

Insulation systems for flat roof

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Building



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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



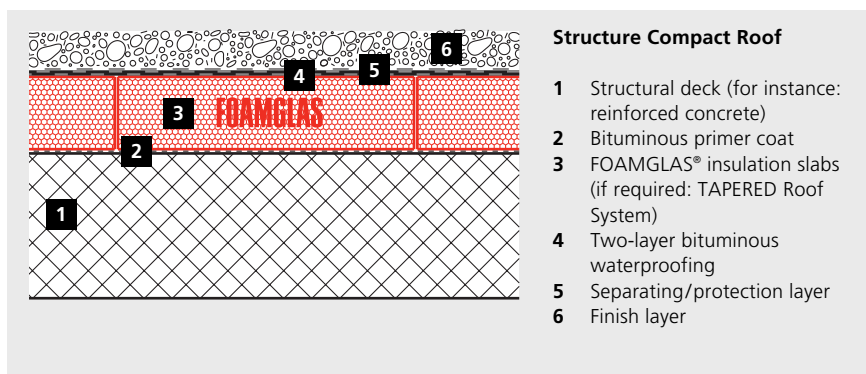
ing to experts – supports the conclusion that FOAMGLAS® roofs will be effective for the next half century.

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 a key 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 water-



proof 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

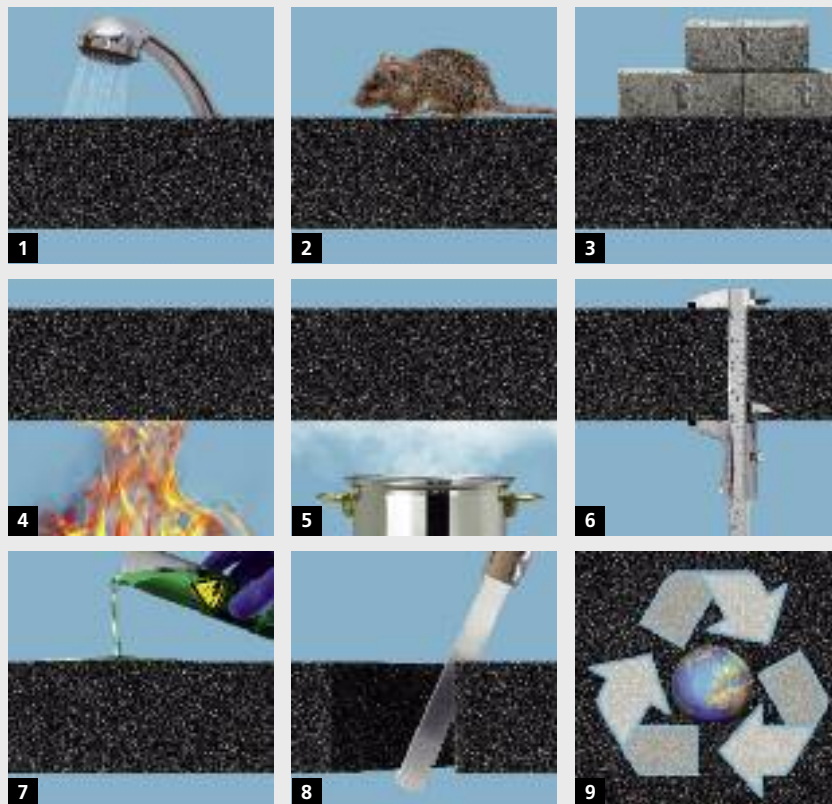
Due to its combination of unique properties, FOAMGLAS® is also called “Safety insulation”. It is unrivalled in performance. Manufactured from crushed glass and carbon, it forms closed glass cells – containing an inert gas –, which provide excellent thermal effectiveness. As a high-density insulation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

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



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.

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-tight because 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.

7 Zurich Airport, Kloten





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.

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.

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

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

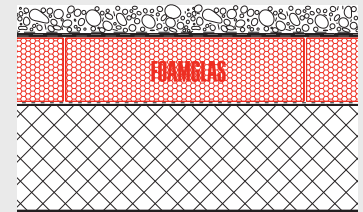


Principal types of roof systems



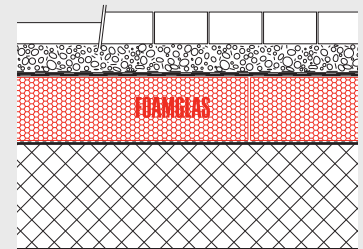
Compact Roof with limited accessibility Page 10 **Compact Roof with heavy protection**

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.



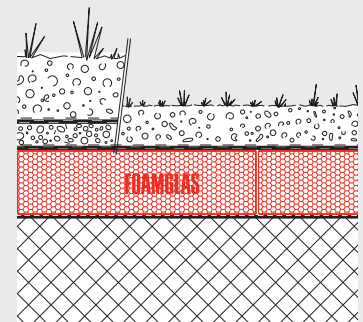
Compact Roof accessible to foot traffic Page 13 **Terrace roof with pavement area**

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.



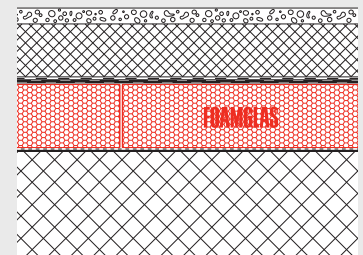
Green Compact Roof Page 17 **Moisture conditions in green roofs**

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 rain-water 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.



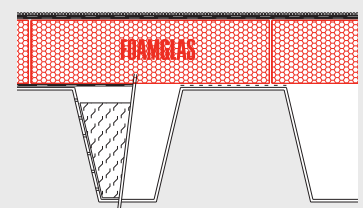
Compact Roof, trafficked/parking decks Page 24 **Traffic accessed car park decks**

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 accommodate 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
with limited
accessibility**

Park Hotel 'Waldhaus' in Flims

Architect H.P. Fontana & Partner, Flims Dorf

Built 2005

FOAMGLAS® application Roof insulation, about 240 m², T4+ slabs.

Tapered Roof System (cut-to-fall elements), average thickness 145 mm and about 900 m², T4+ slabs, 120 mm thick, adhesively bonded

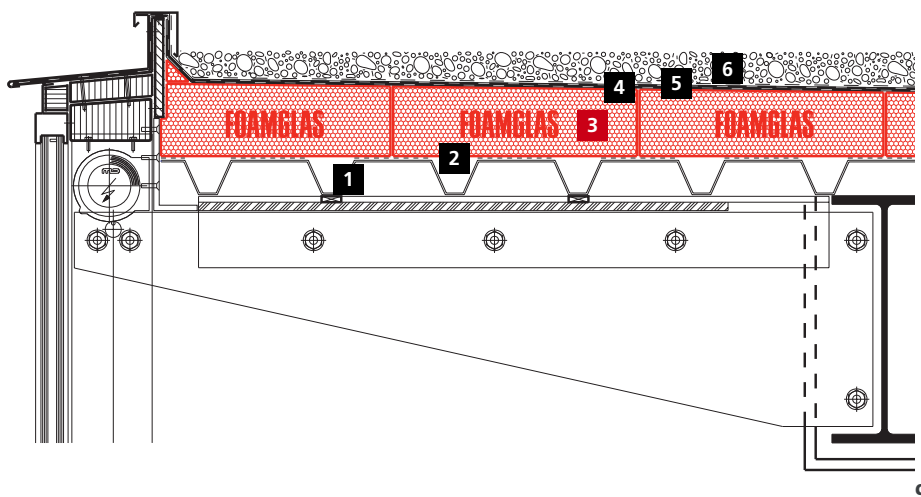
Heavy protection Roofing gravel/intensive greening system

For a spa, effective moisture and temperature control is essential for the outer skin of the building to preserve its structural integrity. Protection against the effects of moisture is a priority. With low density or permeable insulation materials moisture control requires high-quality vapor control layers (vapor-barriers). However, the integrity of overlapping foils jointed with bonding tape cannot be considered fail-safe, for instance with numerous roof penetrations and connection joints. FOAMGLAS® Compact Roof using cel-

lular glass insulation is totally impervious to moisture of any kind, due to the closed cell geometry. It fulfills the vapor control function by itself and does not need an additional protective layer as easily damaged foils. There is no progressive moisture absorption in the insulation. Another system benefit with steel decking: Adhesively bonded cellular glass contributes to a significant stiffening of the whole roof system. The sway stiffness is improved as flexing and vibration is suppressed, as are mechanical stresses on connection joints.

All thermal and physical demands made on the insulation material are surpassed.

