



**Pitched Green Roofs
with System**



Permanent success for pitched Green Roof inst

What is to be considered ?

When are we talking about pitched Green Roofs?

According to the "Special Regulations for Roofs with Waterproofing", flat roofs must have a fall of at least 2%. Pitched roofs, as described in this brochure, start with a slope of 10° (18%).

From 10° on, green roof systems differ significantly in system build-up whether they are for low-pitched or pitched roofs. Shear forces increase with the roof slope and have to be transferred into

stable abutments. The substrate layer also has to be protected against erosion. Plant selection and planting methods are to be adjusted to the relevant slope and exposure.

A root-resistant waterproofing is necessary

A professionally waterproofed roof surface, for example with bituminous or high-polymer membranes, is a precondition for a durable long-lasting green roof.



The waterproofing should be root-resistant; installing an additional root barrier on pitched roofs requires much effort.

It is very important to take the green roof upkeep and maintenance into account as early as the planning stage of the project.

Skylights can be installed as access for later upkeep and maintenance. At roof penetrations it is important that the waterproofing is a min. 100 mm above the substrate surface.

With a low system build-up height, the supply of water can be ensured permanently by installing a sound irrigation system.

Green roof systems can be bordered with the stainless steel Eaves Profiles TRP 140. Regarding roofs with a steeper pitch and/ or high thrust lengths,



additional eaves support brackets are to be installed along the eaves.

Pitched roofs are also capable of supporting solar panel installation. Solar panels can be installed without



penetrating the roof membrane; each project must be individually assessed.



This roof, drained by drainage channels, with a roof fall of approximately 5° does not require special measures.



Taking a look at the shed roof, a shear barrier is placed just over the eaves. The drainage water runs off by a peripheral eaves gutter.



The 30° pitched roof here incorporates shear barriers within the green roof build-up in addition to the reinforced eaves.

Additional irrigation

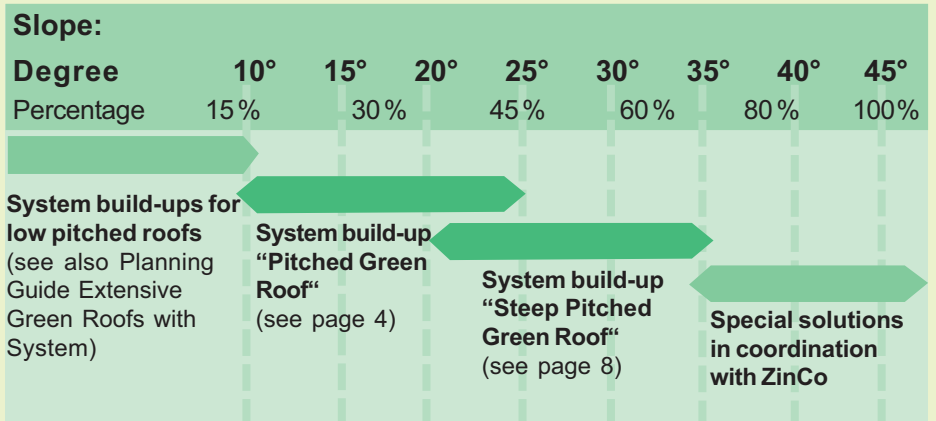
The additional irrigation ensures an impressive appearance of the vegetation in dry seasons and extends the flowering season. The irrigation works either by drip irrigation or with a sprinkler systems.



allations.



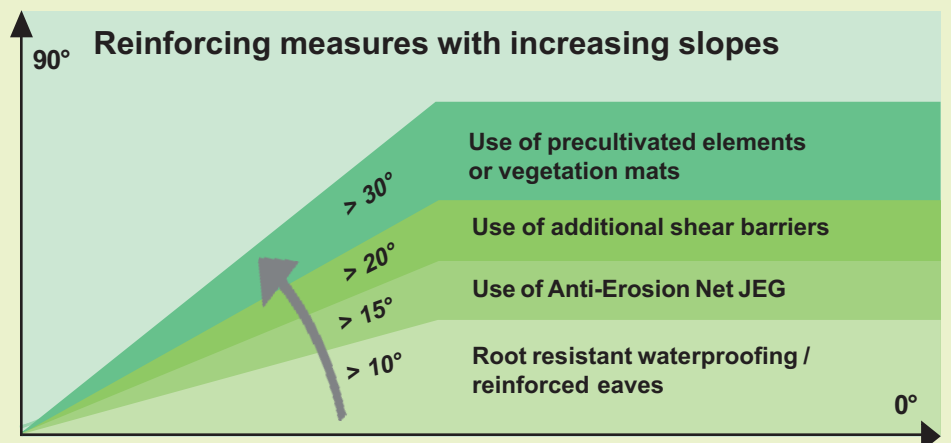
For the structural design of reinforced eaves or shear barriers the saturated weight of the green roof system build-up and the local snow load have to be taken into account.



