooth the inside corners of vertical bituminous waterproofing.*

Waterproofring, protected between two layers of thermal insulation, ensures durable protection against moisture. When waterproofing layer is installed over the polystyrene thermal insulation, we use **self-adhesive waterproofing membranes**, or membranes which are bonded with hot air. Appropriate solution for climate conditions, where winter temperatures can drop even below -10 °C, is the use of **elastomeric bituminous waterproofing**, othevise polimer bituminous membranes should do. (detail 9).

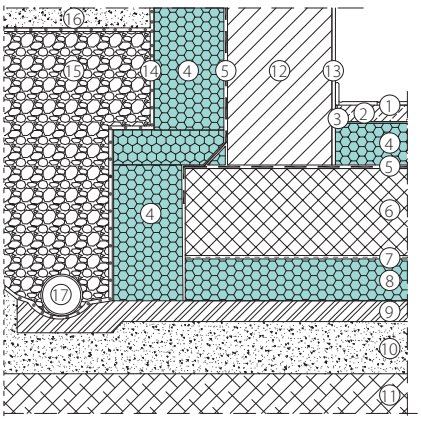
If **clay waterproofing** is used (detail 8), it is applied above the thermal insulation layers. Clay reacts with water from the concrete, and under the influence of weight it is made into a natural clay waterproofing layer. Special attention should be paid to the link between the horizontal and vertical waterproofing.

The use of **PVC** in direct contact with polystyrens is not allowed. A separating layer must be installed between polyvinyl chloride membranes and polystyrene boards.

Self-adhesive waterproofing between two layers of FIBRAN*xps* **400-L** thermal insulation.

d.) Waterproofing on the foundation slab

1. ceramic tiles
2. breeze concrete
3. FIBRANxpe sound insulation and tide up foil
4. FIBRANxps 300-L
5. waterproofing Büsscher E-KV-5
6. foundation slab
7. PE foil
8. FIBRANxps 400-L
9. levelling concrete
10. stone fill
11. soil
12. external wall
13. internal plaster
14. drenage veil
15. gravel
16. sand
17. drenage tube



Detail 10 - Bituminous waterproofing on the foundation slab of a building with basement. Thermal insulation FIBRAN*xps* **400-L** *underneath the foundation slab.*

F. Installation of reinforced concrete foundation slab…

. . . and now the foundation base is prepared for the building of a low-energy house.

Note:
Different phases of building the foundation slab of low-energy buildings are described in detail on site www.fibran.com

II. PROTECTION OF GROUND **AGAINST FREEZING**

Constructions in the ground exposed to frost:

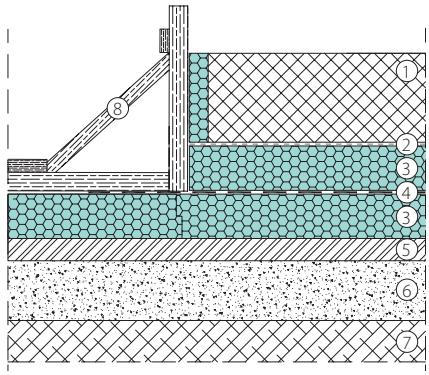
- buildings with shallow foundations,
- outdoor swimming pools,
- underground transport and service channels,
- access to bridges,
- transport paths on marshy ground,
- foundation slabs on the ground,
- columns of bridges and power-lines...

Protection of ground in the frost line

For objects without a basement, grade beam footings or spot footings should be deepened at least to the frost line (from 70 to 120 cm in Slovenia, depending on the climatic data of the location). Freeze-thaw cycles, and consequently swelling of the ground down to the frost line, could cause movements and damages to the object. However, the foundation slab could be built shallower than to the frost line, but in this case the ground should be protected against frost by extending the thermal insulation FIBRAN*xps* **300-L** under the foundation slab outwards beyond the building perimeter, horizontally or vertically, according to standard EN ISO 13793.