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Roof structure

- 1 Steel decking
- 2 Bituminous primer coat
- 3 FOAMGLAS® T4+ slabs, average thickness 145 mm, in hot bitumen, TAPERED Roof System
- 4 Two-layer bituminous waterproofing
- 5 Nonwoven, filter layer
- 6 Roofing gravel





**Compact Roof
with limited
accessibility**

Private House Hirt in Uttwil

Architect Andreas Zech, Romanshorn

Built 2000

FOAMGLAS® application Roof insulation, about 200 m², type T4+, 160 mm thick, bonded in hot bitumen

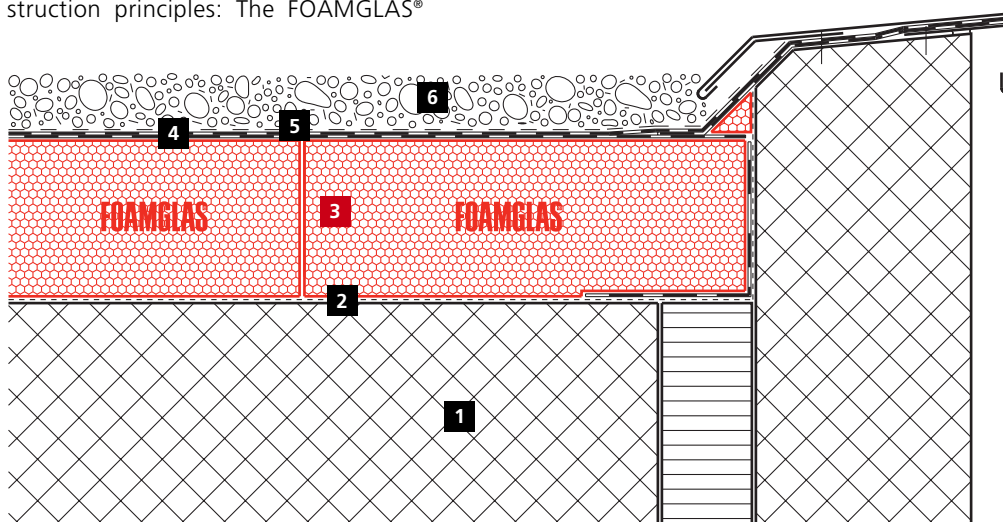
Finish layer Roofing gravel

The stretched building with staircase and suite of rooms is situated on the waterfront of Lake Constance. The intelligible and nearly austere design forms an eye-catching contrast to the superb landscape. Once again with the right roof solution, evidence can be supplied that flat roofs perform better than expected. "Low-end systems" were not considered due to durable construction principles: 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.

**FOAMGLAS® – an
investment for future
generations**

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Roof structure

- 1 Structural concrete deck
- 2 Bituminous primer coat
- 3 FOAMGLAS® T4+ 160 mm, in hot bitumen
- 4 Two-layer bituminous waterproofing
- 5 Nonwoven, filter layer
- 6 Roofing gravel





**Compact Roof,
accessible to
foot traffic**

Swiss federal Institute of Technology, 'ETH Polyterrace', Zurich

Architect/Planner Pfister Schiess Tropeano AG, Zurich

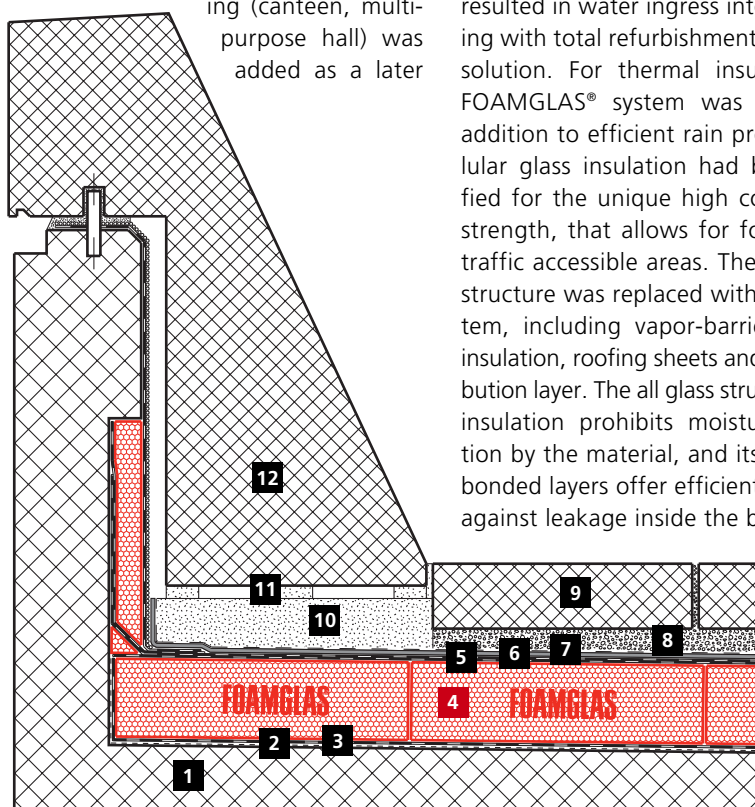
Repair work 2007

FOAMGLAS® application Roof insulation, about 2000 m² type T4+, 80 mm thick and about 2000 m² type F, 120 mm thick, bonded in hot bitumen

Finish layer Concrete slabs, prefabricated

The main building of the Swiss Federal Institute of Technology (ETH Zurich) is very famous for its architectural design in Switzerland. The so-called MM-building (canteen, multi-purpose hall) was added as a later

extension, whose terrace roof forms the accessible 'Polyterrace'. In some places leakage of the waterproofing had occurred over a long period of time. This resulted in water ingress into the building with total refurbishment as the only solution. For thermal insulation, the FOAMGLAS® system was chosen. In addition to efficient rain proofing, cellular glass insulation had been specified for the unique high compressive strength, that allows for foot and car traffic accessible areas. The failed roof structure was replaced with a new system, including vapor-barrier, thermal insulation, roofing sheets and load distribution layer. The all glass structure of the insulation prohibits moisture absorption by the material, and its adhesively bonded layers offer efficient protection against leakage inside the building.



**Totally effective in the
most demanding load
situations**

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Roof structure

- 1 Structural deck in concrete
- 2 Bituminous primer coat
- 3 Emergency waterproofing (basic protection during construction)
- 4 FOAMGLAS® T4+ insulation, 80 mm thick, in hot bitumen
- 5 Two-layer bitumen roofing sheets
- 6 Building protection mat (heavy duty composite rubber mat)
- 7 Glass fibre separating layer
- 8 Drainage-/sub-floor screed
- 9 Prefabricated concrete slabs, 100 mm thick
- 10 Protective screed with reinforcement
- 11 Mortar bed, point by point, 20 mm
- 12 Concrete element





**Compact Roof,
accessible to
foot traffic**

Sports hall of Federal School, Frauenfeld

Architect Stutz & Bolt, Architect's Office, Winterthur

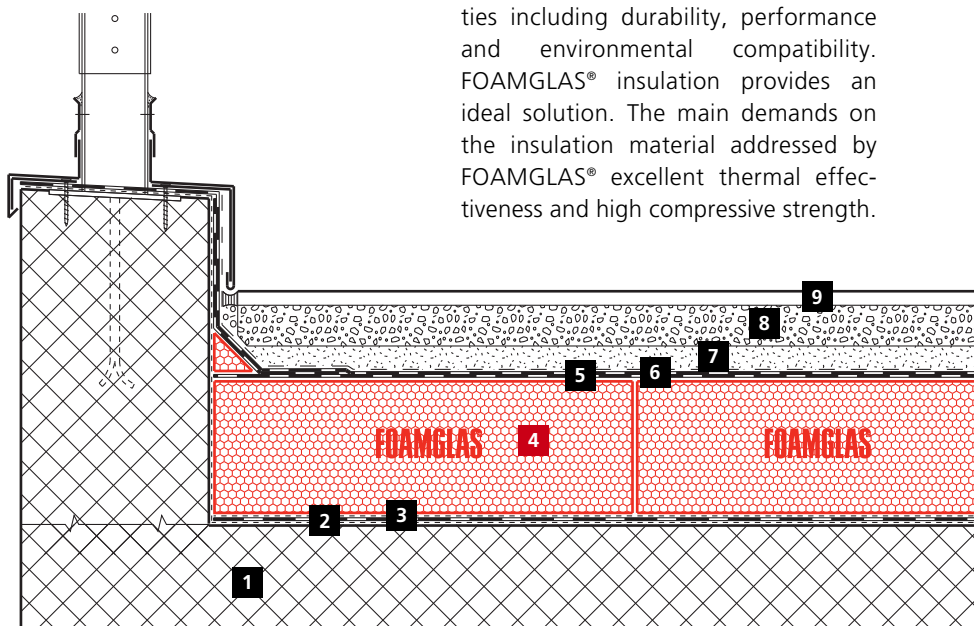
Built 2002

FOAMGLAS® application Roof insulation, about 2000 m² type T4+,
140 mm thick, hot bitumen

Finish layer Sport flooring

With the construction of a new triple gym, the Federal School in Frauenfeld (Switzerland) got a multipurpose sports center. The hall is jointly used by the school, by sport clubs and by the Municipality for different events. The heart of the new complex is the gym,

deeply sunk below ground. The roof covering the hall serves as an outdoor playing field. It is enclosed and covered with a sports flooring. Between the roof and ground, a thermal insulation material was required for outside and inside components with proven qualities including durability, performance and environmental compatibility. FOAMGLAS® insulation provides an ideal solution. The main demands on the insulation material addressed by FOAMGLAS® excellent thermal effectiveness and high compressive strength.