Shear forces

The chart demonstrates the relationship between slope and additional construction measures.

This chart can also be used as a resource if extra measures for the roofs sub-structure must be carried out. The measures are set according to point 4.9 of the "Regulations for Flat Roofs", and are to prevent the green roof system build-up from slipping off. This can already be applicable at slopes of < 10°.



The system build-up for pitched roofs:

“Pitched Green Roofs“ with Floratec 75



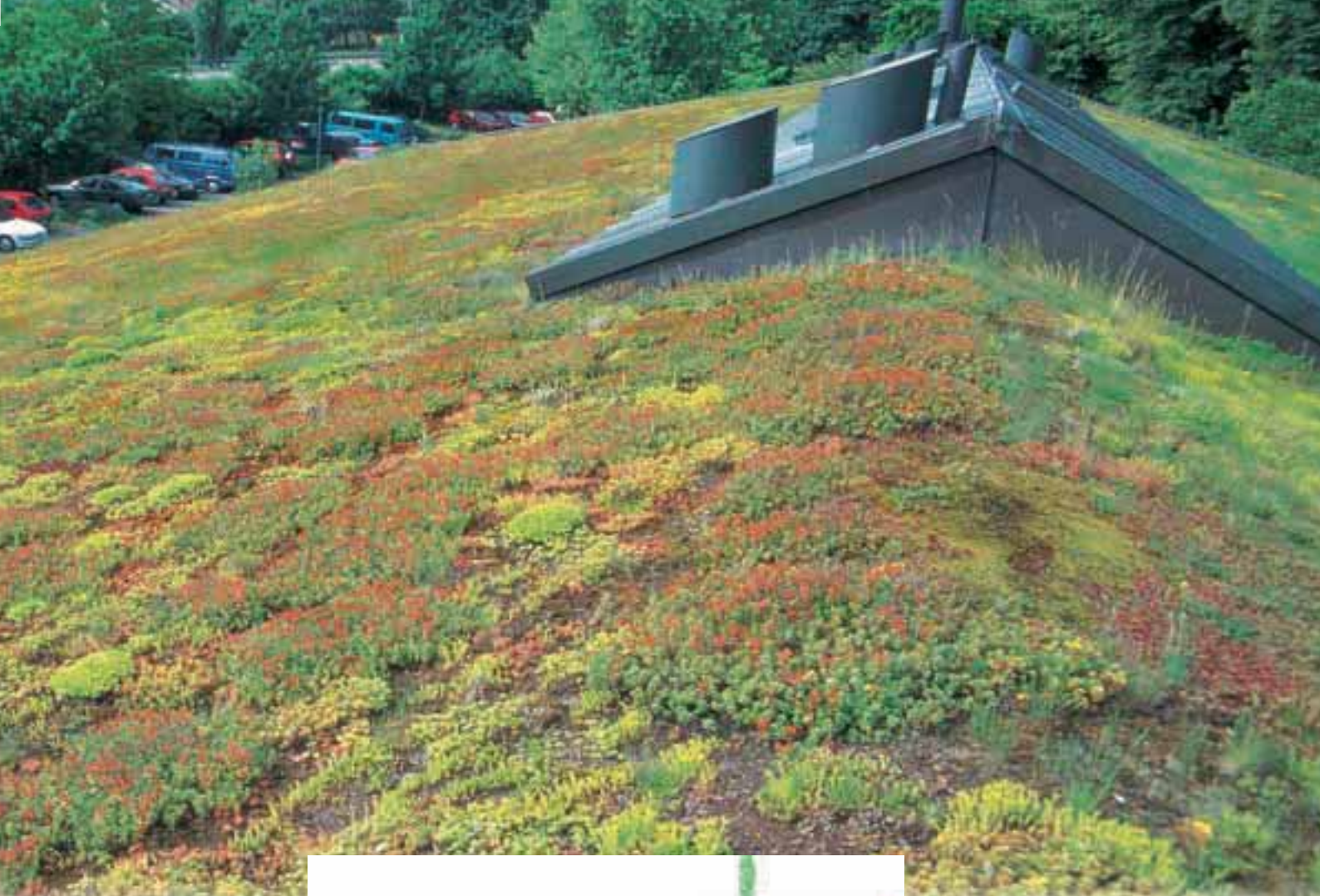
- Determined from thousands of square meters of experience, membranes for pitched roofs, between ca. 10° to 25°, have to be waterproof as well as root-resistant.
- The Floratec elements, installed over the entire roof surface, ensure sufficient interlocking with the substrate and prevent erosion.
- The elements transfer the shear forces into the reinforced eaves or into additional shear barriers which have sufficient load bearing capacity.
- Additional erosion protection is given by coarsely-meshed Anti-Erosion Net JEG, used for pitched roofs > 15° and roofs with strong wind exposure.
- The system build-up is resistant to flying sparks and radiating heat. It is also regarded as a “hard roof“ according to Standard DIN 4102, part 7.