Detail of execution of thermal insulation of the ground under the foundation slab

1. Concrete slab
2. PE foil
3. FIBRANxps 400-L
4. waterproofing Büsscher E- 4 sk
5. levelling concrete
6. stone fill
7. soil
8. form work



*Detail 11 - Load-bearing ground under the building with shallow foundations is protected with the first layer of FIBRAN*xps* thermal insulation, extended outwards beyond the building's perimeter, and the second layer is placed in the formwork of the foundation slab.*

Maintaining the load-bearing capacity and ground friction

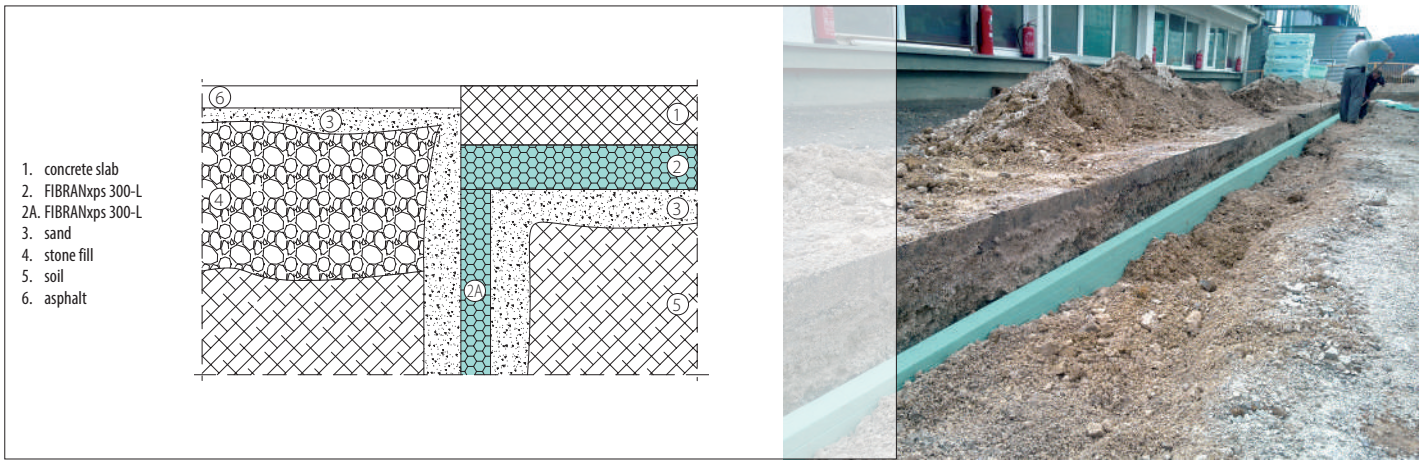
Power-line columns, besides bearing the so-called useful load of cables and wires, are also affected by the load of snow, by the effects of wind and temperature, as well as by uneven sinking of poor load-bearing capacity of the ground. Therefore the building of foundations for slim constructions requires special attention.
Freeze-thaw cycles of the ground may lower its load-bearing capacity in all directions, but they also change the ground friction, which is extremely important in case of slim constructions built on grade-beam footing.

Protection of trafficable surfaces and decks with shallow foundations against the effects of frost in the ground

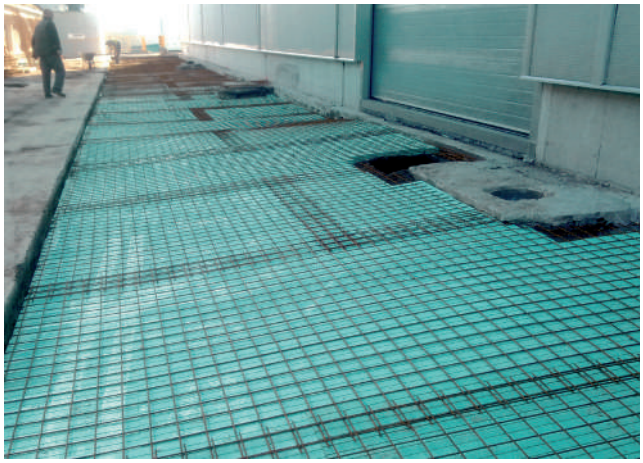
Thermal insulation of the ground protects constructions with shallow foundations or decks against damages caused by freeze-thaw cycles, which result in swelling and sinking of the ground.

FIBRAN*xps* thermal insulation boards of adequate compressive strength are installed directly under the potentially threatened surface constructions, with additional anti-frost protection, horizontally or vertically, at the perimeter of the construction.