**FOAMGLAS® – a key
player**

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Roof structure

- 1 Sloping concrete deck
- 2 Bituminous primer coat
- 3 Emergency waterproofing (basic protection during construction)
- 4 **FOAMGLAS® T4+ slabs, 140 mm thick, in hot bitumen**
- 5 Two-layer bitumen roofing sheets
- 6 Separating layer
- 7 Sport flooring drainage layer AB-6, 20 mm thick
- 8 Mastic asphalt, 40 mm thick
- 9 Sport flooring, 13 mm thick





**Compact Roof,
accessible to
foot traffic**

Andreaspark apartment building, Zurich (Switzerland)

Architects Bob Gysin + Partner AG, Zurich

Built 2006

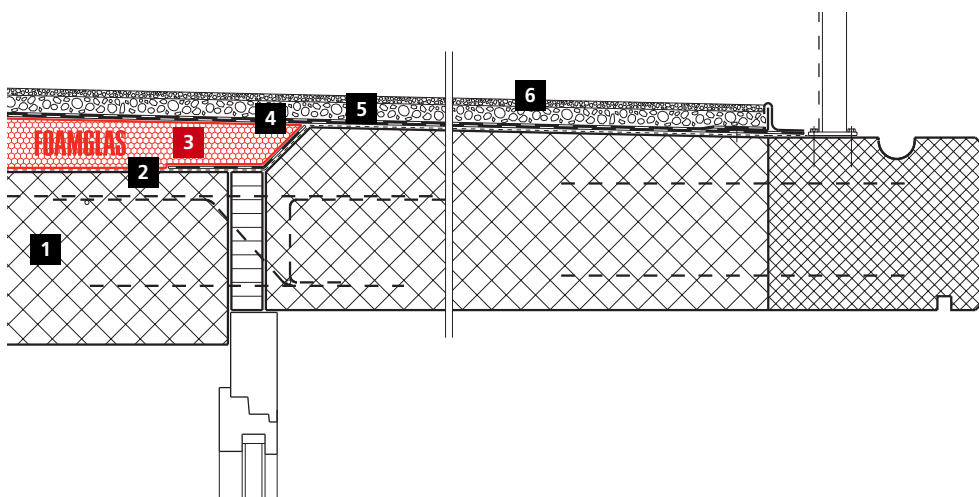
FOAMGLAS® application Roof insulation, about 430 m² type T4+, Tapered Roof System (cut-to-fall elements), average thickness 100 mm, in hot bitumen

Finish layer Playground flooring

FOAMGLAS® is the optimal solution for thermal insulation of terrace roofs. The cell geometry provides high compressive strength, free from deformation under permanent load. FOAMGLAS® has sufficient bearing capacity for common loads on terraces with relatively thin thickness in application. Moreover FOAMGLAS® compressive strength ratio covers a load safety factor that allows for mixed usage (allowing temporary

or later changes of use). Foot traffic accessible flat roofs/terraces using FOAMGLAS® slabs – in combination with waterproof, flexible and soft playground flooring – are the optimal solution for stability, layer thickness, long term thermal efficiency and moisture protection. Particularly for high-traffic flat roofs which have to resist a variety of strains.

When it comes to the point: FOAMGLAS®
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Terrace roof structure

- 1 Concrete decking
- 2 Bituminous primer coat
- 3 FOAMGLAS® T4+ slabs in hot bitumen, 100 mm thick, Tapered Roof System
- 4 Two-layer bitumen roofing sheets
- 5 Playground flooring, (Barfo screed), 25 mm thick
- 6 Wearing course (Barfo playground flooring), 8–10 mm thick





**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

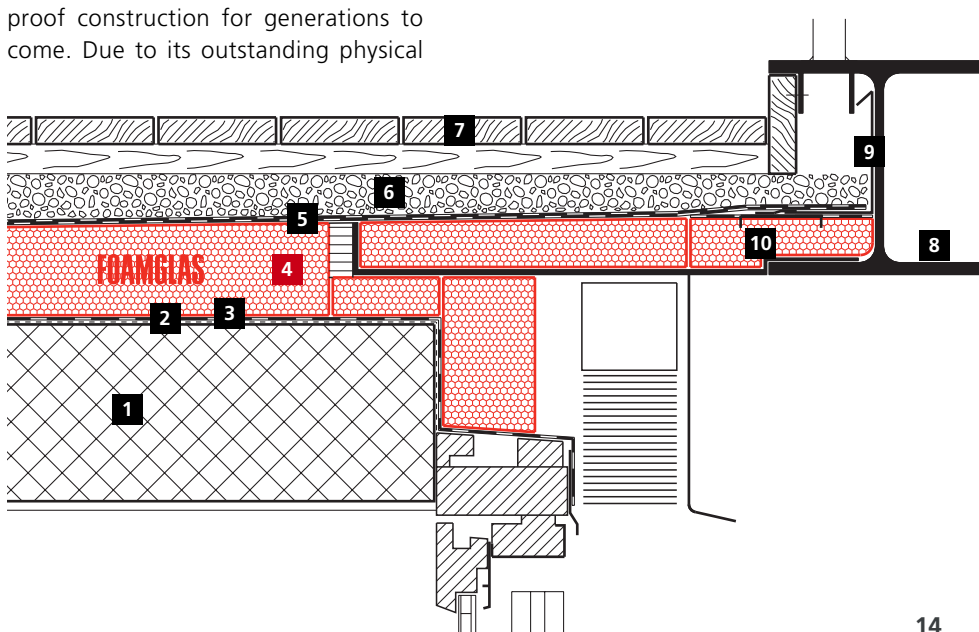
Finish layer Boardwalk in hardwood

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





Green Compact Roof

School for therapeutic pedagogy, Thun-Steffisburg

Architect Architekturwerkstatt 90, Thun / Gassner & Leuenberger Architekten AG, Thun

Built 2004

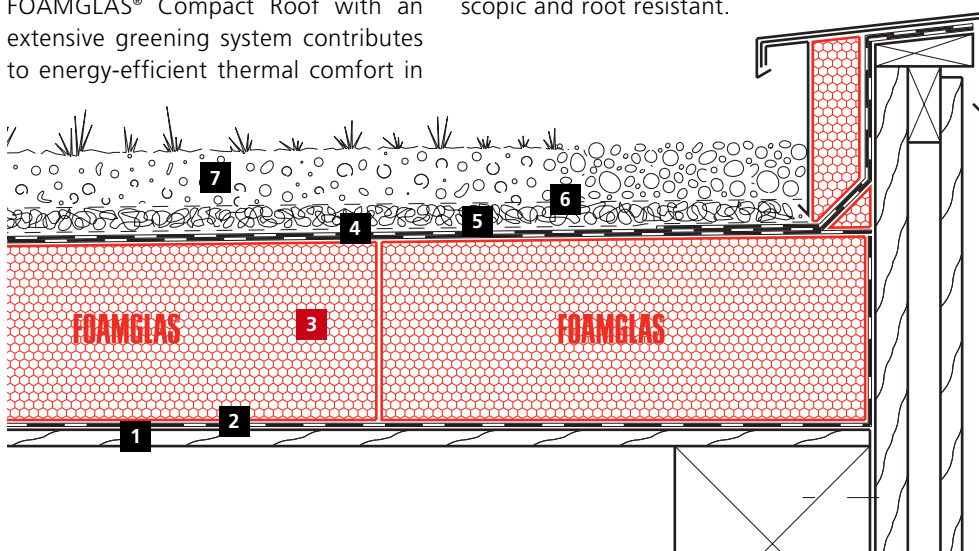
FOAMGLAS® application Roof insulation on the main building, about 1610 m², type T4+ in hot bitumen. Tapered Roof System, 142 mm average thickness

Roof insulation accessible terrace, 200 m² type T4+ in hot bitumen, 60 mm thick

Finish layers Extensive greening system and floor tiles

The new school for therapeutic pedagogy in Thun-Steffisburg offers an optimal environment to educate children and young people with mental handicaps. Well-built architectural design and the pleasant look and feel of the building materials contribute to the comfort of the disabled students and improve the learning experience. A FOAMGLAS® Compact Roof with an extensive greening system contributes to energy-efficient thermal comfort in

the building. The Tapered Roof System with FOAMGLAS® T4+ cut-to-fall slabs was used. Two layers of polymer bitumen roofing sheets were fully bonded to the insulation surface and covered with a cap sheet, offering anti-root qualities. Additional security is provided by the all glass cell structure of the insulation that is totally non hygroscopic and root resistant.