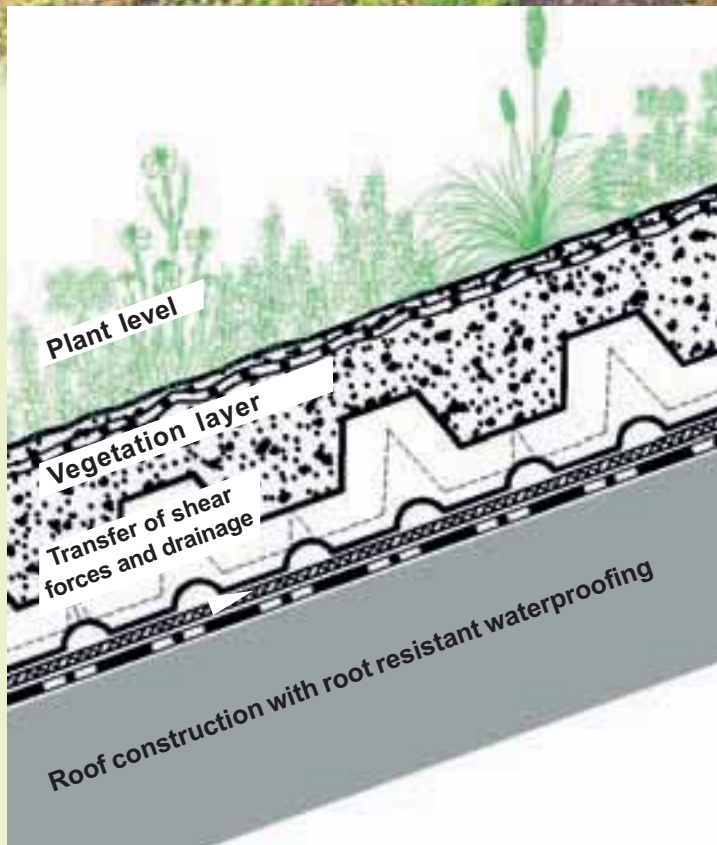
This private home was covered in 1987 with the ZinCo system build-up “Pitched Green Roof“ with perennials serving as the vegetation base. The slope is almost 25°. Without additional irrigation and with maintenance once or twice a year the general character of the vegetation did not change much. Of course, over the years some of the plants disappeared, but others were brought in by wind and birds.

The substrate was fully covered by vegetation and erosion did not occur. Vegetation and root-resistant waterproofing are still fully functioning. The wooden house with its green roof proves an attractive eye-catcher.





