Insulation systems for flat roof

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Building

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Contents

Compact roof – a promising future

The roof probably is the most important element of the outer skin of a building to provide protection against weathering. Owners and specifiers alike demand a lifetime of high performance. This means: The roof – in particular the flat roof – should provide protection against cold, heat and rain for the entire service life of the building. This means a roof must last for decades and for generations of owners. It's clear: Flat roofs have a promising future. The right roof solution ensures lifetime performance without degradation. The optimum system remains effective in the most demanding situations; it meets aesthetic, financial and environmental requirements. Compact Roof systems – using the inherent qualities of FOAMGLAS® cellular glass insulation – are ideal for the most demanding roof situations.

Proven across the world for decades

In the beginning of the 20th century avant-garde architects in Europe got their teeth into new building design using the flat roof. The renowned architect Le Corbusier was one of its most reputable advocates. In the fifties this roof architecture became widely accepted and there are flat roof constructions performing without failure even today – many include FOAMGLAS® Compact Roofs. An average lifetime of 40–50 years can be achieved. The excellent condition of the oldest FOAMGLAS® Compact Roofs – accord-

1 Seebach Center, Zurich
2 CSS Insurance Company, Lucerne
3 School for therapeutic pedagogy, Thun-Steffisburg

ing to experts – supports the conclusion that FOAMGLAS® roofs will be effective for the next half century.

Unique system integrity – long term weatherproofing

A flat roof has undeniable advantages and it offers a new dimension in performance and economy. It extends not only the cubical content but also offers versatility of use for the roof area itself. Choosing a FOAMGLAS® Compact Roof assures best craftsmanship and safe performance for the long-term; it reduces maintenance and replacement costs and plays akey part in saving energy and protecting the environment. No other system can claim similar application possibilities – covering terraces, rooftop gardens, non-accessible or accessible roofs (e. g. parking decks and service decks).

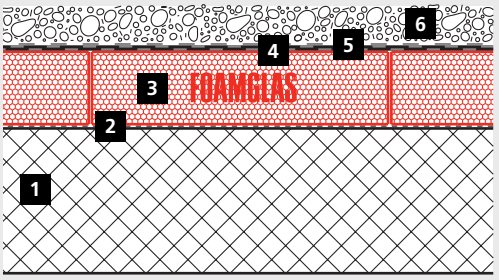
The perfect system

FOAMGLAS® thermal insulation requires only a few components to create the Compact Roof: an exceptionally robust and rainproof flat roof construction. Cellular glass slabs are bonded with hot bitumen on to the structural deck. The slabs are pushed into the adhesive and closely butted, staggered and the joints filled with bitumen to achieve a compact insulation layer. The waterproofing is then fully adhered to the insulation surface using hot bitumen. In the FOAMGLAS® Compact Roof all layers are perfectly bonded to each other. Water ingress into the roof and interstitial moisture can be prevented as the insulation itself creates a waterproof layer. FOAMGLAS® flat roof means double the security and low maintenance demands.

Design and accurate installation method are the key to the outstanding durability of the FOAMGLAS® Compact Roof. Even if the weatherproofing layer becomes damaged, moisture will not spread across the roof, the insulation provides added protection. Any specified slope for flat roofs can be achieved by using the FOAMGLAS® Tapered Roof (a computerized cut-to-fall system) that ensures effective drainage and full thermal protection.

Physical properties

Due to its combination of unique properties, FOAMGLAS® is also called "Safety insulation". It is unrivalled in performance. Manufactured from crushed glass and carbon, it forms closed glass cells – containing an inert gas –, which provide excellent thermal effectiveness. As a high-density insulation the product shows good performance in airborne sound reduction and heat protection in summer.



Structure Compact Roof

1. Structural deck (for instance: reinforced concrete)
2. Bituminous primer coat
3. FOAMGLAS® insulation slabs (if required: TAPERED Roof System)
4. Two-layer bituminous waterproofing
5. Separating/protection layer
6. Finish layer

4. UBS Bank, Suglio, 1997
5. UEFA Headquarters, Nyon, 1997
6. Park Hotel Waldhaus, Flims, 2005


4

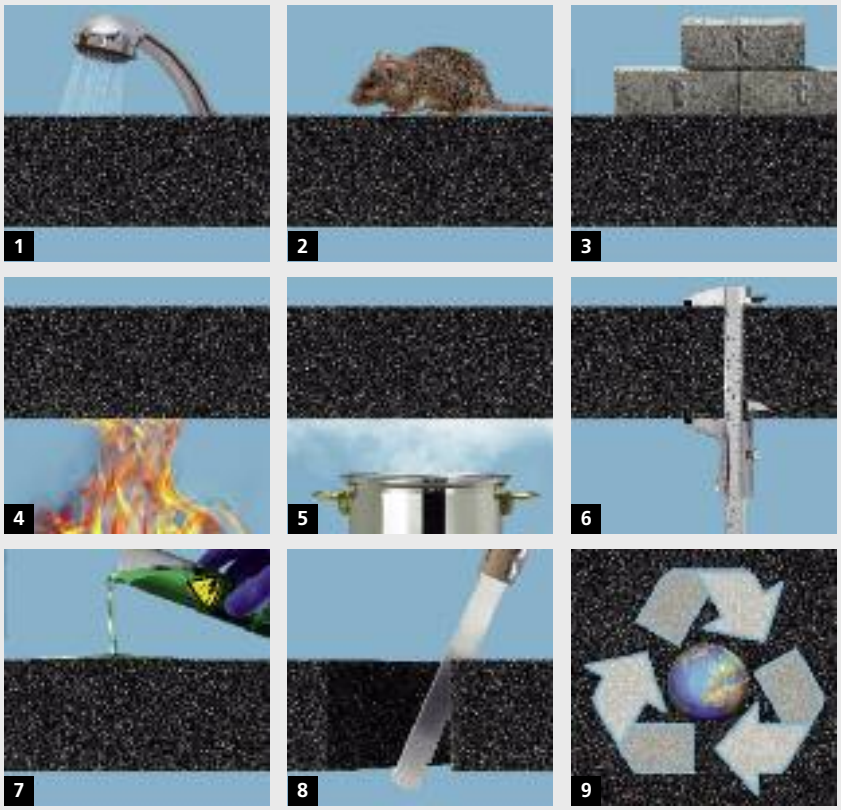

5


6

FOAMGLAS® is totally impervious to water and vapor, it will not absorb water. An additional vapor barrier is not required, as the all glass closed cell insulation fulfills the function to keep moisture out. FOAMGLAS® possesses high compressive strength and is free from deformation in the long-term. Further qualities of the glass material are: non-combustibility and dimensional stability (no shrinkage, no swelling, no warping); it is rot, insect, vermin and acid proof. FOAMGLAS® is an environmentally sound product and certified to standards of health and indoor air quality in buildings.

7 Zurich Airport, Kloten

FOAMGLAS® insulation: unrivalled performance



1 Waterproof FOAMGLAS® is waterproof because it consists of pure glass. **Advantage:** does not absorb any moisture and does not swell.

2 Pest-proof FOAMGLAS® cannot rot and is pest-proof because it is inorganic. **Advantage:** insulation without risk, especially in the base area and the soil. No basis for nesting, breeding or seed germination.

3 Compression-proof FOAMGLAS® is extraordinarily in-compressible even with long-term loads due to its cell geometry without deformation. **Advantage:** use as load-bearing thermal insulation without risk.

4 Incombustible FOAMGLAS® cannot burn because it consists of pure glass. Fire behaviour: Classification according to EN 13501: A1. **Advantage:** storage and processing not hazardous. No propagation of flames in the event of fire (chimney effect) in ventilation space.

5 Vapour-tight FOAMGLAS® is vapour-tightbecause it consists of hermetically sealed glass cells. **Advantage:** cannot soak through and already contains the vapour barrier. Constant thermal insulation value over decades. Prevents the penetration of radon.

6 Dimensionally stable FOAMGLAS® is dimensionally stable because glass neither shrinks nor swells. **Advantage:** no dishing, contracting or creep. Low coefficient of expansion, nearly equal to that of steel and concrete.

7 Acid-resistant FOAMGLAS® is resistant to organic solvents and acids because it consists of pure glass. **Advantage:** no destruction of the insulation by aggressive mediums and atmospheres.

8 Easy to work with FOAMGLAS® is easy to work with because it consists of thin-walled glass cells. **Advantage:** with simple tools like a saw blade or hand saw, FOAMGLAS® can be cut to any desired measurement.

9 Ecological FOAMGLAS® is free of environmentally damaging flame retardants and propellants, no relevant eco-toxic components. **Advantage:** After generations of use as thermal insulation, FOAMGLAS® can be used again: as filler in landscaping or thermally insulating granulate. Ecologically sensible recycling through re-use.

Living spaces on the roof

Contemporary flat roofs offer wide versatility in design and usage. The roof landscape possibilities are limited only by your imagination. FOAMGLAS® Compact Roof offers a wide range of building system solutions for the most demanding situations. Designed with heavy protection (roofing gravel), as a terrace or green roof, as car park deck or as an industrial roof on steel deck: there is a FOAMGLAS® solution for every type of usage and for every roof layout.

Outdoor "living space"

In "Five Principles for New Architecture" Le Corbusier stipulated the creation of green areas with proud vegetation on otherwise void flat roofs in order to create natural spaces in dense urban areas for the improvement of ambient conditions. He described the terrace or green roof as the "zone of preference" in the house. And indeed, terrace roofs as an outdoor living space have a great attractiveness. The rooftop is an ideal platform for a magnificent view over the environment. And the creation of green areas adds greatly to the ecological profile of the building and improves the quality of living for the owner. As the design and construction of a green roof or terrace is a very demanding project, it is essential to consider proven roof systems based on FOAMGLAS®, which enable architect's schemes to be realized.

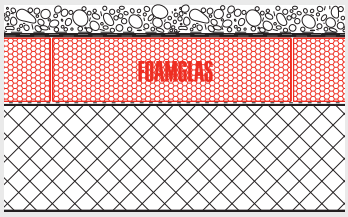
1 University Hospital, Geneva
2 Sports Hall of Federal School, Frauenfeld
3 Migros Shopping Center, Affoltern, ZH

Principal types of roof systems

Compact Roof with limited accessibility **Page 10**

Compact Roof with heavy protection

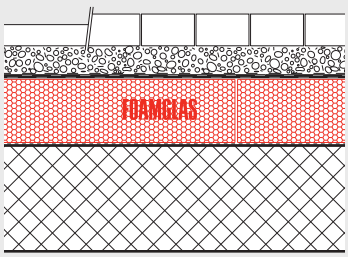
The Compact Roof with limited access subject to foot traffic is a flat roof, which is only accessed for maintenance. Washed roofing gravel is used as heavy protection against mechanical impact and UV-attack. This roof layout is regularly found on industrial roofs with steel decking.



Compact Roof accessible to foot traffic **Page 13**

Terrace roof with pavement area

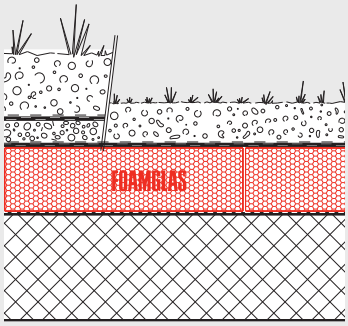
Flat roofs are frequently used as extended outdoor living rooms (terraces). Therefore the trend towards a wide variety of aesthetic tiles and paving stones or wearing courses is increasing. The range of products is wide: concrete pavements, tiles, cast stone, natural stone, boardwalk, playground flooring, court surfaces and others.



Green Compact Roof **Page 17**

Moisture conditions in green roofs

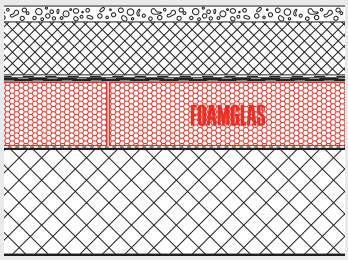
Green roof constructions have positive effects for the environment and the microclimate. The plants keep the air fresh and raise the level of humidity. They reduce fine dust pollution and traffic noise. Green areas on the roof reduce the rainwater load on the urban sewer systems by naturally storing the water. They protect the roof structure from thermal shock and transform the roof surface into a recreational area. Dependent on type, height and care requirements of the plants an extensive or intensive greening system can be used.



Compact Roof, trafficked / parking decks **Page 24**

Traffic accessed car park decks

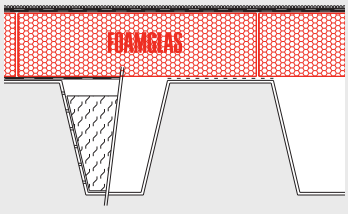
Greater mobility and the need for individual transport characterize the spirit of our times. It is obvious that traffic density is also increasing 'at rest' and requires flat roofs of many building developments to be used as parking decks. This also means that parking spaces should structurally be designed to accomodate delivery, fire and rescue services. Dependent on load assumptions and load distribution slabs, road surfaces in granolithic concrete, asphalt, interlocking pavers or timber paving are possible.