Compact, waterproof and air-tight – a bright future for flat roofs

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Roof structure

- 1 Timber decking
- 2 Bitumen roofing sheet as a separating layer
- 3 FOAMGLAS® T4+ slabs in hot bitumen, 142 mm thick, Tapered Roof System
- 4 Bitumen waterproofing sheets, 2 layers
- 5 Glass fibre separating layer
- 6 Drainage layer
- 7 Extensive greening system





Green Compact Roof

Office building "OPUS", Zug (Switzerland)

Architect Axess Projects AG, Zug

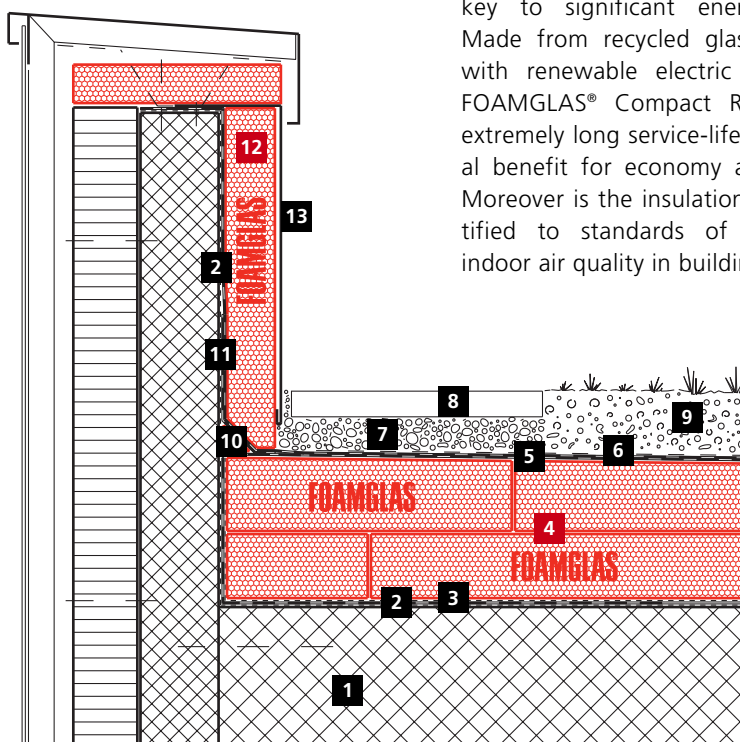
Built 2005

FOAMGLAS® application Roof insulation, about 7280 m² type T4+ slabs in hot bitumen, 2 layers. Tapered Roof System (cut-to-fall slabs), 200 mm average thickness

Finish layer Extensive greening system

Roof greening systems generally have positive effects on the local climate and the environment. The plantings absorb humidity from the air and cool it down. Plants reduce fine dust pollution and traffic noise. Green areas not

only relieve the rainwater load in urban sewer systems – they also protect the building structure from weathering. Choosing a FOAMGLAS® roof system was a natural step to create an ecological solution. FOAMGLAS® is the key to significant energy savings. Made from recycled glass combined with renewable electric power, the FOAMGLAS® Compact Roof has an extremely long service-life, with mutual benefit for economy and ecology. Moreover is the insulation system certified to standards of health and indoor air quality in building.



Flat roof concept – a global approach to urban ecology

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Roof structure

- 1 Concrete decking
- 2 Bituminous primer coat
- 3 Emergency waterproofing (basic protection during construction)
- 4 FOAMGLAS® T4+ slabs in hot bitumen, 200 mm thick, Tapered Roof System
- 5 Bitumen roofing sheets, 2 layers
- 6 Filter layer PP nonwoven 800 g/m²
- 7 Crushed gravel for drainage
- 8 Cement tiles
- 9 Extensive greening system
- 10 FOAMGLAS® angle fillet
- 11 Bitumen roofing sheets, 2 layers
- 12 FOAMGLAS® T4+ slabs, 80 mm thick
- 13 Metal flashing





Green Compact Roof

UVEK Administration Building, Ittigen

Architects GWJ Architekten AG, Bern

Built 2005

FOAMGLAS® application Roof insulation, about 6260 m² type T4+ slabs in hot bitumen, in 2 layers. Tapered Roof System (cut-to-fall slabs), 270 mm average thickness and about 496 m² type T4+ slabs in hot bitumen, 140 mm thick

Finish layer Extensive greening system

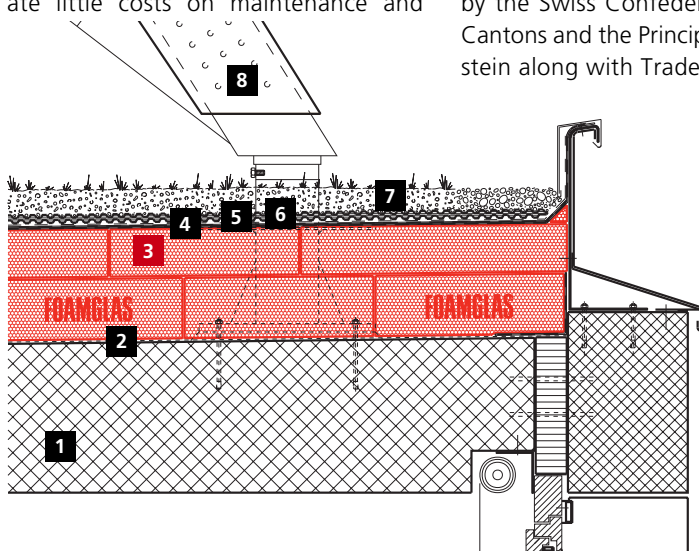
Appealing – sustainable. These are the attributes that best characterize the UVEK administration building (Swiss Federal Department for Environment, Traffic, Energy and Telephone Communication). In recognition of its sustainable performance qualities FOAMGLAS® was chosen as their insulation system for the future. Cellular glass is made from 66 % recycled glass. What about the costs? Considered as economically advantageous were the products that generate little costs on maintenance and

repair over the long-term. That is a primary benefit of FOAMGLAS®. Instead of complicated domestic engineering, a well-designed construction using FOAMGLAS® achieves peak performance in energy efficiency: cellular glass flat roofs meet the high standard defined by the Swiss low-energy label "MINERGIE". "MINERGIE" is a registered quality label for new and refurbished low-energy-consumption buildings. This label is mutually supported by the Swiss Confederation, the Swiss Cantons and the Principality of Liechtenstein along with Trade and Industry.

Roof structure with peak performance in energy efficiency, certified to low energy standards
www.foamglas.com

Roof structure

- 1 Concrete decking
- 2 Bituminous primer coat
- 3 FOAMGLAS® T4+ slabs in hot bitumen, 270 mm thick
- 4 Two-layer bitumen roofing sheets
- 5 Protection layer PP-nonwoven 800 g/m²
- 6 Drainage/water retention element
- 7 Extensive greening system
- 8 Truss





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 emis-

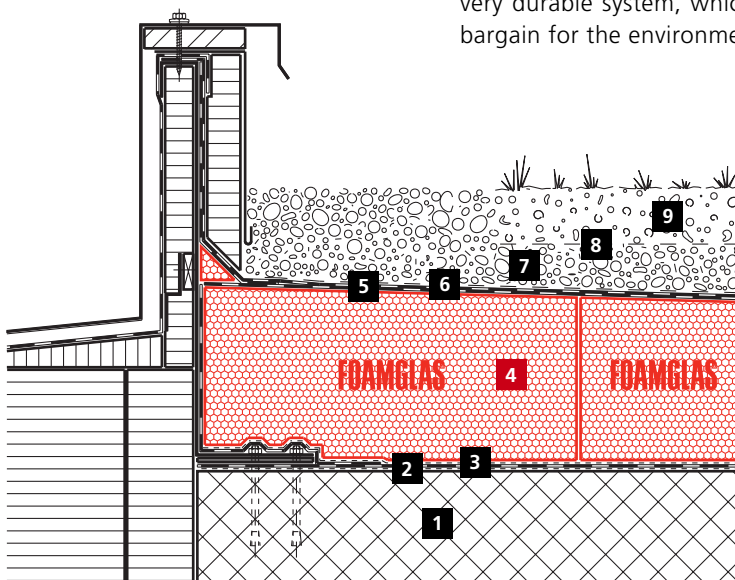
sion” building. By use of the most energy efficient technologies it can be operated without fossil energy sources. A key element of this sustainable energy concept is the use of FOAMGLAS® thermal insulation. Cellular glass insulation is an ecological building product that provides important energy-savings. 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