Weight kg/m ²		Height mm
dry	water saturated	
80	105	> 50
3	10	80
83	115	



Plug plants according to the plant list "Rockery Type Plants"

Slope > 15°

Anti-Erosion Net JEG necessary

System Substrate "Rockery Type Plants" > 50 mm above the top level of the Floratec elements

FLORATEC FS 75

Protection Mat BSM 64

Note:

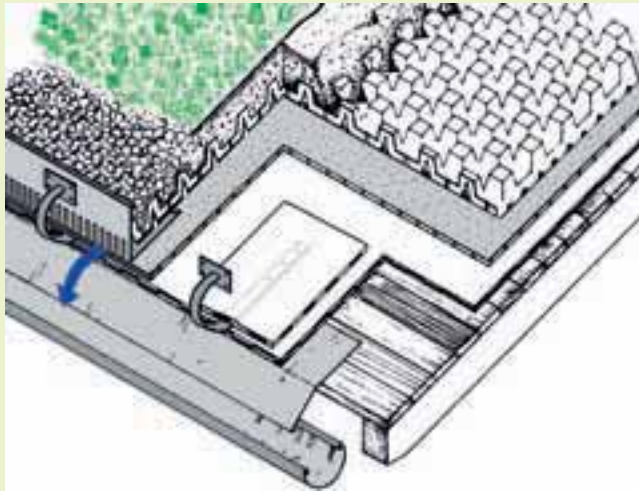
A root-resistant waterproofing is a precondition for pitched roofs. Additional root barriers are not easily installed on pitched roofs.

Slope:		10-15°	15-20°	20-25°	
Build-up height:	approx.	130	140	150	mm
Weight, saturated:	approx.	115	130	145	kg/m ²
Water retention capacity:	approx.	32	36	40	l/m ²

Technically sound details ensure the long of pitched green roofs.

Eaves with gutter

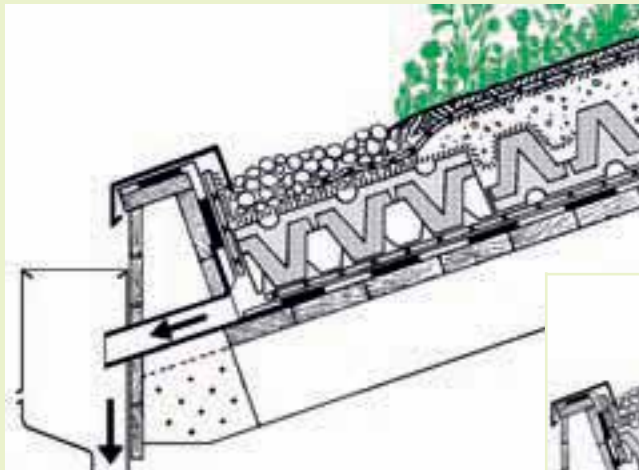
Very often the drainage of rain water on pitched green roofs is transferred into gutters. The shear forces, caused by the green roof system build-up, need to be diverted into the roof construction. This is done either with the slotted Eaves Profiles TRP 140 complimented with support brackets, or with beams ...



... which are fixed to steel angle irons. The beams are installed a certain distance above the waterproofing to allow for excess water to drain unhindered. Eaves support brackets and steel angles have to be installed according to the load bearing capacity calculations.

Eaves with water spouts and eaves troughs

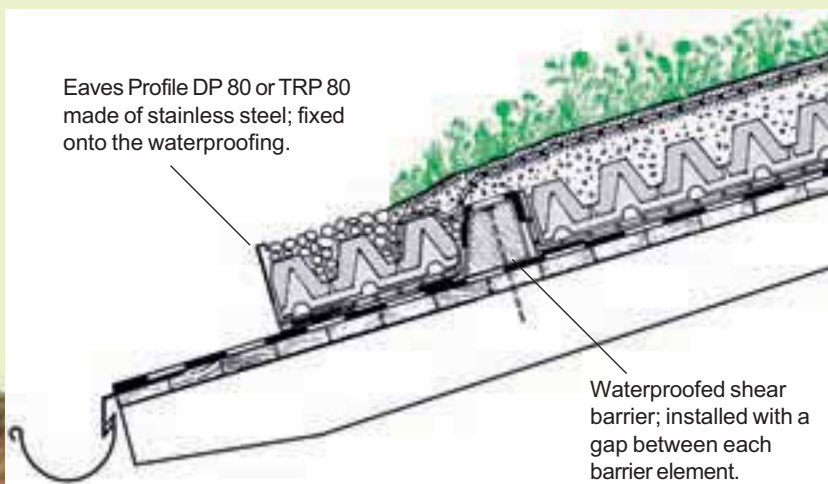
A pitched green roof can be compared with a "tipped" flat roof. The perimeter at the eaves area is to be designed with sufficient height and stability. Using water spouts, excess water is led into eaves troughs and further into down pipes. The channel system on the underside of the Floratec elements provides necessary horizontal distribution of water at the roof's eaves; additional drainage pipes are not necessary. Drains within the roof area are also possible. These gullies or water spouts are to be installed directly at the lowest point.



a distance of 300 mm, as usually required by the "German Regulations for Flat Roofs" for roof penetrations. These measures are not relevant in this case.