Compact Roof **Page 28**

Standard Compact Roof (au naturel) – with two-layer waterproofing

For buildings without heavy protection layers or foot traffic and requiring slight weight, a simple waterproofed roof is the perfect solution. However the roof still needs to sufficiently resist wind forces. The wind loads should safely be transmitted to the building's structure. In the standard FOAMGLAS® Compact Roof this is achieved by bonding all layers to each other. The Standard Compact Roof on steel deck is ideal for lightweight industrial roofing.



Compact roof

New Acropolis Museum, Athens

Architects Bernard Tschumi, Paris, New York – Michael Photiadis, Athens
Construction 2004 – 2007
Thermal insulation FOAMGLAS® Compact Roof
Tapered Roof System (TRS), average thickness 116 mm, 2700 m²
Accessible concrete deck, FOAMGLAS® slabs, 50 mm thick, 1903 m²
Roof finish Marble slabs on adjustable BUZON® pedestals

A project much spoken of has been finalized as a building which has become internationally famous for the Greek classical treasures it is exhibiting. The designers were consistent to their initial main concern for solutions that would combine the integration of the site's excavations, the use of natural light as well as the balance between the Museum and the Acropolis monument.
On the accessible concrete deck of level 2, FOAMGLAS® slabs have been used. The coverage consists of marble slabs placed on adjustable pedestals. With unique technical characteristics – dimensional stability without deformation, high pressure resistance, impermeability to water, water vapour and longevity – FOAMGLAS® has met the extremely high demands of the construction contributing at the same time to the 'environmental character' of the New Museum.

Ecologically recommended insulation material
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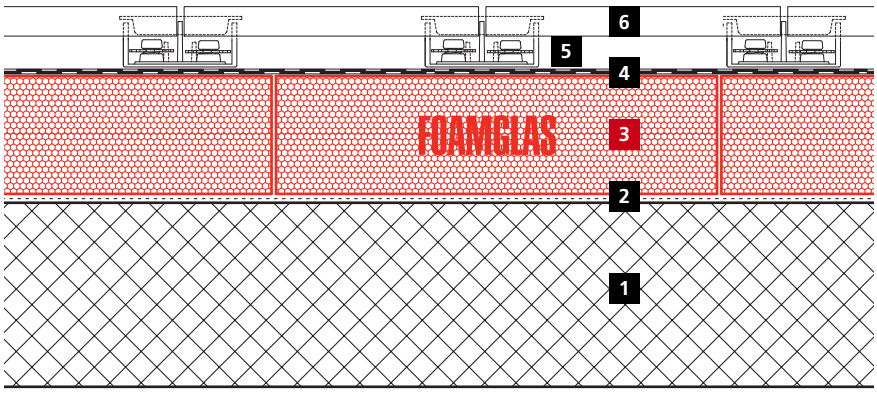


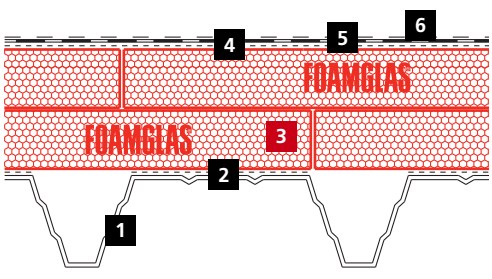
Roof structure
1 Concrete deck
2 Primer coat
3 FOAMGLAS® slabs, in hot bitumen
4 Two layers of bituminous waterproofing membranes, with polyester reinforcement
5 Adjustable support pads
6 Marble slabs

Compact Roof on steel deck

Megasport Arena, Khodynka, Moscow, Russia

Owner Government of Moscow
Architect Bokov Andrey
Year 2005 – 2006
Thermal insulation 35 000 m² FOAMGLAS® T4 140 mm
Finish PVC SIKA

The erection of the Ice Palace in Moscow, later renamed the Megasport Arena started in November 2005 at the Khodynka Field. This beautiful multi-purpose arena was completed in December 2006. Moscow Megasport is an unrivalled construction, meeting all the modern requirements needed to carrying out international sporting events. Basically it is aimed at hosting hockey, figure skating and short-track contests as well as over 20 other sports. The Megasport Arena radiates with its festive look. An unusual hovering ceiling is like a giant chandelier in the centre supporting a media cube providing a large four sided visual display which gives the 14 000 spectators a perfect view of the Ice surface. The media cube provides a colorful backdrop to the multi-colored seating design around the arena. FOAMGLAS® slabs were used in the Roof construction and are adhesively bonded to the crowns of the steel deck. The bonding technique, the high compressive strength & the dimensional stability of the insulation achieve an excellent rigidity of the whole roof system. Non-combustibility of FOAMGLAS® also plays also a key role in preventing possible damage in the future. Warm indoor air with high humidity – like a sport hall building – must not be allowed to condense within the construction build up otherwise the thermal integrity will not be maintained. FOAMGLAS® with its closed cellular glass structure is non hygroscopic, fully water and vapor-proof, keeping moisture out in long term. Insulating the roof of a high humidity building with FOAMGLAS® fulfills all requirements regarding building physics and indoor air quality. Finally this roof solution ensures a lifetime of performance without degradation.



Do it right the first time with FOAMGLAS®
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Build-up
1 Steel deck
2 Primer
3 FOAMGLAS® T4 140 mm in two layers (2 x 70 mm)
4 Top coat of hot bitumen
5 One layer of bituminous waterproofing membrane
6 Top layer of PVC membrane

Swimming pool Wood deck insulation

Swimming pool «Kraví hora», Brno, CZ

Architect Atelier DRNH, Brno
Construction 2002
Build-up FOAMGLAS® compact roof, approx. 1500 m² 160 mm type T4+, with EPDM membrane fully bonded with hot bitumen
Construction Wooden structure with humidity resistant plywood

The building of swimming pool in Brno district Kraví hora was awarded by several architectural prices for its original design. Part of the unique "light look" is given by chosen roofing system – compact FOAMGLAS® roof.

The thickness of the complete roof build-up (from ceiling to the water-proofing) is only 20 cm as it comprises only plywood, FOAMGLAS® and membrane. Despite the subtle look the roof performs perfectly over the humid environment inside the swimming pool. The compact roof is also really light weight itself, because no extra layers were needed (no ballast like in case of inverted roof, no second bearing structure like in case of ventilated roof).

The FOAMGLAS® compact roof also improves the fire resistance of the roof over public area. FOAMGLAS® compact roof enables to construct both subtle and reliable roofs over swimming pools and aquaparks and it gives "free hand" to architect to make creative design.

Ecologically recommended building material
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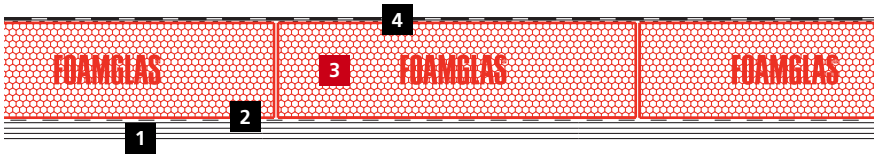


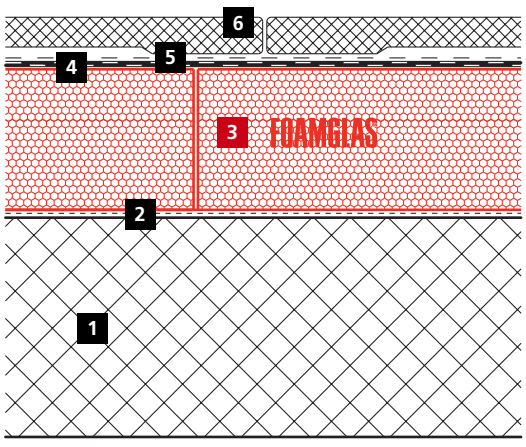
Build-up
1 Humidity resistant plywood
2 Bituminous primer
3 FOAMGLAS® T4 160 mm, compact roof system, in hot bitumen
4 Waterproofing single layer EPDM membrane adhered by hot bitumen

Compact Roof with paving slabs

The Russian White House, Moscow, Russia

Owner Government of Moscow
Architects Vladimir Ilyin
Refurbishment 2008
Constructor OOO Zodchiy
Thermal insulation 1200 m² FOAMGLAS® T4 150 mm with hot bitumen
Finish Paving slabs

Government of Russia Building, also known as the Russian White House, serves as the Russian Parliament. It was designed by the architects Dmitri Nikolaevich Chechulin & P.P.Shteller. The Construction started in 1965 and ended in 1981. This beautiful skyscraper of 119 meters high is built on the opposite bank of the Moskva River from Hotel "UKRAINE". Clad with white marble and a relatively narrow red granite strip around its base, it is one of the most important building in Moscow. An inscription at the base of the tower reads: "The House of the Government of the Russian Federation". The building was involved in the notorious attempted coup to overthrow the government in 1993, during which the tower was eventually bombarded by heavy artillery. The Government of Moscow decided to refurbish the flat roof of this building with cellular glass insulation. The FOAMGLAS® Compact Roof was the only true choice. The insulation is fully bonded to the structural deck using hot bitumen and as waterproofing two-layer bitumen roofing sheets were applied. This roofing solution does not only protect the building's structure in the long-term, but also protects the owner against expensive replacement or refurbishment.



When it comes to the point: FOAMGLAS®
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Build-up
1 Structural deck in concrete
2 Bituminous primer
3 FOAMGLAS® T4+ in hot bitumen
4 Two-layer bitumen roofing sheets
5 Geotextile (300 gr/m²)
6 Water-permeable paving Polymer tiles element (1 cm)

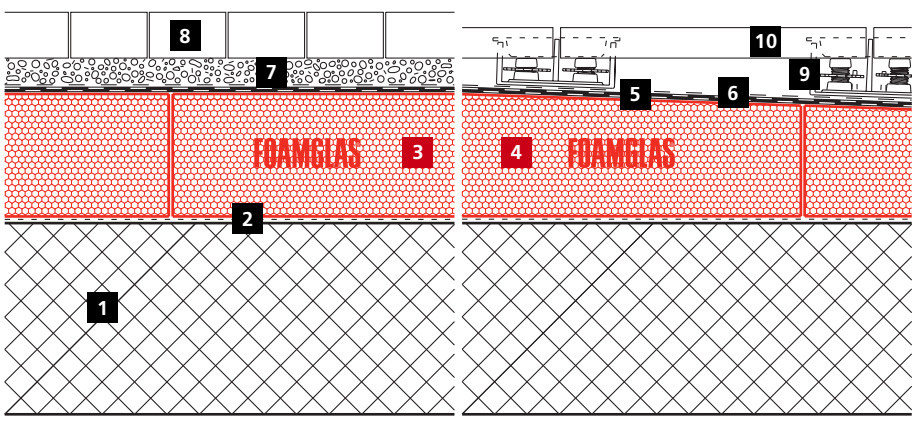
Flat Roof, Terraces

Museum of Islamic Art, Doha-Qatar

Architect I. M. Pei
Construction 2007
FOAMGLAS® application on flat roof. Total area of FOAMGLAS® applied for flat roof and facade behind stone cladding 22 000 m².

The Museum of Islamic Art is situated on the southern part of Doha's seafront on a manmade island about 60 meters off the coast of Doha. Terraces and other roofs with people traffic require a stable underground stone tiles to avoid any deformation or cracks of the finish. FOAMGLAS® can carry the highest load without being flexible. The load can be placed on top of the insulation without any thermal bridges. Where thermal efficiency needs to be combined with load bearing capacity, FOAMGLAS® cellular glass is the key player.

High load bearing capacity combined with highest rigidity enable the perfect detail
www.foamglas.com



Roof structure
1 Concrete roof deck
2 Primer coat
3 FOAMGLAS® slabs or
4 FOAMGLAS® TAPERED ROOF slabs, laid in hot bitumen
5 Two layers of bituminous waterproofing membranes
6 Separating/protective layer
7 Chippings or gravel
8 Interlocking paving stones
9 Support pads
10 Paving

Compact Roof, accessible to foot traffic

Stepped apartment buildings, Meilen

Architects Oliver Schwarz Architekten ETH / SIA / BSA, Zurich
Built 1996
FOAMGLAS® application Roof insulation, about 850 m² type T4+, 120 / 80 mm thick, in hot bitumen
Finish layer Boardwalk in hardwood

An exclusive residence with wonderful views across Lake Zurich is the perfect setting for the stepped apartment buildings with surrounding terraces. These spacious accessible terraces, which form the roof of the lower apartments, required a high performance insulation solution: the FOAMGLAS® Compact Roof. The robust and deformation-free insulation is designed to ensure a rain-proof construction for generations to come. Due to its outstanding physical qualities, FOAMGLAS® allows for a simple roof structure needing just a few basic components. The system is designed to eliminate the risks of water ingress and leakage.