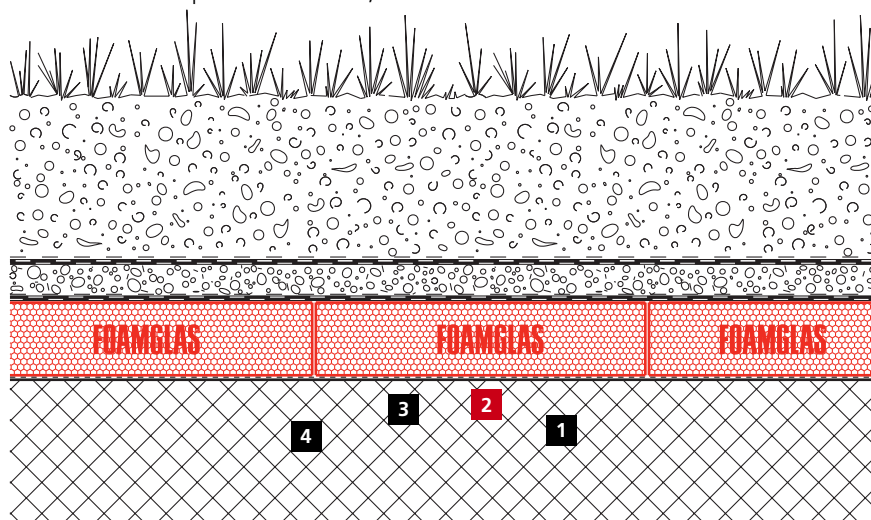
FOAMGLAS® application Roof insulation, about 5200 m² type T4+ slabs in hot bitumen, 100 mm thick

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 weathertight, 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





Green Compact Roof

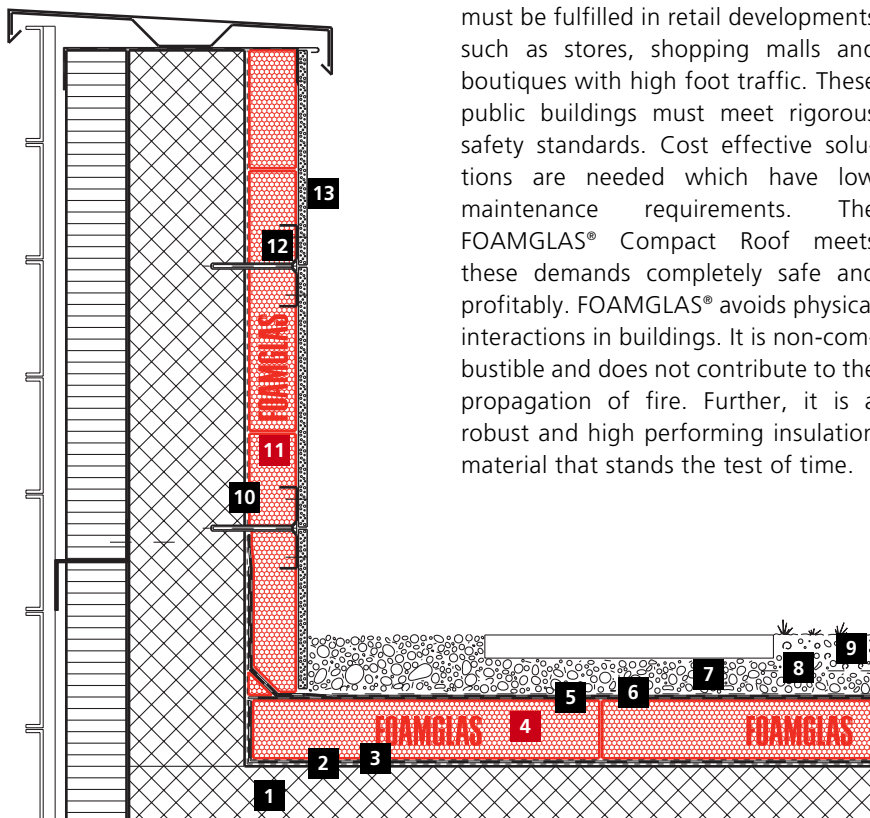
Specialized dealers, Dietlikon

Architect Atelier WW, Zurich

Built 2003

FOAMGLAS® application Roof insulation, about 8290 m², type T4+, slabs, 60/80/100 mm thick and about 1100 m² type F slabs, 100 mm thick, in hot bitumen

Finish layers Extensive greening system, cement boards, Bituzim® (grouting asphalt pavement)



Particularly demanding requirements must be fulfilled in retail developments such as stores, shopping malls and boutiques with high foot traffic. These public buildings must meet rigorous safety standards. Cost effective solutions are needed which have low maintenance requirements. The FOAMGLAS® Compact Roof meets these demands completely safe and profitably. FOAMGLAS® avoids physical interactions in buildings. It is non-combustible and does not contribute to the propagation of fire. Further, it is a robust and high performing insulation material that stands the test of time.

Profitability and efficiency: the FOAMGLAS® factor of success

www.foamglas.com

Roof structure

- 1 Concrete deck
- 2 Bituminous primer coat
- 3 Emergency waterproofing (basic protection during construction)
- 4 FOAMGLAS® T4+ slabs in hot bitumen, 100 mm thick
- 5 Bitumen roofing sheets, 2 layers
- 6 Protection layer PP-nonwoven 800 g/m²
- 7 Drainage gravel 8/16
- 8 Filter layer
- 9 Extensive greening system
- 10 Bituminous primer coat
- 11 FOAMGLAS® T4+ slabs in hot bitumen, 80 mm thick
- 12 PC fixing plates (claw plates)
- 13 Cement boards (Aquapanel® Outdoor)





Green Compact Roof

Centre Patronal, – Employer’s Federation, Paudex

Architect / planner Pierre & Fabien Steiner SA, Brent

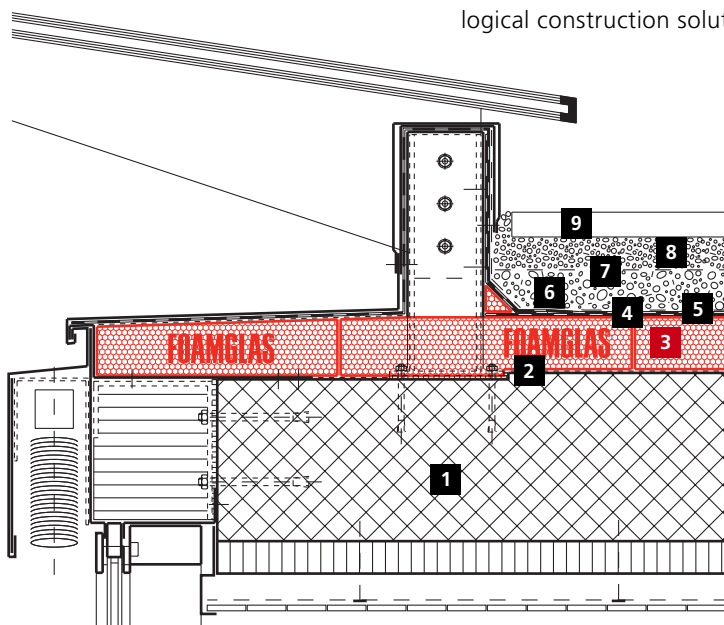
Built 2000

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 construc-

tion 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, trafficked

Letzigrund Stadium, Zurich

Architect Betrix & Consolascio Architekten, Erlenbach

Frei & Ehensperger 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

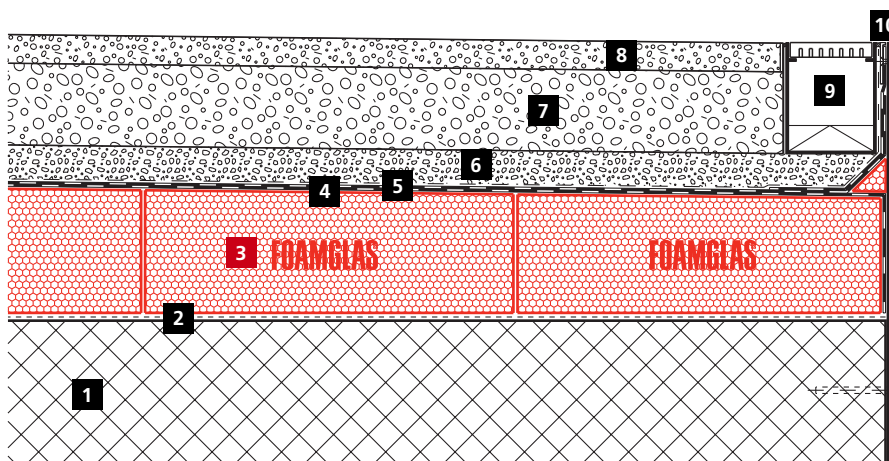
Finish layer Grouting asphalt pavement

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





Compact Roof, trafficked

Commercial College KV, Baden-Zurzach

Architect / Supervision Neff Neumann Architekten AG, Zurich
Bosshard + Partner Baurealisierungen AG, Zurich