Slim eaves?

For aesthetic purposes monopitched roofs are often designed with slim eaves. Waterproofed shear barriers, installed a certain distance back from the eaves, divert the main load into the roof construction. A "slim eaves profile" is sufficient, if installed a short distance down the roof from the shear barrier. These profiles are positioned again a certain distance back from the roof edge and gutter. Under the profiles the waterproofing must be fixed mechanically or adhered onto the roof substructure.

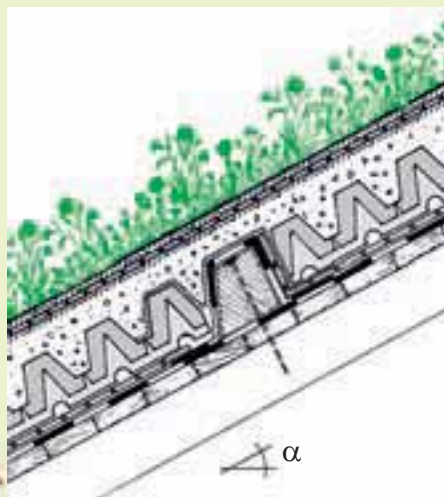




Additional shear barriers

On roofs with a slope of $< 20^\circ$ existing shear forces are transferred into the eaves via the structure of the Florateg FS75 elements; therefore, the substrate is stable and is kept from sliding off the roof.

Regarding steeper pitched roofs and/ or roofs greater in length, the installation of additional shear barriers is necessary. The barriers have to be anchored into the roof's subconstruction and water-proofed separately.



They also need to incorporate gaps to allow excess water to run off.

The load, absorbed by the eaves or the shear barrier, depends on the weight of the system build-up (including snow load), the roof slope ($\sin \alpha$), and shear length. It is recommended to consult a structural engineer.

Disregarding preceding calculations, the following list displays barrier distances that should not be exceeded.*

$\geq 20^\circ$: approx. 10 m (~36%)
$\geq 25^\circ$: approx. 8 m (~47%)
$= 30^\circ$: approx. 5 m (~58%)

* Barrier distances are to be reduced with snow loads exceeding 75 kg/m^2 . Please contact your structural engineer.



The green roof system build-up for slopes $\leq 35^\circ$:

“Steep Pitched Green Roofs“ with ZinCo-Georas

The system build-up “Steep Pitched Green Roof“, based on the ZinCo-Georaster elements, enables green roofs with slopes exceeding 25° to be installed.

The Georaster elements, approximately 540 x 540 mm and 100 mm high, with protected patent rights, are made of recycled polyethylene (HD-PE) and can be connected without requiring tools. This allows for the Georaster elements to interlock and create a stable unit system. An area, covered by raster

elements is safely accessible and can be infilled with system substrate. The Georaster elements cater for plenty of space for the plant root systems to establish and develop.

The plant selection has to be well adjusted to the extreme conditions of steep pitched green roofs. Both heightened solar radiation for south facing roofs, and increased speed of rain water run off are concerns as the roof pitch increases.

To avoid gaps in the vegetation coverage, which would lend to erosion, the option to irrigate should be planned for, even if it is only needed in times of drought.

The system “Steep Pitched Green Roof“ also requires the transfer of existing shear forces into stable eaves and, if necessary, into additional barriers.

Disregarding the use on pitched roofs, Georaster elements are also installed under reinforced lawns, road constructions, in slope protection and other similar roof constructions.

Installation phases of a Steep Pitched Green Roof:



❶ The roof's surface is sealed with a root-resistant waterproofing, meeting German Standard “FLL“ requirements.

❷ The waterproofing is covered with the Protection Mat WSM 150, the Georaster elements are installed starting from the eaves and then upwards.