The insulation system with superior performance minimizes maintenance and refurbishment
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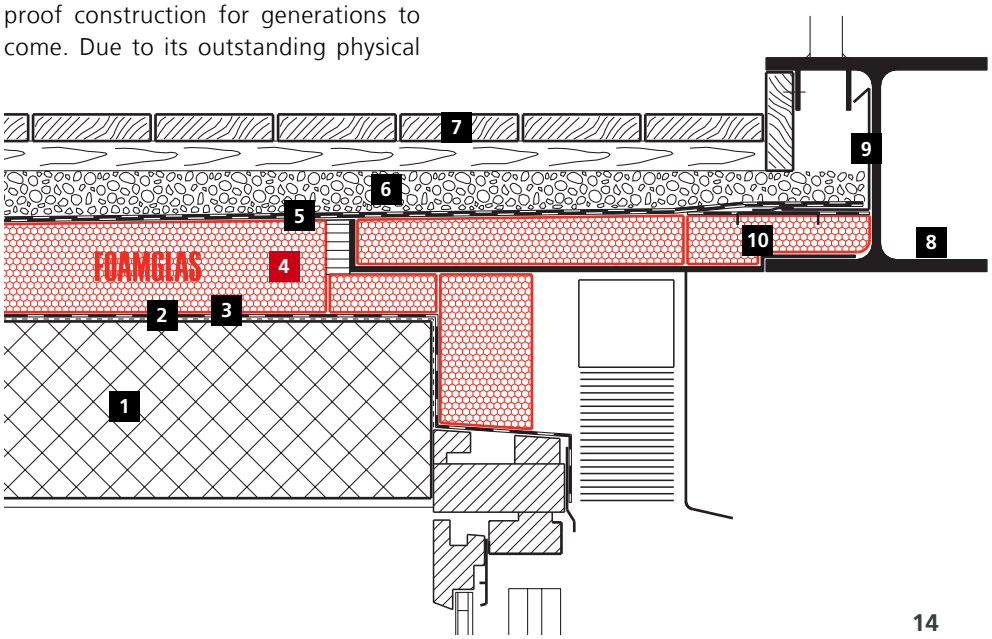
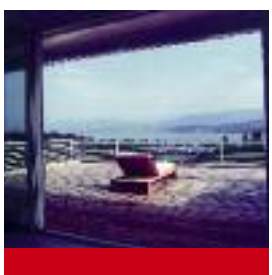


Terrace roof structure
1 Concrete decking
2 Bituminous primer coat
3 Emergency waterproofing (basic protection during construction)
4 FOAMGLAS® T4+ slabs in hot bitumen, 120 mm thick
5 Two-layer bitumen roofing sheets
6 Playground flooring screed (Barfo screed)
7 Boardwalk
8 HEA-bearer
9 Angle bar
10 FOAMGLAS® edge element



Compact Roof, accessible to foot traffic

Atocha Station Info Project, Madrid, Spain

Architect Rafael Moneo, Madrid
Refurbishment work 2010
FOAMGLAS® application Roof insulation, about 800 m² type T4+ Tappered, 50 to 220 mm, bonded in hot bitumen
Finish layer Granite slabs
Building Contractor UTE Dragados Tecsa Atocha Ampliación Complejo Fase I
Project Management ADIF

Atocha Station was inaugurated in 1851 under the name of "Mediodia Station", and was the first railway station at Madrid. This station was renewed after a fire under the direction of Alberto de Palacio, colleague of Gustav Eiffel, and the works took 4 years. The structure of the roof was built in Belgium with De Dion beams and is the more important element of "Atocha Station". Between 1985 and 1992 the refurbishment works intended to increase the passenger's capacity of the station and were leaded by architect Rafael Moneo. Those works and the works finished in 2010 have joint several stations in one: local trains, medium and High range trains (including the high speed AVE), buses, metro and a Parking. The old station was converted in a commercial mall including a tropical garden. The Works that finished in 2011 allows the new connection by high speed with Valencia renewing the "Puerta de Atocha" terminal.

Ecologically Recommended building material
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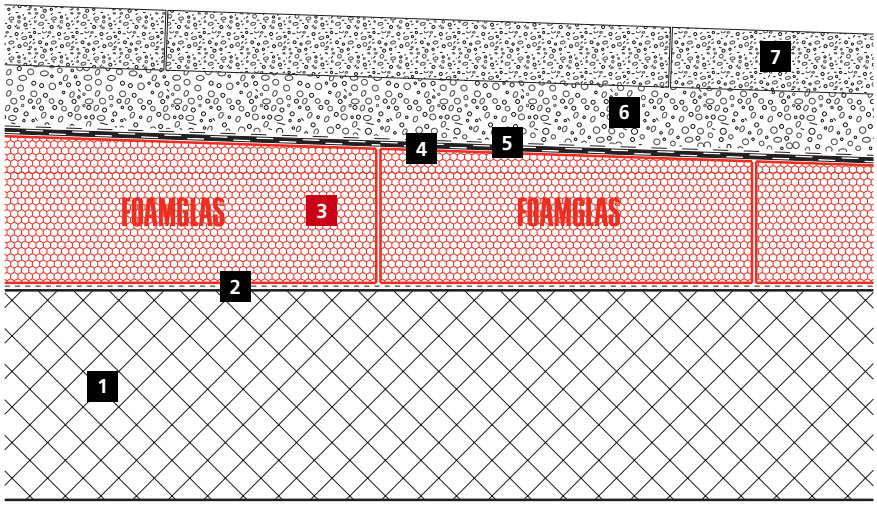


Build-up

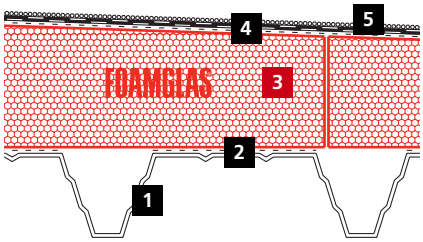
1 Concrete support
2 Bituminous primer ± 0,3 kg/m²
3 FOAMGLAS® TAPERED READY BLOCK T4+ slabs fully adhered with hot bitumen ± 4 – 5 kg/m²
4 Waterproofing membrane (1ste layer a 2nd layer)
5 Geotextile membrane
6 Mortar layer
7 Granite slabs

Compact Roof accessible to foot traffic

Pavilion's Hall of Volokolamskaya Metro Station, Moscow, Russia

Owner Moscow Underground
Architects Nekrasov Alexander Vasilyevitch
Constructor OOO Production Group "Intertransstroy"
Year 2009
Thermal insulation 5000 m² FOAMGLAS® T4 110 mm + FOAMGLAS® T4 TAPERED

The Moscow Metro opened in 1935 with one 11 kilometers line and just 13 stations and was the first underground railway system in the Soviet Union. Currently, 75 years later the Moscow Metro has grown to 182 stations and over 300 kilometers of track. The system is mostly underground, with the deepest section located at a depth of 84 meters. The Moscow Metro was one of the USSR's most extravagant projects. The stations combined aestheticism, technology and ideology. Stalin directly ordered the metro's artists and architects to design a structure that embodied a "brilliant and radiant future". With the use of reflective marble walls, high ceilings and grandiose chandeliers, many of the Moscow Metro stations are so well lit they have been likened to an "artificial" underground sun. This underground communist paradise served as a constant reminder to passengers that Stalin and his party had delivered something amazing to the people in return for their sacrifices. Stalin directed the architects to design structures that would encourage citizens to look upwards to admire the station's art, as if they were looking up to admire the sun – and by extension – him as god. Without hesitation, the Metrogiprotrans choose a FOAMGLAS® Compact Roof system to thermally insulation an area of the accessible esplanade. In addition to its superior waterproofing qualities, the cellular glass insulation was specified because of its uniquely high compressive strength to provide a solid base for the pedestrian and vehicle traffic above.



All thermal and physical demands made on the insulation material are surpassed
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Build-up
1 Steel deck
2 Primer coat
3 FOAMGLAS® TAPERED ROOF slabs, laid in hot bitumen
4 Top coat of hot bitumen
5 Two layers of bituminous waterproofing memnbranes, top layer U-resistant

Compact Roof accessible to foot traffic

Zhivopisny Bridge, Moscow, Russia

Owner Moscow City
Architects Shumakov N., Shurygina N.
Constructor GUP MOSOTRYAD – 4
Year 2005 – 2008
Thermal insulation 1000 m² FOAMGLAS® T4 100 mm & 150 mm
Finish Tiles

Zhivopisny Bridge is a Cable-stayed bridge that spans Moskva River on the north-west of Moscow. Opened £on 27 December 2007 as a part of Krasnoprenensky avenue. It is the highest cable-stayed bridge in Europe. The bridge is unique in that most of its length runs along the river, not across it. Total length of an S-shaped deck exceeds 1,5 km, including a 420 meter long, 47 meter wide main section running 30 meters above and along the centerline of the river. 72 solid orange ropes thirty centimeters in diameter support the bridge, each of them consists of fifty wire cables. This bridge is currently a symbol of Moscow and one of the most beautiful constructions of the city.

FOAMGLAS® meets the most ambitious safety demands.
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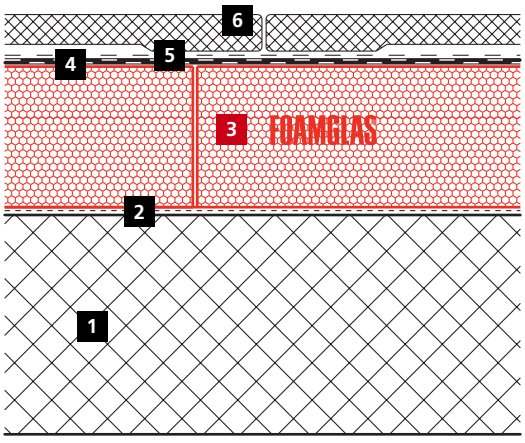
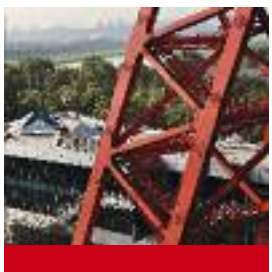


Build-up
1 Structural deck in concrete
2 Bituminous primer
3 FOAMGLAS® T4+ in hot bitumen
4 Two-layer bitumen roofing sheets
5 Geotextile (300 gr/m²)
6 Water-permeable paving Polymer tiles element (1 cm)

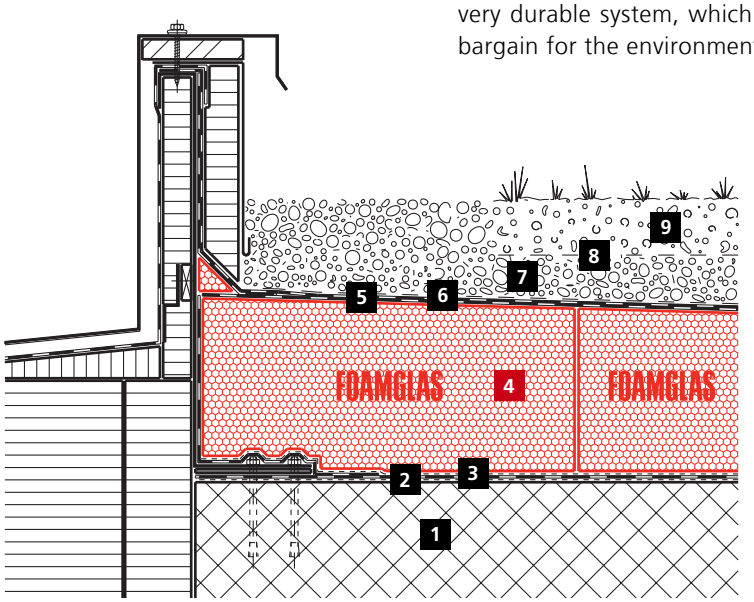


Green Compact Roof

The Home of Fifa, Zurich

Architect Tilla Theus und Partner, Zurich
Built 2006
FOAMGLAS® application Main building, roof insulation: about 3470 m² type T4+ slabs in hot bitumen, 160 mm thick. Cloakroom building, roof insulation: about 1670 m² type T4+ slabs in hot bitumen, 2 layers. Tapered Roof System (cut-to-fall slabs), average thickness: 90/190/290 mm
Finish layers Extensive greening system

When building the new "Home of Fifa", the headquarters of the world's football/soccer governing body, maximum performance was required at all levels. The building needed being constructed in a record time and 'fair play' was required in all environmental matters. New ideas were demanded for decorative art on the building to reference the world of football. The Fifa headquarters is a so-called "zero emission" building. By use of the most energy efficient technologies it can be operated without fossil energy sources. A key element of this sustainable energy concept is the use of FOAMGLAS® thermal insulation. Cellular glass insulation is an ecological building product that provides important energy-savings. It is made from recycled glass using renewable energy sources. Last but not least, the Compact Roof is a very durable system, which is the best bargain for the environment.