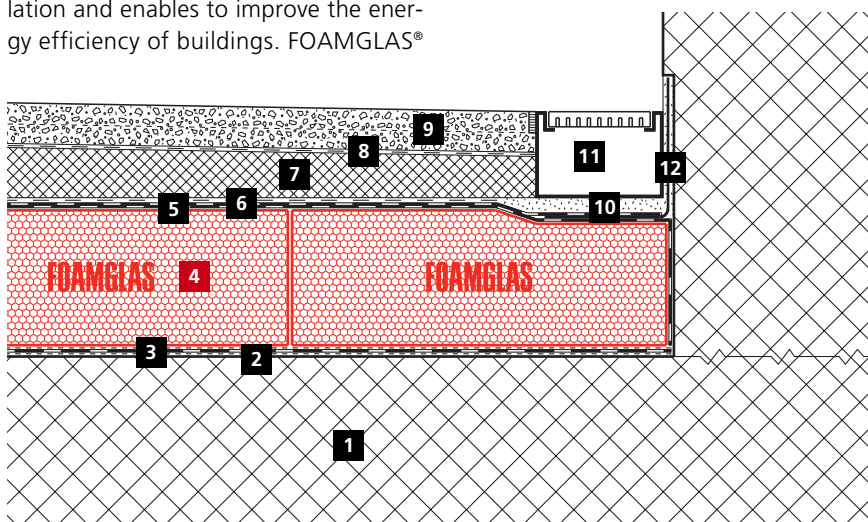
Built 2006

FOAMGLAS® application Roof insulation, about 900 m² type T4+ slabs in hot bitumen, 160/240 mm thick and about 485 m² type S3 slabs in hot bitumen, 160 mm thick

Finish layers Extensive greening system, mastic asphalt

The extension of a commercial college finally brought an end to the squeeze in the classrooms. The new structure bridges the gap to the existing buildings (schoolhouse and gym). Facing concrete is used for the walls of the new building to achieve a thermal efficiency superior to the average value required by European standards. FOAMGLAS® was used as the roof insulation and enables to improve the energy efficiency of buildings. FOAMGLAS®

is the preferred insulation solution, not only because Building Regulations demand exacting insulation values, but also because of its other specific qualities, including water- and vapor-proofing functions, structural stability, non-combustibility, ecological profile, and the long-service life of cellular glass.



FOAMGLAS® – a classic example of a material with a promising future

www.foamglas.com

Roof structure

- 1 Concrete deck
- 2 Bituminous primer coat
- 3 Emergency waterproofing (basic protection during construction)
- 4 FOAMGLAS® S3 slabs in hot bitumen, 160 mm thick
- 5 Bitumen roofing sheets, 2 layers
- 6 Separating layer, PE foil
- 7 Load distribution slab, 50–120 mm thick
- 8 Bituminized separating layer (glass fleece)
- 9 Mastic asphalt in 2 layers, 2 x 25 mm
- 10 Chippings
- 11 Gutter
- 12 Connection strip





Compact Roof, trafficked

Rietberg Museum, Zurich

Architect A. Grazioli / A. Krischanitz, Berlin / Vienna

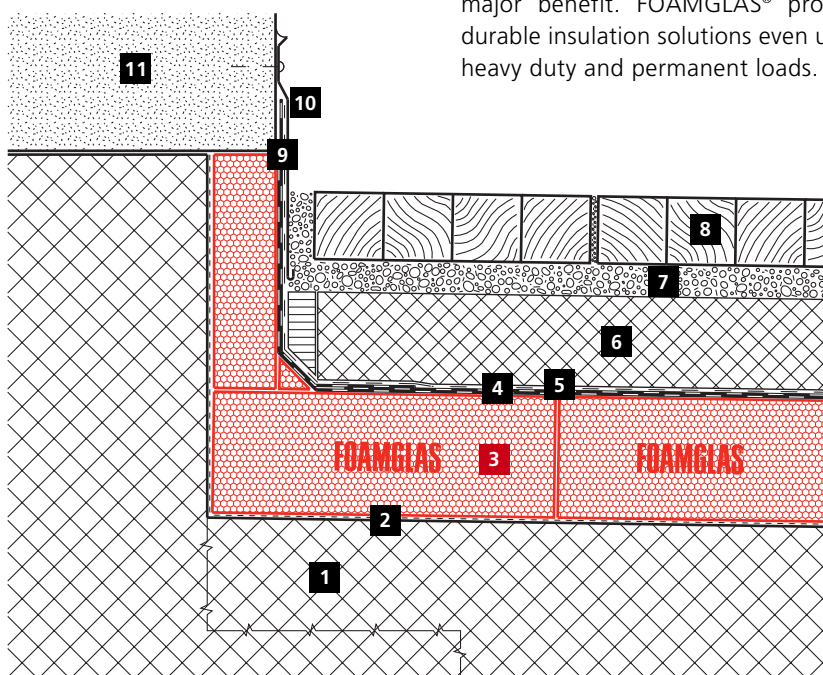
Built 2006

FOAMGLAS® application Roof insulation, about 480 m² type T4+ slabs, 160 mm thick, and about 850 m² type S 3 slabs, 160 mm thick, in hot bitumen

Finish layers Intensive greening system / wood-block pavement

In the transition area from underground to aboveground FOAMGLAS® insulation was installed. The green Compact Roof application was a necessity because efficient water-and damp-proofing qualities were required. Green roofs are particularly exposed to moisture and vapor transport. Cellular glass is the ideal solu-

tion as it eliminates the risk of interstitial condensation and is resistant to water ingress and root penetration. Other special advantages for green roofs include its resistance to acids, vermin, rodents and insects (rot proof). When applied for trafficked roof areas, the unrivalled compressive strength is a major benefit. FOAMGLAS® provides durable insulation solutions even under heavy duty and permanent loads.



FOAMGLAS® meets the most ambitious safety demands.

www.foamglas.com

Roof structure

- 1 Sloping concrete deck
- 2 Bituminous primer coat
- 3 FOAMGLAS® S3 slabs in hot bitumen, 160 mm thick
- 4 Bitumen roofing sheets, 2 layers
- 5 Separating layer, PE-foil
- 6 Load distribution slab in reinforced concrete, 120 mm thick
- 7 Bed of fine gravel, 40 mm thick
- 8 Wood-block pavement 90/90/90 mm
- 9 Separating layer, nonwoven
- 10 Flashing strip
- 11 Sandstone, existing





Compact Roof, trafficked

Migros Shopping Center, Affoltern (ZH)

Architect / planner Bauengineering AG, Zurich

Built 2005

FOAMGLAS® application Roof insulation, about 4,215 m² type S3 slabs, 120 mm thick and about 1,295 m² type T4+ slabs, 120 mm thick, in hot bitumen

Finish layers Site concrete / Extensive greening system

Staff pension funds manage the retirement account of their members. A large percentage of their capital is invested in property. The Migros pension fund as building owner is exercising this responsibility with care. They do not invest for short-term profit maximization with risky solutions, but instead choose high-end, sustainable construction systems to ensure financial profits and lifetime performance.

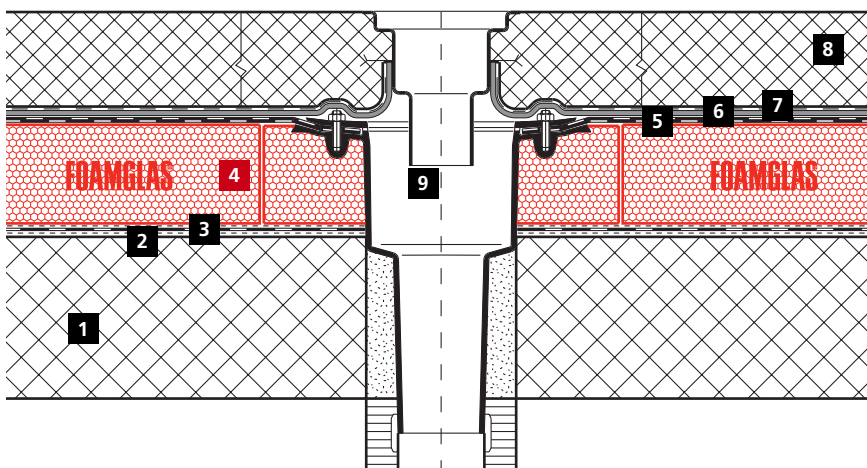
This applies particularly to flat roofs, which must provide a long service life for ecological and economical reasons. Another demand is simple disposal at the end of the building's life, without impairing health or the environment. All FOAMGLAS® Compact Roof systems add a new dimension in performance and economy while protecting against depreciation in value of real estate property.