❸ In this case the system substrate “Heather with Lavender“ is delivered in bulk and is pumped up onto the roof until the Georaster element's top surface is covered with 10 mm of substrate.

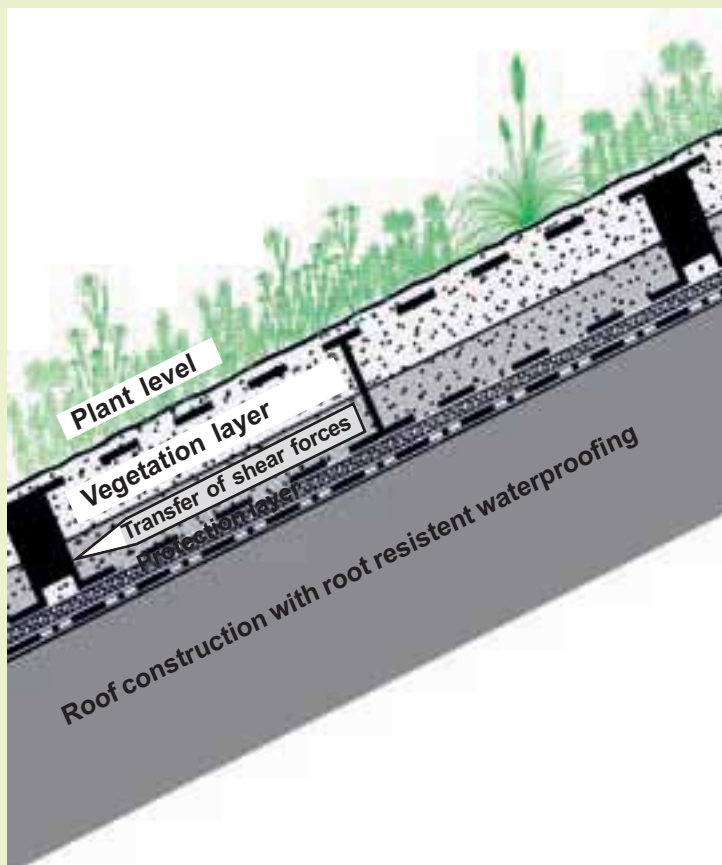
❹ The roof is planted with different types of Sedum and perennials.

❺ After one growing season, the vegetation has mostly grown in. The drainage of the roof works with eaves gutters, in which three water spouts discharge rain water.

ter.



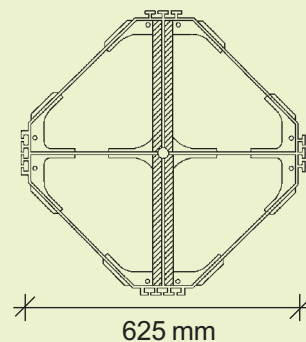
Weight kg/m ²		Height mm
dry	water saturated	
89	ca. 153	120



Dense planting
mainly with Sedum plug plants*
Filled with System Substrate
“Heather with Lavender-light”
(< 10 mm above Georaster element)
GEORASTER elements
Protection Mat WSM 150

Note :
A rootproof waterproofing is
required; additional root barriers
cannot be incorporated.

Georaster element



Build-up height:	approx. 120 mm
Weight, water saturated:	approx. 155 kg/m²
Water retention capacity:	approx. 64 l/m²

* Georaster elements are basically planted with a plant selection of 28 Sedum plants per sqm. This ensures a minimum of two plants per compartment. Additional perennials are regarded as supplemental. For roofs slopes of >30° pre-cultivated vegetation mats are recommended

Project specific green roof system technology unique solutions on pitched constructions.

The project "Prussian Casemats" in Saarlouis was a redevelopment that was fitted with new waterproofing in 2003. ZinCo Georaster elements were used for the green roof installation. Due to missing eaves upstands to support the system build-up, the complete roof surface was covered at first with high-

tensile plastic nets, and the Georaster elements were attached by stable cable binders to those nets. The grid elements were infilled with a special substrate and covered by pre-cultivated vegetation mats.

Already after a few weeks, the mats were rooted tight into the substrate. Irrigation allows for the green roof's vegetation to survive the summer heat.