Flat roof construction with the best scores for economic and ecological performances
www.foamglas.com

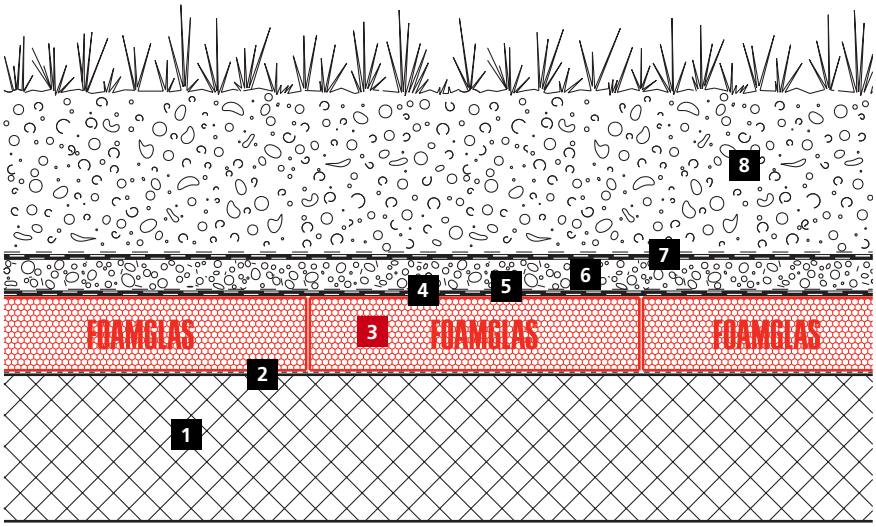
Roof structure
1 Concrete decking
2 Bituminous primer coat
3 Emergency waterproofing (basic protection during construction)
4 FOAMGLAS® T4+ slabs in hot bitumen, 160–200 mm thick, and angle fillets
5 Bitumen roofing sheets, 2 layers
6 Protection layer PP-nonwoven 800 g/m²
7 Drainage gravel 8/16
8 Filter layer
9 Extensive roofing system

Green Compact Roof

Swarovski Group, Wattens

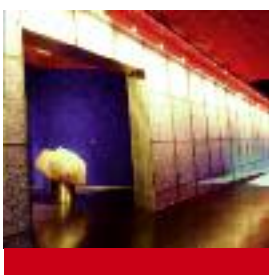
Art director Andre Heller
Architect Mag. Carmen Wiederin and Propeller Z, Vienna
Ing. Georg Malojer, Project Management GmbH & Co, Innsbruck
Built 1995 / 2003 / 2007
FOAMGLAS® application Roof insulation, about 5200 m² type T4+ slabs in hot bitumen, 100 mm thick
Roof finish Intensive greening system

As with the first building of Swarovski Crystal Worlds, FOAMGLAS® insulation systems were chosen for the extension "Sequel of Fairy Tales". "Crystal Worlds" – an underground building – was designed with a most demanding roof structure. A critical concern was replacement and repair work on green roofs of that scale and design could possibly require investment and shut down the enterprise. Therefore, the principal selection criteria for thermal insulation was efficient, totally weatherproof, failure-free roof system that would last for decades. The high compressive strength of the insulation was an additional reason. FOAMGLAS® was selected, since the filled ground topping the roof structure is meters thick and the roof has to bear considerable soil pressure.



FOAMGLAS® – Compact Roof, double security to prevent water ingress
www.foamglas.com

Roof structure
1 Concrete deck
2 Bituminous primer coat
3 FOAMGLAS® T4+ slabs, 100 mm thick, in hot bitumen
4 Bitumen roofing sheets, 2 layers
5 Building protection mat
6 Drainage layer
7 Filter layer
8 Intensive greening system

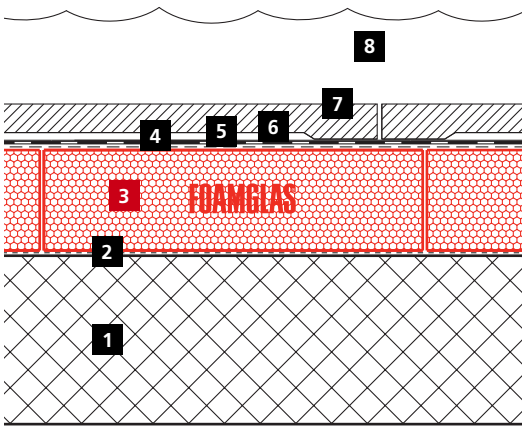


Compact Roof covered by an expanse of water

Walterboscomplex, Apeldoorn, Holland

Architect Neutelings Riedijk Architecten, Rotterdam, Holland
Built 2004
Application 11 000 m² of FOAMGLAS® T4
Finishing Water

The Walterboscomplex houses one of the largest branches of the Netherlands Central Tax Office. The original buildings wer built in the 1960s and consisted of four office towers surrounded by parking bays and number of temporary buildings. By the late 1990s, the site required modernization and a new master plan was commissioned to bring complex up to date. The new main architectural element that can be seen by the public from the street is the large reflecting pool with a clutch of stainless steel-clad cones rising from it. Architects designed this plinth building as a sunken structure, which opens into two large underground patio gardens. The roof of the sunken building is covered by an expanse of water, a reflecting pool that gives the grounds a natural aura and connects with the parkland surrounding the complex. All central facilities are located beneath the pool. The reflecting pool also works as a security barrier to protect the grounds from intruders. At the same time, the water is a buffer tank used for cooling the building & for sanitary water. Captive roof's are being increasingly designed as a buffer for rainwater in order to relieve the drainage system during heavy rains. But they also offer other options: Aesthetic beauty as well as a reservoir of water in case of fire! With over 5 million liters above the head of this Green Complex, the FOAMGLAS® Compact Roof has been logically chosen by the specifier. The system is designed to eliminate the risks of water ingress and leakage due to the impervious qualities of the cellular glass insulation.



Captive Roof's, no risk if you chose FOAMGLAS®
www.foamglas.com

Build-up
1 Concrete slab
2 Bituminous Primer
3 FOAMGLAS® glued with hot bitumen 110/30
4 Coating of hot bitumen
5 Bituminous membrane
6 EPDM/SBS membrane
7 Tiles as protection in option
8 Level of water

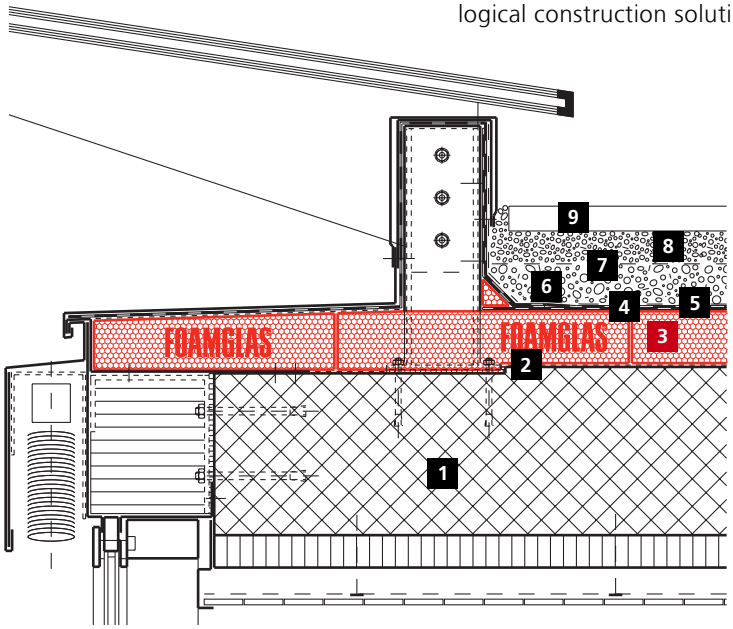
Green Compact Roof

Centre Patronal, – Employer's Federation, Paudex

Architect / planner Pierre & Fabien Steiner SA, Brent
Built 2000
FOAMGLAS® application Roof insulation, about 6600 m² type T4+ slabs, 200 mm thick and about 900 m² type S3 slabs, 80 / 100 mm thick, in hot bitumen
Finish layers Extensive and intensive greening systems

The architecture of green flat roofs is far more than a feast for the eyes. Having chosen for a FOAMGLAS® system, excellent thermal insulation and efficient protection of the roof structure is ensured. The high compressive strength of the FOAMGLAS® insulation makes it an ideal product for all types of green roofs. Green roof construction moreover has the beneficial effect of reducing rainwater runoff into the sewer system and improves the microclimate. Outstanding physical qualities including rain- and vapor-proofing capacity, high compressive strength, resistance to acids and organic solvents, resistance to all kinds of vermin enable FOAMGLAS® insulation to lead the way to sustainable and cost-efficient ecological construction solutions.

Forward looking planning: FOAMGLAS® – simply a question of cost efficiency and ecology
www.foamglas.com



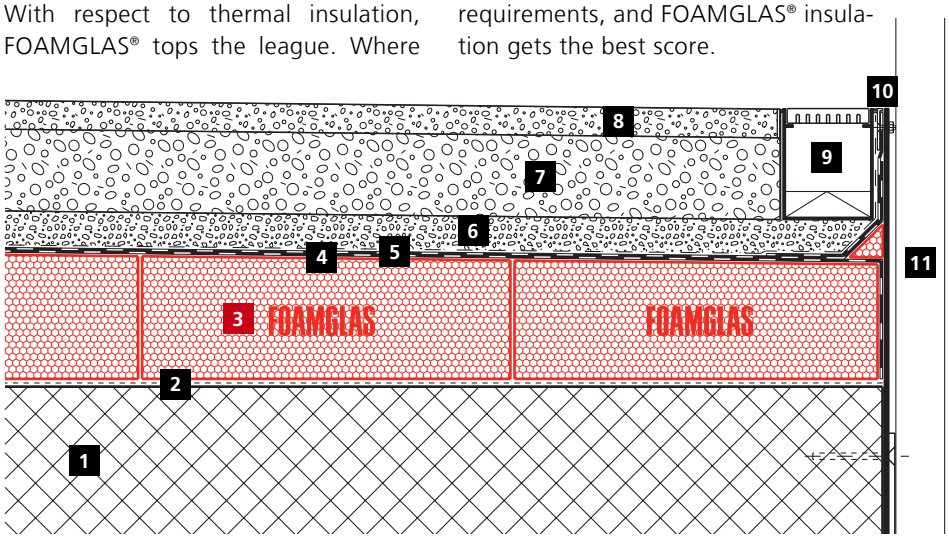
Roof structure
1 Concrete deck
2 Bituminous primer coat
3 FOAMGLAS® S3 slabs in hot bitumen, 80 mm thick
4 Bitumen roofing sheets, 2 layers
5 Protection layer, nowoven
6 Expanded clay
7 Filter layer, glass fibre membrane
8 Bed of fine gravel
9 Cement tiles

Compact roof for Car Park decks

Letzigrund Stadium, Zurich

Architect Betrix & Consolascio Architekten, Erlenbach
Frei & Ehrensperger Architekten, Zurich
Built 2007
FOAMGLAS® application Roof insulation, about 2680 m² type F slabs in hot bitumen. Tapered Roof System (cut-to-fall slabs), 130 mm average thickness
Finish layer Grouting asphalt pavement

The characteristic feature of the new Zurich Letzigrund Stadium is elegance and not intrusion. Slim, slanting stays support the stadium roof. The inner court and the stands are partially embedded in the ground. It is a multi-purpose event arena, where soccer/football and athletic sports (Zurich World Championships in Athletics) have excellent facilities and utilities. With respect to thermal insulation, FOAMGLAS® tops the league. Where thermal efficiency needs to be combined with heavy duty (trafficked service decks), FOAMGLAS® cellular glass insulation is a key player. It is also a front-runner as an ecological building product. It does not give off harmful emissions (low-e product) and fulfills all requirements regarding health and indoor air quality in buildings. Finally, durability is one of the essential requirements, and FOAMGLAS® insulation gets the best score.



Peak performance: compressive strength, safety, durability
www.foamglas.com

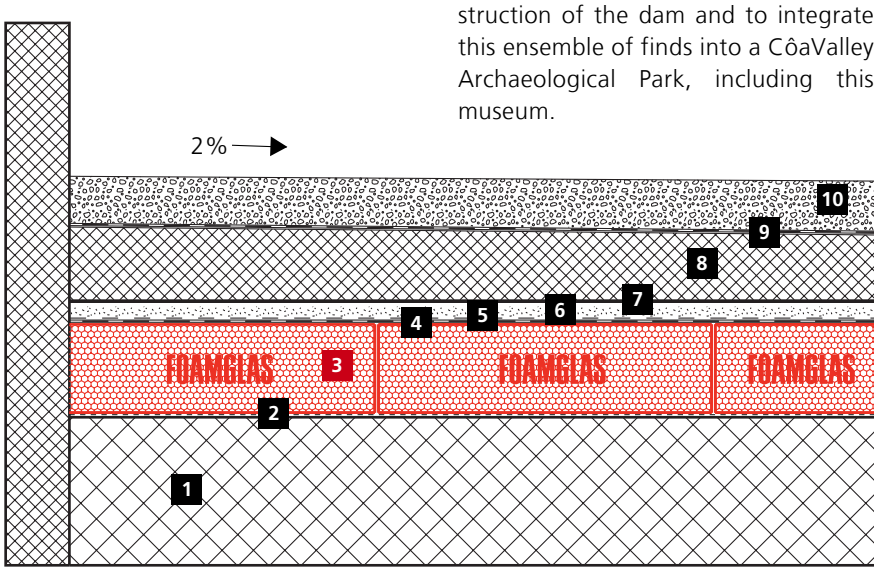
Roof structure
1 Concrete deck
2 Bituminous primer coat
3 FOAMGLAS® F slabs in hot bitumen, 130 mm thick, Tapered Roof System
4 Bitumen roofing sheets, 2 layers
5 Separating layer
6 Protection layer in mastic asphalt, 30 mm thick
7 HMT top layer, 100 mm thick
8 Grouting asphalt pavement, 35 mm thick
9 Gutter
10 Flashing strip
11 Parapet

Parking Roof Foamglas® S3 Compact Roof

Museu de Arqueologia de Foz Côa, Portugal

Architecture Pedro Lacerda Pimentel – Camilo Rebelo
Engineeering GOP – Gab. de Organização e Projectos Lda
Nunes da Silva and Ana Silva
Construction 2007–2009
Thermal Insulation FOAMGLAS® Compact Roof
Final Roof coverage asphalt

In 1989, E.D.P. (Electricidadede Portugal) ordered an Environmental Impact Study to be caried out in the Côavalley, in preparation for the construction of a large dam to be located near the mouth of the river. In the framework of that study, a team of archaeologists made a preliminary survey of the area to record and evaluate the cultural heritage items that would be submerged or destroyed as a result of the construction of the dam. An important aray of archaeological sites was identified, including four rock-shelters with prehistoric paintings. In November 1995, recognisingthe importance of the cultural heritage of the region, the Portuguese government decided to halt the construction of the dam and to integrate this ensemble of finds into a CôaValley Archaeological Park, including this museum.