Quality components – protection against depreciation in value

www.foamglas.com

Roof structure

- 1 Concrete deck
- 2 Bituminous primer coat
- 3 Emergency waterproofing (basic protection during construction)
- 4 FOAMGLAS® S3 slabs in hot bitumen, 120 mm thick
- 5 Bitumen roofing sheet, 2 layers
- 6 Building protection mat (heavy duty composite rubber mat)
- 7 PE-foil
- 8 Load distribution slab
- 9 ACO-Passavant outlet





**Compact Roof,
au naturel –
with two-layer
waterproofing**

Administration building of customs goods clearing, Chiasso

Architects Massimo Marazzi and Elio Ostinelli, Chiasso

Built 2005

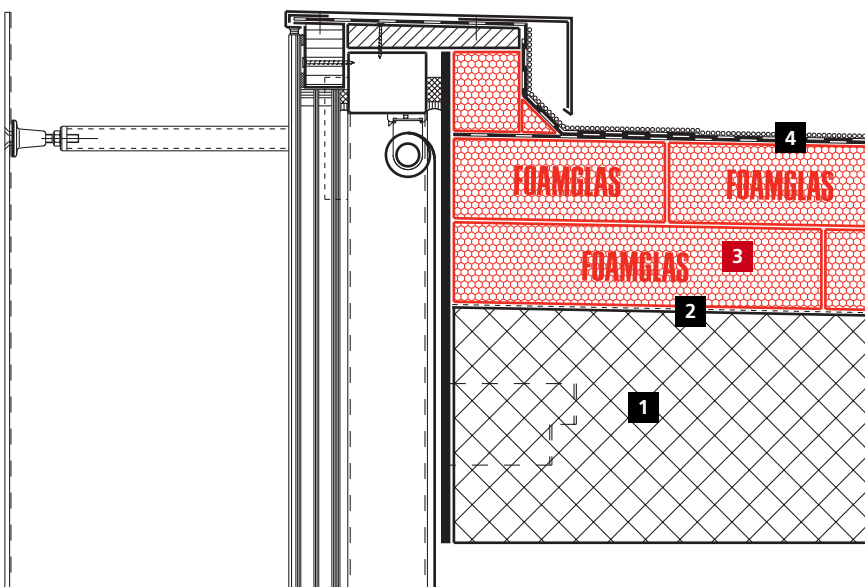
FOAMGLAS® application Roof insulation, about 330 m² type T4+ slabs,
2 layers in hot bitumen, 200 mm thick in total

Finish layer Roofing sheets, 2 layers, cap sheet with mineral finish ('naked' roof)

For the first public building in the Ticino County, meeting low-energy requirements (according to Swiss low-energy standard, 'Minergie'), the building envelope, including the roof, had to be designed for high thermal efficiency. A vital part of the design was the use of FOAMGLAS® for the roof construction. Cellular glass insulation provides full system integrity in the flat roof, with a

minimum of components. Each component and layer is bound to the others using hot or cold bitumen, forming an impervious skin that prevents the ingress of water. The roof system eliminates the risk of interstitial condensation. This means that FOAMGLAS® remains totally effective in the most demanding situations and keeps roof maintenance costs low.

**A well-engineered
system: cost-effective
and stable under all
conditions**
www.foamglas.com



Roof structure

- 1 Sloping concrete deck
- 2 Bituminous primer coat
- 3 FOAMGLAS® T4+slabs in hot bitumen, 200 mm thick
- 4 Bitumen roofing sheets, 2 layers





- 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.

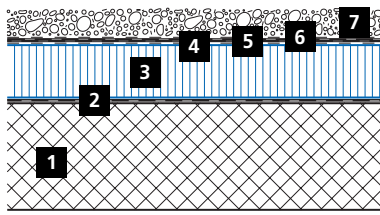
■ **With rigid FOAMGLAS® being laid on plain structural decking there is no need to install an additional vapor-barrier, because cellular glass Compact Roofs are totally impermeable to diffusion.**

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.**



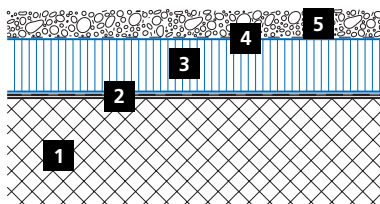


Conventional roof structure of a non-ventilated roof ("warm roof")

- 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

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.



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

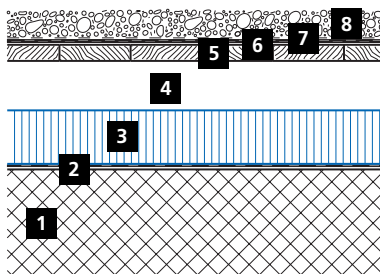
- 1 Structural deck (in general reinforced concrete)
- 2 Waterproofing membrane
- 3 Extruded polystyrene boards (XPS) with shiplap edge profile
- 4 Filter layer (permeable to diffusion)
- 5 Finish layer

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.

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.



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

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.**

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

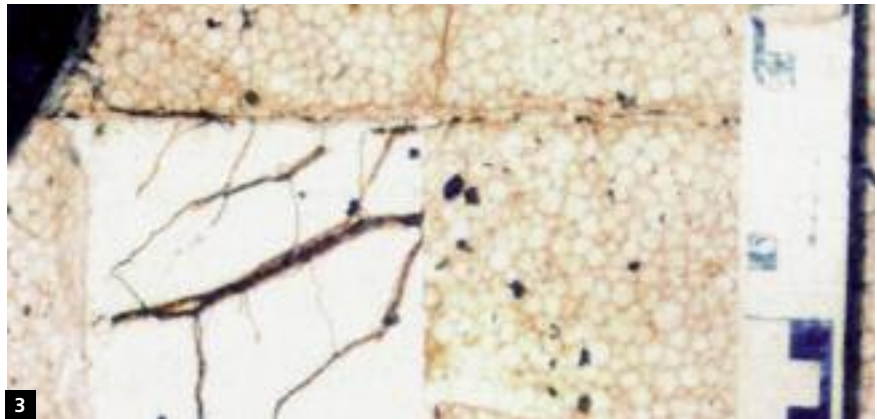
Cold roof

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**



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.

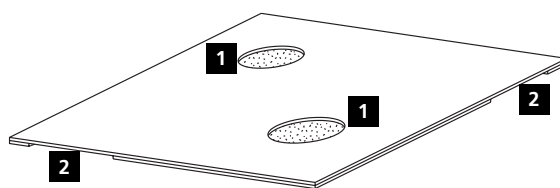
Weatherproofing – one- or two-layer system?

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 compressive 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



- **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 lay-outs: 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.



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.





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 develop-

ment – 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 smoldering 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 glass 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.

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.

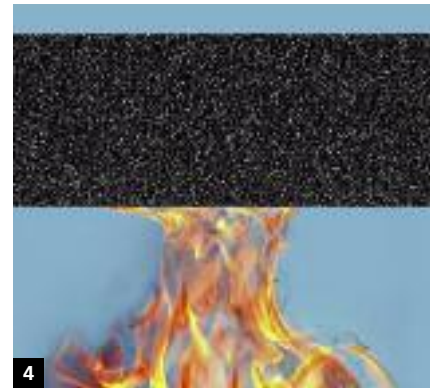
Superimportant for roof construction

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/flamable 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.

- 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.