This photo shows the "Prussian Casemats" in Saarlouis before the refurbishment in March 2003. Tarps barely protect the building against penetrating precipitation.



The roof's 45° slope is covered by stable high-tensile plastic nets. The Georaster elements are attached to the nets by stable cable binders.



The special substrate had to be infilled, in a moist condition, and to avoid hollow space it had to be compressed, therefore enabling the installation of the pre-cultivated turf.

From a technical point of view: A demanding project.



The basic construction of the new office building of the "Riedel-Baustoff-Recycling" in Moers, also called "UFO", is an

old Cebit-exhibition booth made of steel. The roof is made entirely of reclaimed wood. To protect the one-layer high-



polymer roof covering, the green roof system has been installed. Supporting the concept of recycling, system substrate and drainage elements were made of recycled materials. A special challenge was the covering of the roof's perimeters with a 45° slope. The base, 120 mm eave profiles, manufactured of stainless steel, were built in for the edging.

gy allows for



The “Prussian Casemats” in Saarlouis, at the beginning of the pedestrianized zone, hosts a number of restaurants.

Steep constructions for architectural diversity.



Floratec FS 75 elements and ca. 80 mm of System Substrate “Rockery Type Plants”, serve as a base for the installed Sedum vegetation mats.



Green roofs often display remarkable designs. The photos demonstrate examples of pitched green roofs in Duisburg (above) or in Köngen at the Neckar river (left). Both green roofs were built with Floratec elements.

A visual highlight, a technical challenge.

The new residential and commercial building Zoller was designed as the showpiece for the Zoller company. The building provides solar-panels on the southern exposure, whilst the upper section consists of a ZinCo green roof system. The lower section, designed

with a steeper roof, is made of a flexible metal roofing with standing seam technology. Because of the complicated accessibility of the roof's surface, a vegetation requiring low maintenance was needed. Still the plants had to be deeply rooted to avoid erosion effects.

For the base of the ZinCo green roof system a root barrier was used, then covered by a moisture retention and protection mat.

The 400 mm high Floradrain® elements were installed in pre-cut strips on top.



As an additional measure to transfer the shear forces, steel tube columns were installed inside the green roof area, running in rows parallel to the eaves. These posts were anchored and waterproofed into the roof's sub-construction. Perforated profiles, made of stainless steel installed in front of the posts retain the substrate.

On top of the System Substrate "Rockery Type Plants" with a depth of 100 mm, the wide-meshed Anti-Erosion Net JEG was installed and afterwards infilled into the substrate's upper layer.

The vegetation selection "Rockery Type Plants" was installed in the form of plug plants. The density of the plants for the flat area was ca. 16 pieces/m² and for the steeper area ca. 24 pieces/m².

Another idea for roofs:

A combination of brick and green roof systems.



These two semi-detached houses in Kusterdingen, near Tübingen, also display the contrast of different building methods with facades of wood or plaster and roofs of brick and green roof systems. The 30° pitched green roof is now 10 years old.

This residential building of the Widenhorn family, near Lake Constance shows the green roof in combination with a brick roof. The base for the landscaped section is a root-resistant waterproofing. The green roof system corresponds to the system build-up "Pitched Green Roof" described on pages 4 and 5 in this brochure.





The residential and commercial building “Zoller“ near Vaihingen/Enz captivates with its unusual design.

Basic facts of green roof systems on barrel roofs.



With stable eaves upstands even barrel roofs can be installed with the system build-up “Pitched Green Roof“. If the barrel roof has a higher curvature, the Floratec elements need to be divided in two, as done at the former fortress “Lunette“ in Rastatt (photo above).

In the case that eaves upstands are missing on barrel roofs, the deep drainage mats of Floradrain® FD 40, produced in customized lengths, can be installed. Without using a filter sheet, the substrate and the drainage layer interlock in a way that allows for the shear forces within the green roof system to be transferred into tensile forces. This method of construction, for example, was used on the egg-shaped

prefabricated garages of the Zapf company (photo top right). For barrel roofs there is no standard solution. In cooperation with the ZinCo technical department project specific solutions are created. The photo on the bottom right displays a building with a roof made of stainless steel.

Having a steeper pitched roof, the substrate area needs to be divided into smaller parts. This can be achieved by installing cross directional profiles on stainless steel strips. This construction is then

covered by substrate. The use of Georaster elements on barrel roofs is possible but conditional.