Ecologically Recommended building material
www.foamglas.com

Parking roof description
1 Concrete support
2 Bituminous primer ~0.3 kg/m²
3 FOAMGLAS® S3 Slabs fully adhered with hot bitumen ~5–7 kg/m²
4 Waterproofing membrane
5 Polyethylene sheets
6 2 cm mortar
7 Acoustic layer
8 Light concrete
9 Waterproofing membrane
10 8 cm cold bituminous asphalt

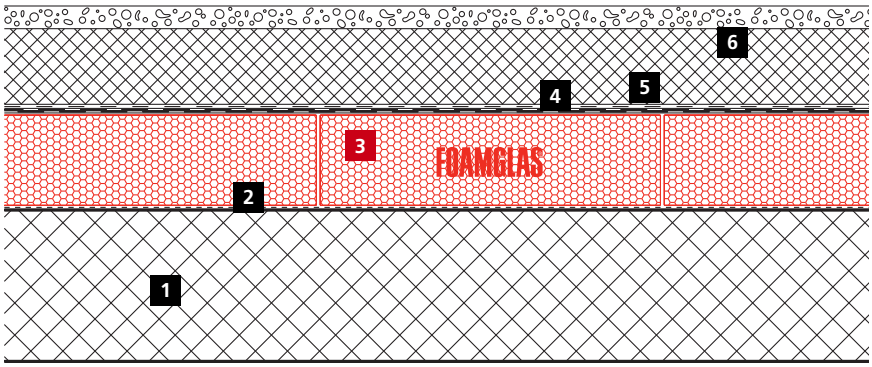
Parking roof

Shopping Mall, Merter M1 Merkez Santiyesi, Istanbul

Owner Metro Group
Contractor builder IS
Insulation Contractor ICS
Thermal insulation FOAMGLAS® T4 in 8 cm thickness
Year 2009

In Istanbul, the owner and the contractor decided to use FOAMGLAS® as thermal insulation on the parking roof of the shopping mall. FOAMGLAS® was choosen not only because of his high compression resistance but also because the compact roof systems was one of the best guarantee for the Real Hypermarket underneath the roof. The 2000 m² of roof where insulated with FOAMGLAS® fully adhered to the concrete slab. On top of FOAMGLAS® two waterproofing membranes where 100 % adhered and a slip layer was loose laid before applying a finishing concrete.

On the safe side.
www.foamglas.com



Parking roof description

1 Concrete support
2 Bituminous primer ~0.3 kg/m²
3 FOAMGLAS® Slabs fully adhered with hot bitumen ~5–7 kg/m²
4 Two waterproofing membranes
5 Slip layer, PE 0.2 mm +/- 200 g/m²
6 Concrete finishing for road traffic

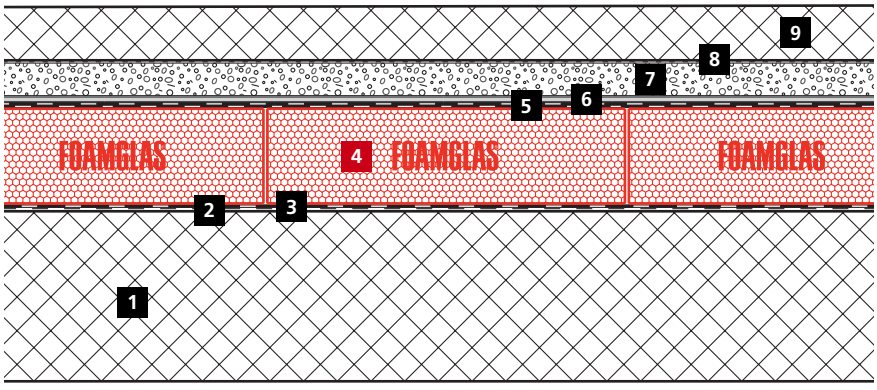
Parking deck for heavy traffic Bus terminal

Shopping centre «MERCURY», České Budějovice

Architect Atelier 8000, České Budějovice
Construction 2006
Build-up FOAMGLAS® compact roof, approx. 8500 m² 140 mm type S3, with 2 layers of bituminous membranes fully adhered by hot bitumen
Surface finish Concrete redistribution slab on acoustic layer

The Architect's task was to place the bus terminal of 100 000 citizens city České Budějovice on the roof of Shopping centre located on the premises of old ground Bus terminal. The FOAMGLAS® compact roof offered the unbeatable compressive strength and most reliable solution compare to all competitive build-ups. The main advantages of FOAMGLAS® in this project are: high compressive strength and rigidity, chemical resistance to oil products, durability and water-tightness of entire roof build-up. The bus terminal serves several hundreds of buses every day and is located directly above the shopping floor. The acoustic layer based on rubber mat and gravel layer was adapted to the design. The bus terminal build-up is designed not only for bus passing or its short stops, but also for longer time parking and enables also to carry minor repairs – i. e. tyre exchange which requires use of the lifting jack and can cause heavy point loads.

Ecologically recommended building material
www.foamglas.com



Build-up
1 Concrete
2 Bituminous primer
3 Temporary waterproofing
4 FOAMGLAS® S3 140 mm, compact roof system, in hot bitumen
5 Waterproofing 2-layers bituminous
6 Rubber mat
7 Fine gravel
8 PE-foil
9 Reinforced concrete deck

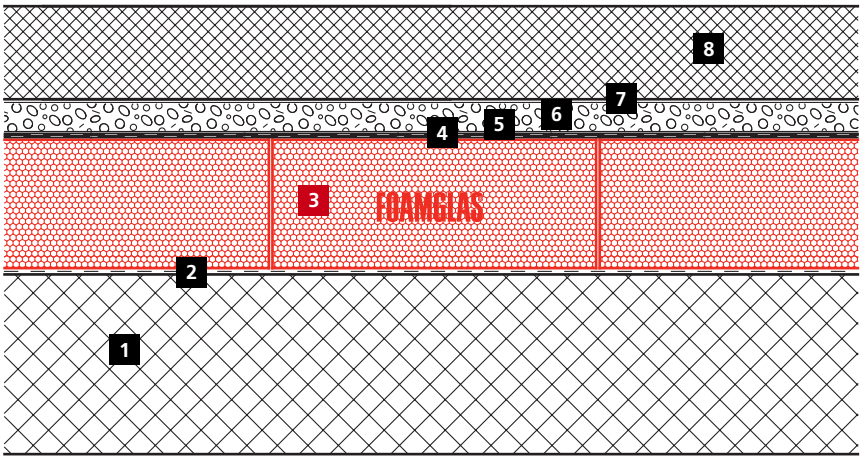
Compact Roof for Car Park decks

Château d'Yquem, Sauternes, Bordeaux, France

Owner Château d'Yquem
Architects Atelier d'Architecture A3A
Constructor Sarec
Year 2009
Thermal insulation FOAMGLAS® S3 180 mm

The Château of Yquem, in Sauternais, has an international reputation within the wine world. The Castle itself was acquired by Jacques de Sauvage in December 1593. The history of Château d'Yquem is like a novel. It is an epic saga full of intrigue, fortune and colorful figures covering more than four centuries. The secret of the wines of Château d'Yquem are still a mystery, cultivated by a family passion that passed through more than 12 generations, and pursued today by LVMH, the majority shareholder group of the Estate since 1999. To optimize its logistics operation, the Domain built near the Castle a parking roof specifically for the frequent heavy traffic used to distribute the estate's produce to the world. Thanks to its outstanding qualities, the Compact Roof FOAMGLAS® will ensure a lifetime of performance without degradation.

FOAMGLAS® – a classical example of a material with a promising future
www.foamglas.com



Build-up
1 Concrete deck
2 Hot bitumen
3 FOAMGLAS® S3 18 cm
4 Bitumen roofing sheet, 2 layers
5 Desolidarisation
6 Gravels
7 Desolidarisation
8 Load distribution slab

1 Secondary school Weid, Pfaffikon (Switzerland)
2 Lack of dimensional stability of insulation materials can cause warping and the roofing felt joints to burst open.

Roof constructions covering heated rooms

Three variations exist in the construction of thermally insulated flat roofs: the single skin flat roof (warm roof), the inverted roof and the twin-skin flat roof (cold roof). The design challenges associated with flat roofs can easily be avoided by choosing a FOAMGLAS® solution. In the following sections, some successful FOAMGLAS® solutions are outlined.

Warm roof

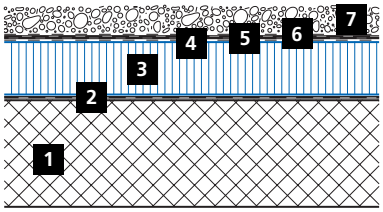
Flat roofs, using insulation materials that are not stable when exposed to the effects of rain or frost-thaw cycles are at risk of thermal performance loss and need a 100 % effective waterproofing membrane for moisture protection. As the roofing sheets on top are generally very impermeable to water vapor, a vapor control layer has to be laid beneath the insulation layer.

■ **With rigid FOAMGLAS® being laid on plain structural decking there is no need to install an additional vapor-barrier, because cellular glass Compact Roofs are totally impermeable to diffusion.**

The waterproofing is at serious risk where point loads puncture the roofing sheets that have been installed over low-density and compressible insulation. The compressive strength of the insulation is quickly exceeded. Lack of dimensional stability of insulation material when exposed to thermal shock can also cause damage to the weatherproofing membrane.

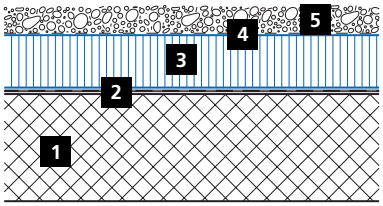
■ **Dimensional stability and integrity of FOAMGLAS® is absolute. It remains stable, and even under permanent load, the roof system is fully supported by the high compressive strength of FOAMGLAS®. The structural integrity and puncture resistance of the system reduce the likelihood of leakage.**

2



Conventional roof structure of a non-ventilated roof ("warm roof")

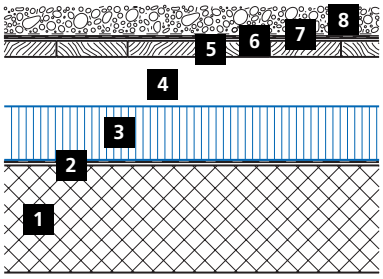
1 Structural deck (e. g. reinforced concrete)
2 Vapor-barrier
3 Thermal insulation (tapered slabs, if required)
4 Separating layer, dependent on type of roofing sheets
5 Roofing sheets
6 Protection and separating layer
7 Finish layer



Roof structure of a non-ventilated roof ("Inverted roof")

1 Structural deck (in general reinforced concrete)
2 Waterproofing membrane
3 Extruded polystyrene boards (XPS) with shiplap edge profile
4 Filter layer (permeable to diffusion)
5 Finish layer

As in the FOAMGLAS® Compact Roof moisture is kept away from the structural deck, as the weatherproofing membrane is directly bonded on to the deck.



Roof structure ventilated roof (cold roof)

1 Structural deck (e. g. reinforced concrete)
2 Vapor-barrier
3 Thermal insulation
4 Ventilation space
5 Outer shell (e. g. timber deck)
6 Separating layer
7 Roofing sheets
8 Finish layer

In rare cases of water ingress, moisture is generally kept at the surface of the insulation. **FOAMGLAS® forms an impervious skin that protects the roof. All roof components and layers are bonded to each other so the insulation will not absorb water and the system prevents the spread of water.**

With conventional systems, water which has entered the roof, will find its way to any imperfection in the vapor control layer, run on the concrete deck and leak out inside the building. This makes it difficult to detect the origin of the damage, and is likely to have harmful consequences for the insulation.

Inverted roof

The waterproofing membrane is directly applied to the structural deck and then covered with an insulation that is moisture resistant when exposed to intermittent water load. Often extruded polystyrene insulation (XPS) is used.

However, in many environments insulation boards are frequently soaked by rainwater and XPS-boards become permeable to diffusion. Diffusion-tight covering layers can lead to increased moisture content in the insulation, and, wet insulation results in significant heat loss as the heat is withdrawn by the water flow beneath the insulation boards. Permanently wet layers have the same effect as a topside vapor-barrier and should be avoided.

For inverted green roofs, Green Roof Building Regulations demand protection of the thermal insulation from root penetration. This requires anti-root membranes, which are, totally vapor-proof. Use of these special roofing sheets is, however, contrary to the requirement of using covering layers permeable to diffusion.