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 66%+ 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 (CO₂) 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

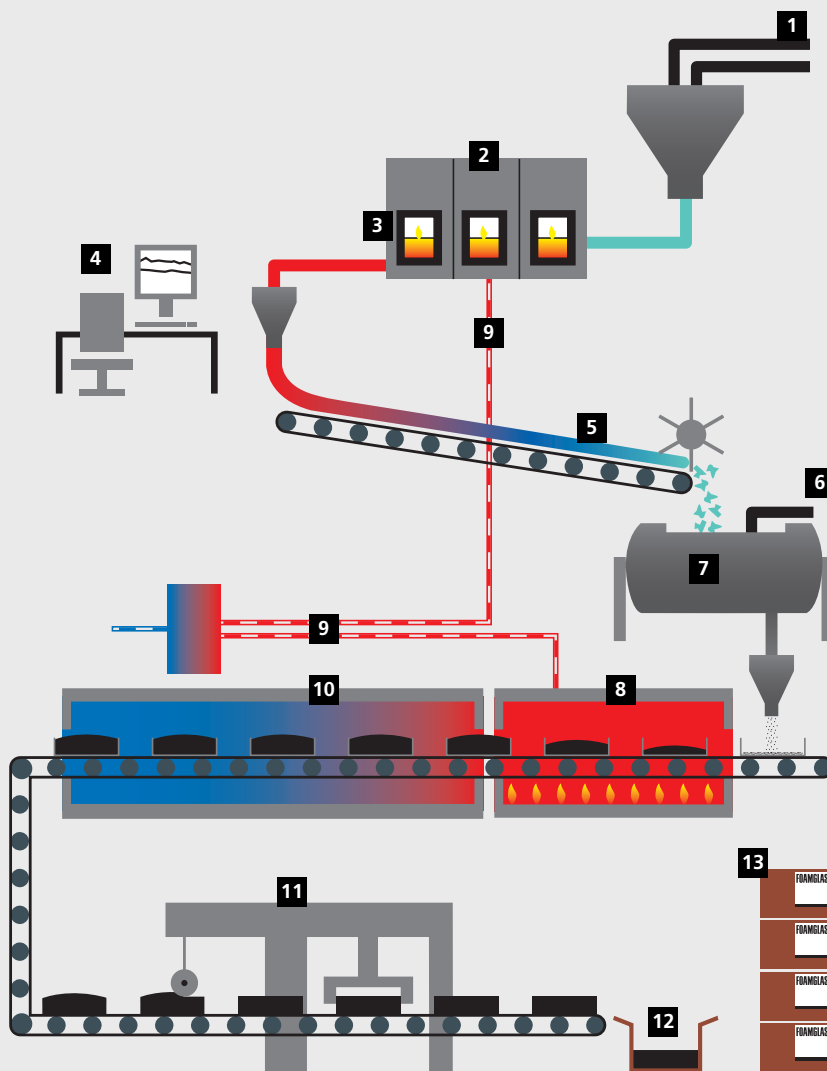
Due to improvements in process engineering and in the energy supply (coming from hydro electric energy and wind turbines) significant progresses has been achieved in recent years regarding air pollution, greenhouse gas emissions, consumption of energy and resources:

- 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 66 %.
- 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

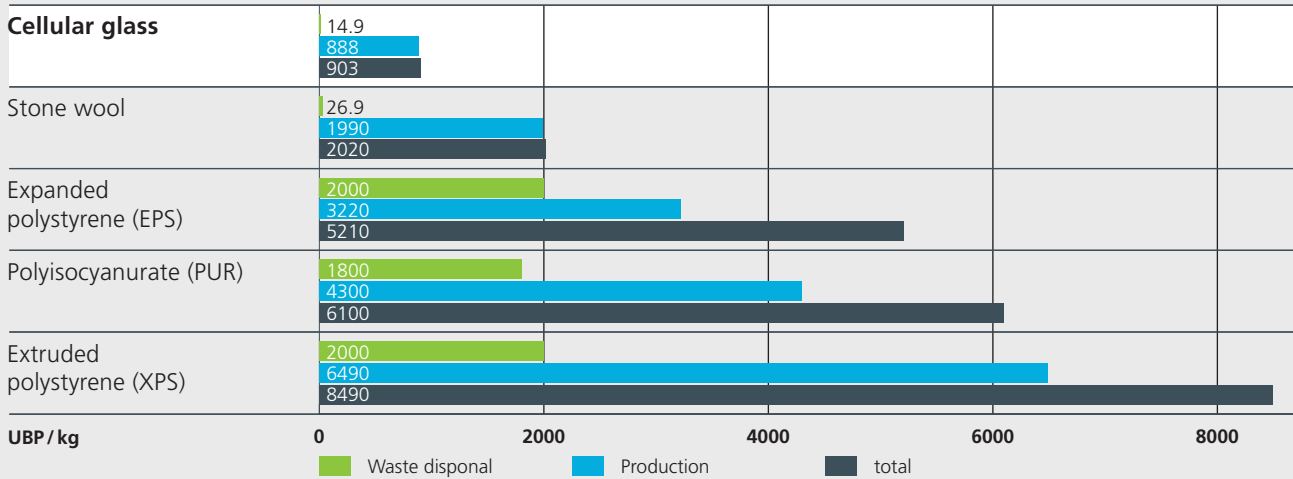
(Tessenderlo Plant, Belgium)



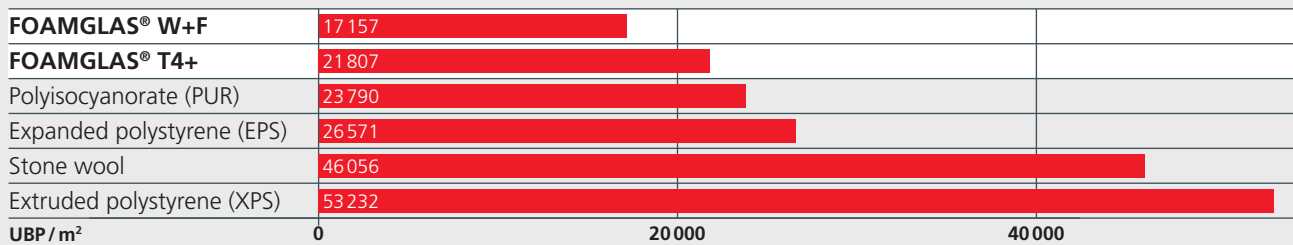
- 1 Mixing and batching of the raw materials: Recycled glass, feldspar, sodium carbonate, iron oxide, manganese oxide, sodium sulphate, sodium nitrate.
- 2 the smelting furnace has a constant temperature of 1250°C.
- 3 molten glass is drawn out of the furnace.
- 4 control room for monitoring the production.
- 5 The glass is drawn off and falls onto the conveyor band where it cools down before entering into the ball mill.
- 6 Production waste is re-introduced into the process.
- 7 Addition of "carbon black".
- 8 ball mill grinds all ingredients into a fine powder before putting into stainless steel moulds.
- 9 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.
- 10 energy recovery of heat.
- 11 The FOAMGLAS® blocks pass through an annealing oven to allow carefully controlled cooling of the block without thermal stress.
- 12 The blocks are cut to size and sorted by batch. Production Waste returns back into the process.
- 13 FOAMGLAS® slabs are then packaged, labelled and palletized.
- 14 Finished FOAMGLAS® products are stored and prepared for transport.

FOAMGLAS® stands comparison

The environmental 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 m ²	UBP* per kg	UBP per m ²
	kg/m ³	W/mK	m	kg/m ²	UBP/kg	UBP/m ²
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
Polyisocyanurate (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 environmental 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 select-ed recycled glass (in the past the main raw material was silica sand). The sup-plies 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.

Service life

Having outstanding qualities (mineral, impermeable to water and vapor, resist-ant 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 build-ing. 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 environ-ment. 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 instruc-tions are followed, cellular glass insula-tion 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 environ-ment, even in small quantities. In par-ticular plastic foam materials are classi-fied as harmful. In the case of burning of these materials high levels danger-ous emissions are released than in com-bustion 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 com-bustion in a waste incineration plant, there is high impact to the environ-ment, 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.

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	Yellow	Yellow	Orange	Yellow	Yellow	Orange	Orange
Stone wool	Yellow	Yellow	Orange	Yellow	Yellow	Orange	Orange
Cellulose insulation	Yellow	Yellow	Yellow	Yellow	Yellow	Red	Yellow
Pure expanded cork	Yellow	Red	Yellow	Yellow	Orange	Orange	Yellow
Expanded polystyrene	Orange	Red	Yellow	Yellow	Orange	Orange	Orange
Extruded polystyrene	Orange	Red	Orange	Yellow	Orange	Yellow	Red
Polyurethane (PUR)	Orange	Red	Orange	Yellow	Red	Orange	Red
FOAMGLAS®	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow

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 umweltver-traglich Dämmen.] 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 66 %+ 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.



- 3 The percentage of recycling glass in the FOAMGLAS® production is from 30 to 66 %.
- 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®.

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ELUAT – elution test. FOAMGLAS® meets the requirements of ELUAT test (Investigative report EMPA Nr. 123544 A, based on the successful testing of bitumen coated FOAMGLAS® specimens). According to declaration scheme D.093.09 of the Swiss Technical Directive for Waste Management [Technischen Verordnung über das Abfallwesen (TVA)], FOAMGLAS® is an authorised material for inert waste disposal sites.

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