Crucial for pitched green roofs in the long run:

The correct plant selection.



The vegetation cover of pitched roofs should stay full all year long to avoid erosion. In addition, surfaces of pitched green roofs are highly visible and therefore need to have a pleasant appearance. Compared to flat roofs sloped roofs are subject to: faster water run off, less efficient water retention and

higher degrees of solar radiation on southern exposures. The effects become more extreme as the pitch increases. Very often, more depth of substrate is impossible due to the load bearing capacity. Without additional irrigation, only a very limited plant selection can be used. Three photos of the municipal gardening station of Tübingen show the vegetation growing on pitched roofs

without any additional irrigation units installed ("Pitched Green Roof" installed in 1986). The initial precultivated turf, installed on the north side died off completely after a short period of time. Gradually, the "Sedum-herb-vegetation" that covered the southern roof surface (plant selection "Rockery Type Plants"), extended to the northern side.

"Grass on roofs"

This project in Munich demonstrates that lawn can also be installed on pitched roofs. Although it has to be taken into consideration that the lawn needs to be mown regularly and the trim needs to be removed from the roof. In cases of low build-up heights the water supply can be ensured by installing an irrigation system. Usually, it is better to choose a drought resistant grass-herb-vegetation, for example, the plant selection "Grassy Pasture" in combination with Sedum, instead of choosing only lawn vegetation.



The result is a wild meadow character on top of the roof, as shown here at the log house in Gotha. Mowing once a year will help support the abundance of species.





Selection of plants

On pitched roofs, plug plants of the selection “Rockery Type Plants“ can be used. In general, Sedum makes up the majority of the green roof vegetation. For a roof pitch of $> 20^\circ$ that is not exposed to full sun other perennials can be used as additional vegetation and colour interest. Usually, plants should be planted in groups of three or five (at a maximum of seven). On a roof slope $> 25^\circ$ the portion of perennials should be reduced, because Sedum is able to grow with a low supply of water and

ensure erosion protection at the same time. Roofs with a roof slope $> 30^\circ$ should be covered only with Sedum. It needs to be considered, that areas covered only with one type of Sedum, should be limited to approximately 1 to 2 m². At least four different Sedum types will allow for durable vegetation coverage. Suitable Sedum types for pitched roofs are listed in the table below, and can also be found in the ZinCo plant lists: “Sedum Carpet“ or “Rockery Type Plants“.



Recommended plants for pitched green roof systems

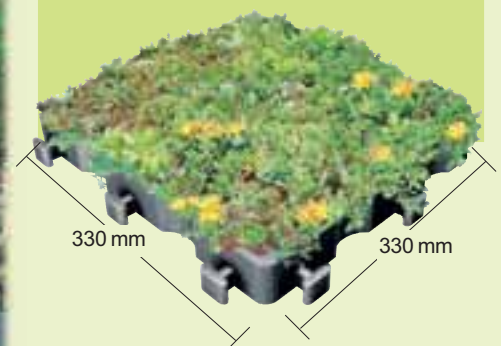
- Sedum album
in different varieties
 - Sedum floriferum
“Weihenstephaner Gold“
 - Sedum hybridum
“Immergrünchen“
 - Sedum sexangulare
 - Sedum spurium
in different varieties
 - Perennials of the plant selection
“Rockery Type Plants“.
-
- Plant density:
 - ≤ 15°: 15 - 20 pieces/m²
 - > 15°: 20 - 25 pieces/m²
 - > 25°: ≥ 28 pieces/m²



Roof slope $> 30^\circ$:

On pitched roofs $> 30^\circ$ as well as on exposed ridges and perimeter areas pre-cultivated Sedum mats are required or EcoSedum elements are to be used.

For special applications: ZinCo EcoSedum



Green Roof solutions for a roof slope $> 35^\circ$ as well as plant recommendations are given by the ZinCo Technical Department.

With system technology green roofs are

sound and long lasting.

This planning guide is intended to provide a detailed overview of the technology available to support you in developing project-specific, highly effective pitched green roof specifications for your future building projects.

Our

ZinCo Technical Department

as well as our

technical consultants

will assist you with help and advice: from the planning stage through to the writing of the

specification documentation.

Challenge us!



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