■ **FOAMGLAS® cellular glass is impervious to the effects of moisture and is not affected by heat loss or interstitial condensation. A dry insulation is the best protection against roots.**

Deformation and irregularities in the structural deck can also be harmful to the weatherproofing sheets and can even damage them. Irregularities in the weatherproofing surface (e.g. side overlaps of bitumen roofing sheets, in particular with 5 mm thick torch-on membranes) can create voids beneath the insulation, which are likely to haul concrete stone pavements of trafficked roofs. **FOAMGLAS® installation method is fast and easy. Potential irregularities at the insulation surface, which may be passed on from the sub-construction, can simply be levelled out with a grinding tool. FOAMGLAS® thus provides an optimal, stable and plane bearing surface for the roofing sheets.**

Cold roof

This construction is twin-skin based on a thermally insulated sub-roof and an outer shell with weatherproofing – and in between a ventilated roof space. In principal, the ventilation space helps to prevent condensation from being absorbed. In comparison with warm roofs, cold roofs have the advantage that wet insulation has the chance to dry.

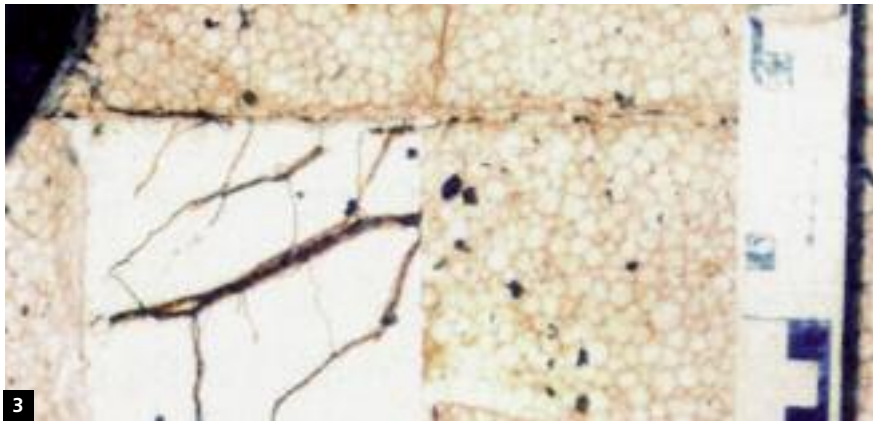
■ **FOAMGLAS® roof systems do not require a ventilation space, as cellular glass is resistant to moisture absorption (water and vapor) and acts as an efficient vapor-barrier. The rainproof insulation does not get wet from rain or mist. This eliminates the risk of wet insulation being built in.**

In a ventilated roof very small leaks may not affect the construction, as there is a chance for it to dry out. In cases of more significant leakage, even after repair, the problem may persist unless all roof components are removed. With an unpredictable leakage path, resolving it may prove to be a futile task.

■ **The FOAMGLAS® Compact Roof is impervious with all insulation slabs and layers being bound to each other, forming a water tight layer that prevents the ingress of water. As it is a sealed system, the problem tracking in case of leakage is very easy.**

Accessible or trafficked flat roofs, which must meet additional demands and require appropriate building technology, generally have no cold roof layout.

3 Durchwurzelte Kunststoffdämmung
4 Wassergesättigte Bereiche in einer Umkehrdachdämmung
5 Durchfeuchtete Wärmedämmschicht unter Pflasterbelag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Sloping roofs

In the direction of the roof slope, the weather-proofing level should present a falling gradient of at least 1.5 % to the outlet or drainage gutter. If the falling gradient is less, specific measures have to be taken. For instance, the drainage capacity needs to be improved by lowering the outlet opening by at least 20 mm below the weatherproofing surface. For balconies, accessible roofs, terraces or roofs without protection and mastic asphalt layers or for non-ventilated timber constructions a falling gradient lower than the stipulated bare minimum is not allowed (see Building Regulations).

With warm roof construction the falling gradient can be created by a screed to fall on the concrete deck or by using cut-to-fall insulation slabs.

Inverted roofs should not be designed with extruded polystyrene cut-to-fall insulation slabs, as adaptation and leveling out by grinding become necessary. The full integrity of the foamed skin is essential to ensure the performance of the roof system. In addition, the lowering of the rainwater outlets (if the falling gradient is lower than stipulated) becomes problematic, since the waterproofing sheets are applied to the structural concrete deck and 'soft' insulation is not well suited to make recesses once installed.

You should also be aware that accessible roofs – designed with thermal insulation on top of the waterproofing – do not allow for a reverse gradient. Unlike warm roofs, totally horizontal inverted roofs cannot be designed (with regard to the constructional tolerances).

■ **FOAMGLAS® Tapered Roof System provides an intelligent solution. The insulation slabs are tapered for any specific project and specified gradient. The construction of a FOAMGLAS® Tapered Roof is recommended in all cases where an additional screed-to-fall on the structural deck is not practicable, either because of stability and load limitations or because of the roof drainage pattern.**

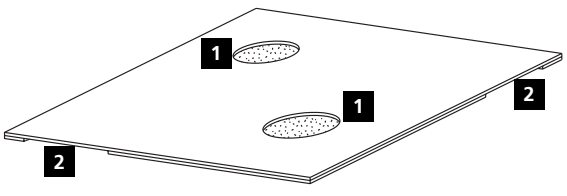
In order to prevent any water ingress FOAMGLAS® Compact Roofs or inverted roofs using FOAMGLAS® should not be constructed with an additional screed-to-fall layer on top of the insulation. This is to prevent the risk of leakage paths within the screed where flashings/connections to parapet walls, doorsills or roof outlets may be finished improperly.

Weatherproofing – one- or two-layer system?

A two-layer waterproofing system is preferable to one, as two layers applied to the insulation have better puncture resistance and product reliability in case of bad spots in the roofing membrane. With single-ply roofing membranes (and felt joints) full imperviousness to rainwater must be achieved. With two or multiple layers of weatherproofing bonded to each other, minor imperfections in one of the sheets does not allow water ingress into the roof.

1 Imperfections in the cap sheet
2 Imperfections in the underlay sheet

Two layers of roofing sheet fully bonded to each other provide safer rain proofing in case of bad spots in one layer or the other



1 Stadium ‘Stade de Suisse’ Wankdorf, Berne

Types of usage and construction layout

Compact Roofs are classified according to the type of usage: Compact Roofs with limited accessibility, accessible Compact Roofs (terrace roofs), green Compact Roofs, trafficked Compact Roofs and ‘natural or naked’ Compact Roofs. The following section outlines the different kinds of usage and the specific design principles. With focus on failure-free performance, some planning rules are provided how to avoid possible damage.

Compact Roof with limited accessibility

The Compact Roof with limited access is a flat roof where accessibility is only allowed for maintenance. Thermal insulation is FOAMGLAS® T4+ and the slabs are fully bonded to the structural deck using hot bitumen. A polymer bitumen weatherproofing is applied in two layers – and covered by a protection layer; for instance a synthetic fiber fleece that fulfills mechanical protection and filter functions. To ensure long membrane life, a heavy protective layer of washed roofing gravel (shingle) is placed, to offer resistance against mechanical stresses and UV-attack.

For details of the different FOAMGLAS® roof systems see page 9.

Accessible Compact Roof

The accessible Compact Roof is frequently situated in close proximity to common rooms. It covers heated rooms and can be used as outdoor living space. The elementary structure up to the weatherproofing is identical to the Compact Roof with limited accessibility. In cases where no impact noise is also an issue, sound insulation boards can be laid to replace the fleece layer. The flooring is generally made of ceramic, concrete, cast stone or natural stone tiles, occasionally asphalt layers or boardwalk finishes are laid. Tiles are either set into a mortar screed, into a bed of fine gravel or placed on pressure distributing rubber pads.

Green Compact Roof

With green roofs, distinction is made between extensive and intensive planting systems. Typical coverings for the extensive planting systems are low-level foliage and ground-cover plants, which are not very demanding regarding soil thickness, nutrition and irrigation requirements. A soil thickness of 5 to 10 cm is sufficient for these types of plants and they can even grow on pitched or sloping roofs.

Typical possibilities for the intensive planting systems are conventional roof gardens, where time is spent and which are kept immaculate. Plant and landscaping choices are nearly unlimited. The plant species require a soil thickness from 15 cm to 1.5 m. Depending on the type of plantings and their maintenance/nutrition requirements a distinction is made between "simple intensive plantings" (grasses, herbaceous perennials, low-growing bushes) and "intensive plantings" (including bushes and trees, needing space for development). The layout of a green Compact Roof from the waterproofing level upward generally includes the following functional layers (from top to bottom):

Soil: or the planting medium for the plants
Filter layer: to prevent fine particulate soil from obstructing the drainage layer
Drainage layer: to carry off rainwater or for water retention
Building protection mat: to offer protection against mechanical damage of the anti-root membrane and the roofing sheets
Anti-root membrane: to protect the waterproofing against root penetration (not required as an additional layer, if the roofing sheets themselves are anti-root)

For extensive planting systems a falling gradient of at least 1.5 % is recommended. With intensive planting systems the rainwater is generally used to feed the plants and the installation of a water retention irrigation system on top of a zero degree waterproofing level meets the requirements.

The planting system protects the building's waterproofing against thermal stresses. However, risks of damage may come from activities as:

- **horticultural work and outdoor leisure (risks of mechanical damage)**

With extensive planting systems the effort to detect possible leakage and to complete repair work are as complicated as on terrace roofs with tiles in a bed of fine gravel. With intensive planting systems (thick soil layers etc.) these efforts and expenses can be much more significant.

As the source of the damage and the damage caused by leakage are not located together, it is highly recommended to use materials, that limit or prevent the moisture penetration inside the insulation: therefore fully bonded and impervious FOAMGLAS® Compact Roof systems are the best choice.

Trafficked Compact Roof

In this application preference is given to the FOAMGLAS® system due to the high compres-sive strength and the higher resistance to edge pressure of cellular glass. This is true also for heavy traffic – for instance, heavy goods vehicles (HGV). The allowable stresses can be applied without any deformation of the insulation. The result is total security with a slim roof construction.

In rooftop car park decks, roofing membranes are directly applied to the insulation layer. To protect the waterproofing skin a load distribution layer is required. The thickness/reinforcement of the pressure distribution slab is dependent on the load assumptions and the wheel load. If an asphaltic wearing course is demanded, a mat reinforced concrete slab of about 8 cm must be laid beneath the two-layer mastic asphalt topping. This reinforced concrete slab must be used for areas that are exposed to weathering and not sheltered by a roof. In these exposed areas, heating and softening of the mastic asphalt may be considerable. In addition, it has to be taken into consideration that, compared to non-accessed flat roofs, car park decks are subject to various additional stresses, which can be quite high and induced by:

2 Insulation penetrated by roots
3 Spreading/deformation of the pavement in consequence of a soft, resilient substrate
4 Breakage of tiles and tilt up of sleepers as a result of deflecting insulation in sub-construction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- **Mechanical stresses on the waterproofing caused by the pavement and the traffic load**
- **By braking and acceleration, shear forces around curves**
- **On the joints / transition zones of large paving slabs or on joints of the load distribution slab**
- **Stresses on the waterproofing due to the deformation of the supported load distribution slab (changes in temperature)**
- **Stresses at fissures in the load distribution slab (caused for instance by insufficient or lacking joint cutting)**
- **Stresses on the waterproofing due to deformation of the structural deck under the traffic loads**
- **Stresses on the waterproofing during construction (for instance during laying of the concrete or the pavement blocks)**
- **Stresses on the borders of the overlay in front of rising walls (in particular with rigid topping).**

The above inventory of stress factors makes it obvious that the choice of a high-grade waterproofing and thermal insulation system is essential for the service life of a car park deck. Particularly critical is that the weatherproofing membrane be both robust and flexible.

Dependability of car park deck layouts: Leakage detection on warm roofs with reinforced concrete pavement is rather difficult because of the long leakage paths and repair work requires extensive effort and money. That being the case, FOAMGLAS® solution is the first choice. Cellular glass thermal insulation slabs fully adhered and bound to each other with hot bitumen (and the waterproofing applied by pour and roll) ensures system integrity and provides protection against water ingress.

Standard Compact Roof (au natural) – with two-layer waterproofing

Where roofing efficiency and minimal dead load are key requirements, the standard Compact Roof without any protection layers or specific use finishes provides the ideal solution. The roof system must ensure full wind load resistance. The wind forces have to be passed on to the structure without any risk. In the standard Compact Roof au natural this is accomplished by means of bonding all layers to each other; from structural deck to insulation, to the weather-proofing. Since this is in general, the layout of industrial lightweight roofs on steel deck, this application is examined in more detail in the following.

Industrial lightweight roof: Lightweight construction is increasingly being used for commercial and industrial buildings. This means that flat roof systems without any protection or finish layers are being built. Where the indoor use requires thermal insulation, requirements for stability and the control of interactions in building have to be met as well. Conventional insulation systems often do not provide the same efficiency and safety in the long term as FOAMGLAS® systems can ensure. An insulation made of high compressive and non-combustible cellular glass has proven advantages.