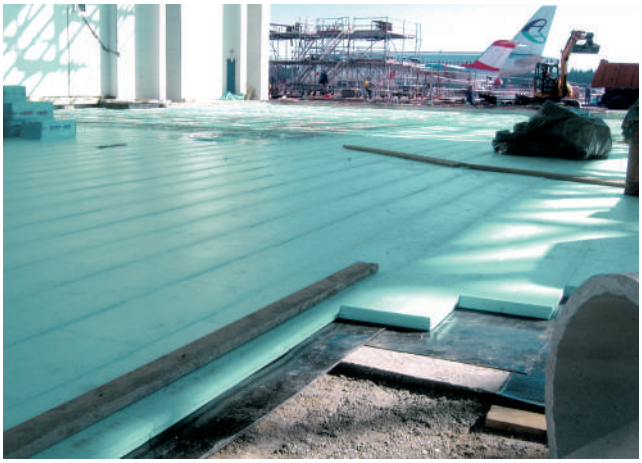
Detail of execution of shallow foundation slab



Detail 12 - Vertical thermal protection of the ground (2A) along the load-bearing deck, with FIBRAN*xps* **300-L** insulation.



Horizontal thermal protection of the ground (2) with FIBRAN*xps* **300-L** *under the deck built on foundations.*



Thermal protection of the ground of airplane hangar with FIBRAN*xps* **700-L**.

FIBRAN*xps* thermal insulation for extreme loadings maintains the warmth of the ground and reduces penetration of frost in winter, thus preventing the swelling and sinking of the ground during the annual freeze-thaw cycles. Just the opposite effect is obtained in summer, by installing insulation on mostly frozen ground. The insulation prevents melting in depth, which would cause reducing of load-bearing capacity of the ground soaked with water (which does not apply in warmer regions of our country).

The purpose of thermal insulation is to control the heat (cold) transmission. Rigid thermal insulation boards FIBRAN*xps* with declared compressive strengths from 300 to 700 kPa, are intended for protection of the ground against frost, with a combination of technical properties thaat ensure durable effective ENERGY **SHIELD** for constructions exposed to water and moisture.

Closed-cell structure of FIBRAN*xps* thermal insulation boards, with completely smooth surface, which is achieved with extrusion process, prevents water absorption, which ensures thermal insulation of this kind to maintain the intended thermal insulation properties.

We cooperate with excellent architects and contractors...

Instructions for use of FIBRAN*xps* **thermal insulation material:**

FIBRAN*xps* thermal insulation boards from extruded polystyrene can remain unprotected outside for several weeks and remain unaffected by rain, snow or frost, but this is not the case with sunlight. The foamed polystyrene boards, like other hard foam synthetic materials, are sensitive to long-term exposure to ultra-violet light. When installing FIBRAN*xps* boards they need to be simultaneously protected against the sun's radiation, therefore immediate installation of subsequent layers is recommended. Boards that are not installed immediately at the construction site need to be placed in the shade or protected with bright-coloured synthetic material. Under transparent or dark covers temperature rises significantly and could deform the boards or cause damage to their surface. Maximum usage temperature is 75°C as the boards' surface starts to melt in case of higher temperatures. The use of naked flame near FIBRAN*xps*, as well as any other polystyrene thermal insulation, is not permitted.
FIBRAN*xps* boards from extruded polystyrene have to be placed on flat and clean surfaces.
FIBRAN*xps* is affected by solutions based on petrol, tar, formic acid, gases such as methane, ethane, propane, butane, heptane….but also chlorides. Because of chlorides which are present when using a PVC waterproofing membrane, a separating layer (such as Geotextyle) should be placed between the membrane and polystyrene boards.
FIBRAN*xps* can conditionally exist in contact with petroleum (oil), heating oil, paraffin oil, vaseline, phenol, fat and oil. These substances can affect the surface in the long-term. Totally neutral regarding FIBRAN*xps* are bitumen, lime, cement, plaster, as well as saltwater, lyes, acids including sulphuric and phosphoric acid, anorganic gases, alcohol, silicon…

All information given in this brochure are mere recommendations for planners and designers. This data has been obtained on the basis of standards of some European countries with long tradition of thermal protection of underground constructions, and organized legislation regarding this subject.
Technical support division of FIBRAN d.o.o. is always available for designers and building contractors to help them clarify questions regarding characteristics and applications of FIBRAN*xps* **products on:** www.fibran.com

0100 Product Catalogue

0111 Inverted Flat Roofs

0130 Façades

0150 Below Grade

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FIBRAN d.o.o. | Tisk: Kočevski tisk d.d., Kočevje | 06/ 2018