Bonded system: particular requirements: With profiled steel decking for lightweight construction the trend towards particularly thin steel sheets, wide spans and wide troughs are observed. This is where the use of FOAMGLAS® adds to the structural stability of the roofing design.

FOAMGLAS® Boards and slabs are adhesively bonded to the crowns of the steel deck. The bonding technique, the high compressive strength and the dimensional stability of the insulation achieve an excellent rigidity of the whole roof system.

Non-combustibility and the imperviousness to water and water vapor of cellular glass play a key role in preventing possible damage as explained in the following.


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Damage symptoms and how to prevent them

Typical defects on flat steel deck constructions can be categorized in four groups:

- **Leakage (rainwater ingress from outside) – e. g. because of a combination of different materials, insufficient fixing at connections and edges, imperfect butt- and side-joints on the roofing sheets.**
- **Construction and functional deficiencies – due to non-observance of building physics (permeability to water-vapor and thermal insulation), installation of wet insulation material**
- **Storm damage – due to insufficient anchoring of canopies or poor workmanship in sealing / bonding technology**
- **Ageing of materials, failure of materials: no weather-resistant top coatings, crack formation due to UV-attack, unsuitable roofing felts.**

"A flat roof is as efficient as its connection joints": In addition to damage from physical interactions in building the second contributory damage factor is faulty connection joints.

Building physics

Steel decks, contrary to heavy concrete decks, have very low thermal mass. Fluctuation in temperature has a direct effect on the indoor climate. In addition, steel decks will not absorb moisture from ambient air. Condensation forming on the soffit from dripping water is likely to appear more frequently, if thermal insulation is insufficiently designed.

It must be ensured that the insulation layer is adequately dimensioned and remains dry to ensure thermal performance after installation. An essential consideration is moisture transport related to vapor diffusion. Warm indoor air with high humidity must not be allowed to condense moisture into the insulation structure. To prevent the passage of vapor, full vapor barriers must be used with bonding tape on the joint connections to form an airtight layer. In many cases this is not done, even with good workmanship.

FOAMGLAS® with its closed cellular glass structure is non hygroscopic, fully water-and vapor-proof and keeps moisture out in the long term. Because of its all glass closed cell geometry the vapor-barrier function is automatically incorporated.

Deterioration in thermal performance caused by water or water vapor can be avoided. Even in case where there are deficiencies in the weatherproofing membrane, the insulation performance remains unaffected. And: the roof system layout keeps potential leakage confined to a limited area.

No risks of corrosion

The long-term behavior of a roof may substantially be compromised by corrosion when mechanical fixing of the thermal insulation and the vapor-barrier to the steel deck is required. For a 5000 m² roof area, using 4 mechanical fasteners per m² surface area, this means that the steel deck has 20,000 perforations. Furthermore, the fasteners create cold bridging and can be harmed by condensation water. The FOAMGLAS® Compact Roof solution on steel deck avoids these difficulties. Using the compact construction method where all layers are adhesively bonded, including steel deck, FOAMGLAS® insulation and the weatherproofing membrane, there is no need for mechanical fasteners. In addition, the load-dependent vibrations and deflections of the steel deck are considerably reduced as FOAMGLAS® stiffens the roof system. Residual dynamic stresses can be supported by the FOAMGLAS® roof system without problems.

5 Obvious folds in the vapor-barrier The consequence: moisture is carried by airflow into the insulation layer.
6 Corrosion damage on a steel deck roof.
7 Perforated steel deck sheets on the soffit side. Each mechanical fastener forms a cold bridge and is at risk of corrosion.
8 Condensation and shear stresses contribute to the destruction of fasteners by corrosion.


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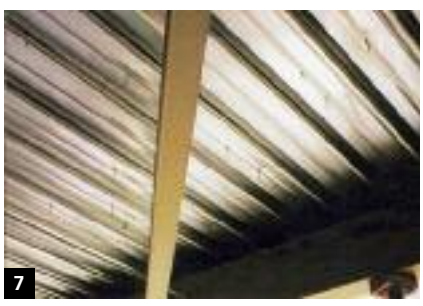
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A win-win situation

Construction should be assessed for the long-term. The building owner wants to use their real estate for decades and seeks sustainable performance without expensive replacement or refurbishment. The guiding principle for investment should be "Once and for all". This strategy will pay off: The FOAMGLAS® Compact Roof system is likely to provide a service life of 50 years or more. Be it residential, commercial, industrial or public construction: the quality of the insulation system is critical for the service life of the roof and the sound structure of the building over the long-term. It plays a key part in the overall cost efficiency!

Good investments help you save money

Escalating prices for energy make "investment in thermal insulation" the order of the day, and probably for many decades to come. In considering the profitability in construction, it's clear that excellent thermal insulation is the key to optimal efficiency. The axiom, "a penny saved is a penny earned" is valid. The best solution is not the low-cost one, but the one that steadily saves energy costs and eliminates expensive replacement or refurbishment. It pays off to invest in high-quality materials and

1 Seebach Center, Zurich
2 Migros Distribution Center, Neuendorf (Switzerland)

systems. FOAMGLAS® Compact Roof design ticks all the boxes. Compact Roofs bring a new dimension in structural performance and economy.

Durability

Particularly for flat roofs, thermal insulation is the key to long-term preservation of value of the building. Thermal insulation makes part of the construction elements difficult to access so the repair or replacement can even be cost prohibitive. It is thus essential to pay great attention to the choice of materials and workmanship. It is without doubt, that high-end FOAMGLAS® Compact Roofs set the course for a bright future.

For good and all

With 50 years of experience in flat roof insulation it's a fact: FOAMGLAS® Compact Roofs offer solutions for the most demanding roof situations, with performance that remains totally effective for the lifetime of the building. This has been acknowledged by many building-professionals. The trend towards quality, according to the principle "Once and for all", is increasing on construction projects. In today's challenging economic environment, the need for energy-efficient house building and the use of ecological construction materials is vital to our future.

Optimal protection for your building investments

Well-engineered FOAMGLAS® insulation technology – for the protection of the fabric of the building from the effects of cold, heat and rain – is a booming market, particularly for flat roofs. Cellular glass insulation ensures that thermal performance remains effective for the long-term and protects the building against serious damage from all sorts of catastrophes. This adds up to an all-inclusive value proposition, that smart architects and clients appreciate and choose.

3 CSS Insurance Company, Lucerne

1 The propagation of fire across the roof can cause total damage on the building.

Preventive fire protection

After fire strikes intense discussions take place regarding responsibilities and fire precautions. The part played by insulation materials is a frequent issue. Studies provide clear evidence: FOAMGLAS® contributes to efficient preventive fire protection. Cellular glass is non-combustible and does not give off fumes or toxic gases.

Preventive action starts with the choice of materials

"Fire disaster", "There is evidence that fire safety regulations have not been followed", "Rapid propagation of the fire has been encouraged", "Sea of flames"

These headlines make evident: To fight a fire in a building – in particular at roof level – is rather difficult, even if fire regulations have been followed.

All the more care and attention has to be given to preventive fire protection. By choosing adequate materials and roof systems the risk of fire development – in particular the spread of fire across voids and flammable materials – can be reduced significantly. In many cases FOAMGLAS® cellular glass insulation, especially the Compact Roof system, can help avert disaster.

Smoldering fires – extraneous perils

Fires of this nature generally spread inside construction elements where they may go undetected for a long time. Sometimes there are hours between undetected ignition and blazing up of a fire.

The specific structural and chemical characteristics of some insulants increase the risk of smouldering fires. This is not the case with FOAMGLAS®. The all glass closed cell structure of the insulation forms a shield.

Foam insulation, for instance polystyrene or polyurethane, are combustible. During combustion, liquefied and blazing parts of the material drip down, causing fire to spread. In particular for public buildings, in conference and exhibition halls, office buildings, hotels, restaurants and catering buildings the use of combustible/flammable materials is not recommended.

FOAMGLAS®: Neither fumes nor toxic gases

Fire disasters may not always exhibit "a sea of flames". Flashback to the events at Düsseldorf Airport (1995), with 17 casualties or the fire in the Montblanc Highway Tunnel (1999), which caused the death of 39 people. In both cases toxic gases from insulation materials, that were not fire safe, were considered responsible for the fatality (polystyrene in Düsseldorf, polyurethane at Montblanc).

By contrast FOAMGLAS® does not give off fumes or toxic gases. In respect to fire safety FOAMGLAS® performs unlike all other insulation materials, classified as "non-combustible".

FOAMGLAS® melting point > 1000 °C

According to german DIN 4102-17 the melting point of FOAMGLAS® was tested at MPA Braunschweig Institute (D). More than 50 % of the insulation thickness lasted the 90 minute fire period without significant damage. As an official result the melting point is > 1000 °C.

General protection with FOAMGLAS® in case of fire: Melt Shield-Effect

Comparable as a thermal protection shield the melted glas surface of the flame treated area is protecting the lower cell structure. The temperature on bearing structure is remaining low. FOAMGLAS® is defending the building structure in case of fire.

Superimportant for roof construction

The need for structural measures to improve protection against fire in roofs cannot be over-stated. The propagation of fire across a roof can cause total damage to a building. Combustible/flammable insulation materials and vapor control layers make up an important fire load in the roof and influence the intensity and duration of the fire – vapor control layers and insulation can soften and burn. The fire can rapidly spread across the whole roof and the prevention of total destruction is likely to be difficult. This does not apply to FOAMGLAS®. The FOAMGLAS® Compact Roof stops the spread of fire across the roof and prevents complete combustion at roof level. A decelerated development of a fire is a precious gain of time for fire fighting – the property damage can be reduced and there is more time to rescue people in danger.

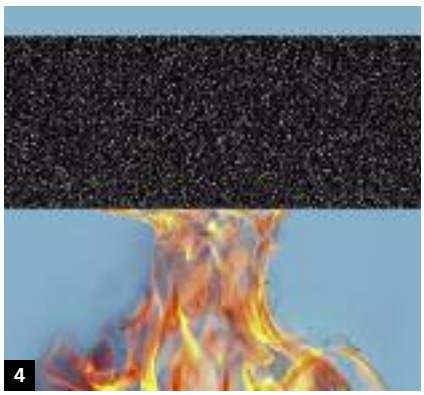
To play safe

A series of fire testing concluded that cellular glass has excellent fire control attributes. Relevant test certificates are available from the national FOAMGLAS® subsidiaries. With regard to recent findings in preventive fire protection, architects and clients should redefine their safety requirements, which should be geared towards low-risk management for the roof construction under fire conditions.

FOAMGLAS® offers superior performance regarding preventive fire protection.

- **FOAMGLAS® is a safer product as it is pure and non-combustible cellular glass insulation. Reaction to fire classification: EN standard. Euro Class A1.**
- **Closed cell FOAMGLAS® insulation prevents oxygen from passing through the material to tease the trouble spot.**
- **FOAMGLAS® is gas-tight. The transfer of hot gases through the insulation and their development inside the insulation is avoided. FOAMGLAS® is a safety insulation that forms a barrier against the propagation of the fire.**

4 No contribution to the propagation of the fire under fire conditions. FOAMGLAS® cellular glass is non-combustible
5 The propagation of fire across the roof can cause total damage on the building
6 Conclusion after test procedure: FOAMGLAS® melting point > 1000 °C.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Excellent Ecological profile

FOAMGLAS® insulation systems are stable under all conditions of use and protects the owner from unexpected expenditures for heating or expensive replacement of the insulation or repair. FOAMGLAS® systems safeguard the environment one way or another. They allow for energy saving and, from the cradle to the grave, they do not contribute to environmental pollution, a safe product consistent with the principles of building physics. Cellular glass is certified to standards of health and indoor air quality. Ecologically viable product recycling is possible in the case of building demolition.

Typically 60 %+ of the raw material is recycled glass. A very low percentage of carbon is added during manufacturing which makes the charcoal grey color of the insulation. In the cellulating furnace the soft, viscous glass is foamed through release of carbon dioxide (CO_2) and forms millions of airtight glass cells enclosing the gas. This closed cell glass structure ensures full resistance to the transmission of vapor (resistance to water vapor transmission $\mu = \infty$).

Production and composition

FOAMGLAS® manufacturing is two sub-processes. In the first part of the process the recycled glass is melted and subsequently batched with the remaining raw materials and crushed in a mill. In the second sub-process the powder mix passes in the cellulating furnace at high temperature where FOAMGLAS® cellular glass is foamed – comparable to the process of fermentation in bread baking.

1 Renewable energy sources are increasingly used in FOAMGLAS® production.
2 FOAMGLAS®: millions of airtight glass cells

Environmentally friendly production

The raw materials used in the FOAMGLAS® production are inherently mineral and thus environmentally friendly. Principal raw material is recycled glass. Further raw materials are feldspar, sodium carbonate, iron oxide, manganese oxide, carbon, sodium sulfate and sodium nitrate. By the introduction of recycled glass into the production FOAMGLAS® makes a relevant contribution to the protection of the environment.

Minimal environmental pollution

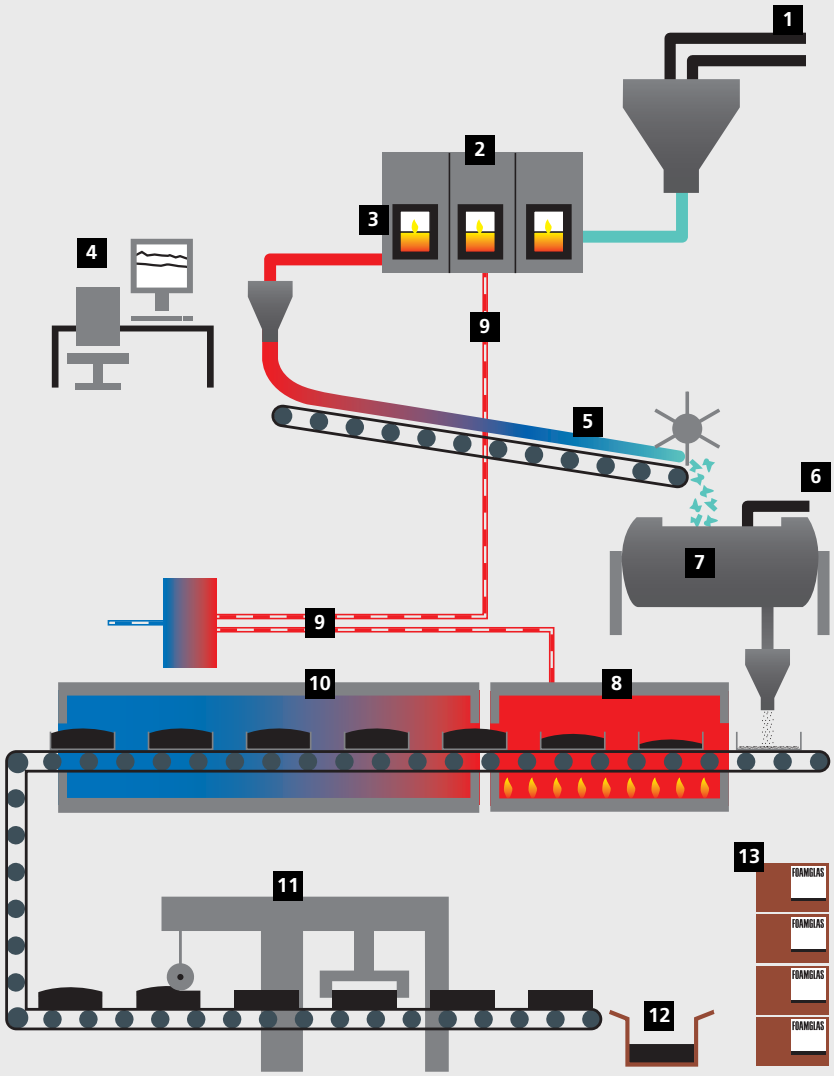
Due to improvements in process engineering and in the energy supply (coming from hydro electric energy and wind turbines) significant progresses has been achieved in recent years regarding air pollution, greenhouse gas emissions, consumption of energy and resources:

- **The demand for non-renewable energy was reduced 4.24 kWh / kg.**
- **Greenhouse gas emissions have been halved.**
- **The percentage of recycled glass was progressively increased from 0 % to 30 and to 60 %.**
- **The environmental pollution score (UBP97) was reduced from 1619 to 743 points.**
- **The eco-indicator (EI99 H, A) dropped from 0.13 to 0.09 points.**

Reduction of the production energy means that the time period for energy amortization of the investment in thermal insulation – as an important evaluation unit – is considerably reduced.

FOAMGLAS® manufacturing

(Tessenderlo Plant, Belgium)



1 Mixing and batching of the raw materials: Recycled glass, feldspar, sodium carbonate, iron oxide, manganese oxide, sodium sulphate, sodium nitrate.

2 The melting furnace has a constant temperature of 1250°C.

3 Molten glass is drawn out of the furnace.

4 Control room for monitoring the production.

5 The glass is drawn off and falls onto the conveyor band where it cools down before entering into the ball mill.

6 Addition of "carbon black".

7 Ball mill grounds all ingredients into a fine powder before putting into stainless steel moulds.

8 The filled moulds pass through a cellulating oven (Foaming furnace) with a temperature of 850°C. This is where the material gains its unique cell structure.

9 Energy recovery of heat.

10 The FOAMGLAS® blocks pass through an annealing oven to allow carefully controlled cooling of them without thermal stress.

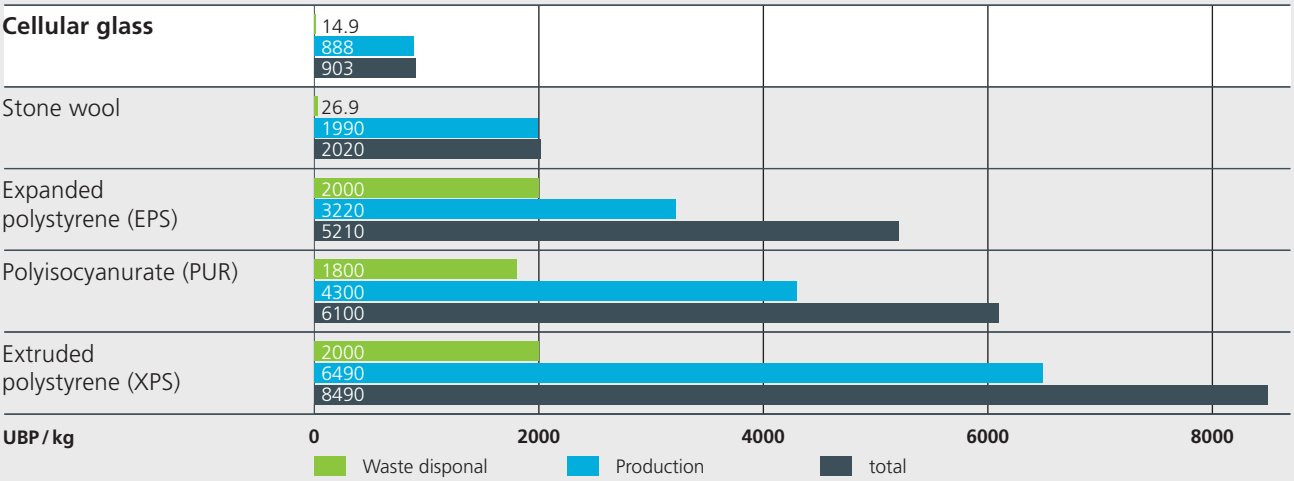
11 The blocks are cut to size and sorted by batch. Production waste is recycled.

12 FOAMGLAS® slabs are then packaged, labelled and palletized.

13 Finished FOAMGLAS® products are stored and prepared for transport.

FOAMGLAS® stands comparison

The environemental pollution score (UBP 2006**) for the production and waste disposal of FOAMGLAS® is 903 points/kg (insulation). This puts FOAMGLAS® into the pole position in eco-balance. Other insulation products show points between 2020 (stone wool) and 8490 (Extruded polystyrene).



Compared to surfaces, with a specified insulation value of 0,20 W/m²K, FOAMGLAS® performs very well. The environmental pollution score (UBP 2006**) of cellular glass is 17 157 points (FOAMGLAS® W+F), 21 807 points (FOAMGLAS® T4+) per square meter. Other insulation products show 23 790 points (PUR), 26 571 points (EPS), 46 056 points (stone wool) and 53 232 points (XPS) for an identical U-value (see table).

Insulation	ρ	λ_D*	d	weight per m²	UBP* per kg	UBP per m²
	kg / m³	W / mK	m	kg / m²	UBP / kg	UBP / m²
FOAMGLAS® T4+	**115**	**0.041**	**0.21**	**24.15**	**903**	**~ 21 807**
FOAMGLAS® W+F	**100**	**0.038**	**0.19**	**19.00**	**903**	**~ 17 157**
Polyisocyanorate (PUR)	30	0.026	0.13	3.90	6100	~ 23 790
Stone wool	120	0.038	0.19	22.80	2020	~ 46 056
Expanded polystyrene (EPS)	30	0.034	0.17	5.10	5210	~ 26 571
Extruded polystyrene (XPS)	33	0.038	0.19	6.27	8490	~ 53 232

* The data are taken from building database KBOB / EMPA, june 2009.

** The environemental pollution score (UBP 2006) quantifies the pollution coming from resources, water consumption, emissions into air, water and ground and also for the waste disposal. The environment pollution through grey energy and global warming are included in the UBP score.

World resources

The principal raw material of FOAMGLAS® production today is selected recycled glass (in the past the main raw material was silica sand). The supplies of recycled glass are ample, as in the construction and other industries large quantities amass and have to be disposed of as waste. Plastic foam insulation, however, is produced from crude oil, which is a non renewable fossil fuel.

FOAMGLAS® cellular glass insulation products now with natureplus label

Natureplus, an international organisation for the development of a culture of sustainability within the building sector, has selected cellular glass thermal insulation from Pittsburgh Corning Europe SA as a green building product and awarded the natureplus quality label. "Cellular glass thermal insulation by Pittsburgh Corning Europe SA ideally meets the quality requirements for a sustainable construction product", noted Uwe Welteke-Fabricius, president of natureplus e.V., when handing-in the certificate. The natureplus quality seal is the symbol of recognition for building products with a high level of quality in the areas of health, the environment and functionality. Pittsburgh Corning's FOAMGLAS® types W+F, T4+, S3 and F from the Tessenderlo plant (Belgium) are tested and certified successfully.

Service life

Having outstanding qualities (mineral, impermeable to water and vapor, resistant to acids, non-combustible, high-temperature resistant), cellular glass is a very durable material. The long service life of the material has very positive effects, ecologically and financially, on the service-life of the construction and, consequently, on the life of the building. Maintenance and replacement cycles can significantly be reduced by the use of durable materials.

Emissions / nuisance during installation and use

Cellular glass does not release harmful or toxic components into the environment. It does not contain green house gases or ozone depleting products, no flame retardant and no con-taminative or carcinogenic particles and fibers. When recommended installation instructions are followed, cellular glass insulation does not produce emissions that degrade the environment or health, at production, installation nor use.

Emissions in case of fire

Dumping and burning of construction waste is most critical for the environment, even in small quantities. In particular plastic foam materials are classified as harmful. In the case of burning of these materials high levels dangerous emissions are released than in combustion in an incineration plant. Studies have been conducted in Germany on thermal combustion of polystyrene insulation, which clearly indicated that released fumes are acutely toxic. Serious adverse health effects in the long-term cannot be excluded. Even with combustion in a waste incineration plant, there is high impact to the environment, as annually several thousand tons of slag and filter residue have to be transported to special disposal sites. The non-combustibility of cellular glass makes the toxicity issues irrelevant.

natureplus – The European quality seal for approved green building products.

Ecological assessment for different thermal Insulation materials.

	Production energy	Resources	Nuisance for workers	Emissions during production	Emissions in case of fire	Long-term performance	Disposal / Recycling
Glass wool							
Stone wool							
Cellulose insulation							
Pure expanded cork							
Expanded polystyrene							
Extruded polystyrene							
Polyurethane (PUR)							
FOAMGLAS®							

Very good *Acceptable* *Critical* *Very critical*

Positive ecological assessment for FOAMGLAS®: Source: Cellular glass insulation, a cost-effective and environmentally sustainable solution. [Schaumglas-Dammstoff, Wirtschaftlich und umweltvertraglich Dammen.] Markus Welter, Lucerne

Waste disposal

In the assessment of insulation materials one consideration is repercussions on the environment from waste disposal. There are significant differences between the various insulation products. In total evaluation – and considering the scarcity of raw materials – as documented in eco-balance data sheets for the building industry, plastic foam insulation receives poor ratings for environmental pollution.

Recycling

Cellular glass being non-combustible, combustion in a waste incineration plant is not a possibility. An option is the recycling of cellular glass as crushed stone (for bedding in road construction) or infill material for noise barriers. Recycled FOAMGLAS® is a safe and suitable product for these applications, as it is dimensionally stable, neutral for the environment, inorganic, rot-proof and without any risks for the ground water (meets ELUAT-test requirements). If crushed and recycled FOAMGLAS® is not used as bedding or infill material, it can be taken to an inert waste disposal site, like crushed concrete or brick.

FOAMGLAS® – a valuable contribution to the protection of the environment.

■ Today FOAMGLAS® is made from 60 %+ recycled glass. The FOAMGLAS® manufacturing concept is waste reduction and green energy utilisation.
■ For the FOAMGLAS® production only energy from renewable sources is used.
■ Environmental pollution during manufacturing has halved when compared to 1995.
■ FOAMGLAS® insulation meets all environmental and health requirements for construction products.
■ At the end of its service-life FOAMGLAS® disposal is simple. One option is the use of recycled cellular glass as infill in trenches or back-up for buried pipes.
■ FOAMGLAS® has an outstanding service-life, which is clearly the best for the environment.
■ On balance: FOAMGLAS® is an insulation concept fit for the future that gives an answer to the genuine concerns for the environment. The system ensures that all demands on performance, durability, environmental integrity and sustainability are fulfilled.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3 The percentage of recycling glass in the FOAMGLAS® production is from 30 to 60 %.
4 Crushed FOAMGLAS® – a recycled filler material for trenches.
5 FOAMGLAS® Environmental product declaration (according to ISO 14025) confirms the sustainable and ecological value of FOAMGLAS®.

www.foamglas.com

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