



PLANNING GUIDE

Systems for Pitched Green Roofs

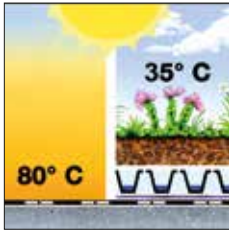
Life on Roofs



Green Oases for our Cityscape

Environmental, urban and engineering benefits of a green roof:

Protection of the Roof Membrane



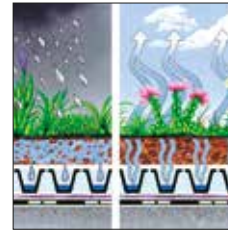
- Protects the roof membrane from UV radiation, heat, cold and hail

New Habitat



- Avoids sealing and creates new habitat for plants and animals

Rainwater Retention



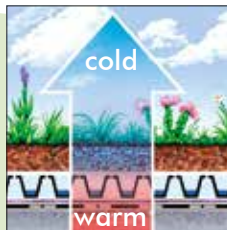
- Reduces run-off

Binds Dust



- Enhances the microclimate by filtering out dust and smog particles

Reduction of Energy Costs



- Thermal protection and reduction in heating and cooling costs

Noise Protection



- Enhances sound insulation

Features

- In contrast to flat roofs where roof gardens are often installed, pitched roofs are usually equipped with low maintenance extensive green roofs.
- Shear forces are to be derived into stable eaves edgings and – if necessary – into additional shear barriers using load absorbing elements.
- Due to the faster water runoff on pitched roof areas the substrate layer needs to be increased; the possibility of an additional irrigation should be given.
- To prevent erosion on pitched roofs plants should be applied with a higher density; in case of a steep pitch precultivated vegetationmats are recommended
- On pitched roofs the orientation of the roof area (North / South) might affect vegetation development.

Principles

Green roofs are created and installed by ZinCo in line with prevailing standards and with system.

Our five principles at a glance:

- The System Build-up is adapted to the given roof.
- The choice of plants is selected to suit the extreme location of a pitched or steep pitched roof.
- The System Build-up provides for a good balance of moisture and air.
- Depending on the building conditions, additional irrigation should be an option.
- The level of maintenance required depends on the pitch of the roof and the vegetation used.



More Options with ZinCo



What Do we Need to Know?

4



Pitched Green Roof with Floraset®

6



Steep Pitched Green Roof with
ZinCo Georaster®

10



Technically Sound Detail Solutions

10



Greening Barrel Roofs

12

Plant Selection

12



Green roof solutions
for creative pitched roofs

14

Enduring Success with Pitched Green Roofs – What Do we Need to Know?



When is a Green Roof Pitched?

While even flat roofs should have a pitch of at least 2 % for the purposes of this brochure a pitched roof is one with a pitch of at least 10°, which is just under 18 %. Upwards of this pitch, the green roof build-ups differ from those that are used for flat roofs and low-pitched roofs.

On one hand, the shear forces from the green roof build-up increases the steeper the roof pitch is and needs to be diverted to a sufficiently stable counter support. On the other hand, the substrate layer also has to be protected from erosion. The choice of plants and their application must be compatible with the roof pitch and the level of exposure.



Additional Irrigation

Additional irrigation during dry periods guarantees an impressive appearance and extends the flowering season. Irrigation can be provided either by means of drip lines installed along the roof ridge or “over head” by means of a sprinkler or spray nozzle.



A Root-Resistant Waterproofing is a Requirement

A professionally sealed roof area, e.g. with bitumen or a synthetic membrane, is required for a green roof to function permanently. The waterproofing membrane should be root-resistant, as it is very difficult to install additional root-resistant sheets on pitched roofs.

It is important that the issue of the maintenance of the green roof is addressed right from the beginning. Skylights can be used to access the roof area. A sufficient number of anchor points should be planned for around the roof area, to which people can anchor themselves when carrying out maintenance and service works on the roof.



In the case of roof penetrations it is important to ensure that the waterproofing layer is drawn up to at least 100 mm above the upper edge of the substrate layer. Green roof build-ups can be bordered using the stainless steel Eaves Profile TRP 140 in combination with shear retainers (either Support Bracket TSH or Shear-Fix LF).



This roof with a pitch of approx. 5° is drained using a gutter and does not yet require any special measures.



With this roof, which has a pitch of approx. 30°, a shear barrier was installed within the roof area, in addition to the stable eaves upstand.



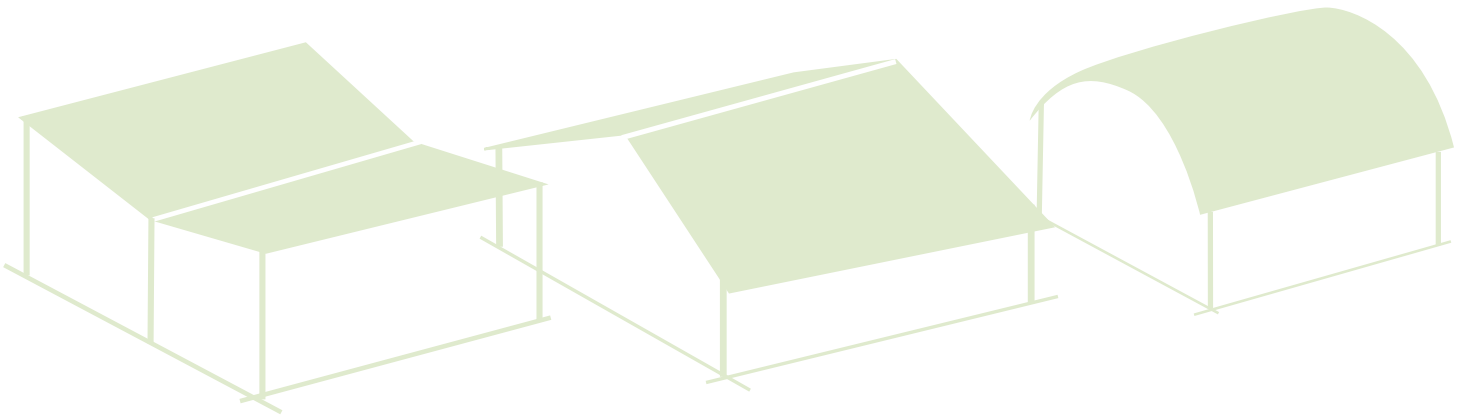
A shear barrier is placed just above the eaves on this monopitch roof, which is drained by means of an outer-lying gutter.



When determining the dimensions for eaves upstands or shear barriers, it is not only the saturated weight of the green roof build up that is relevant. Local snow loads must also be taken into consideration.



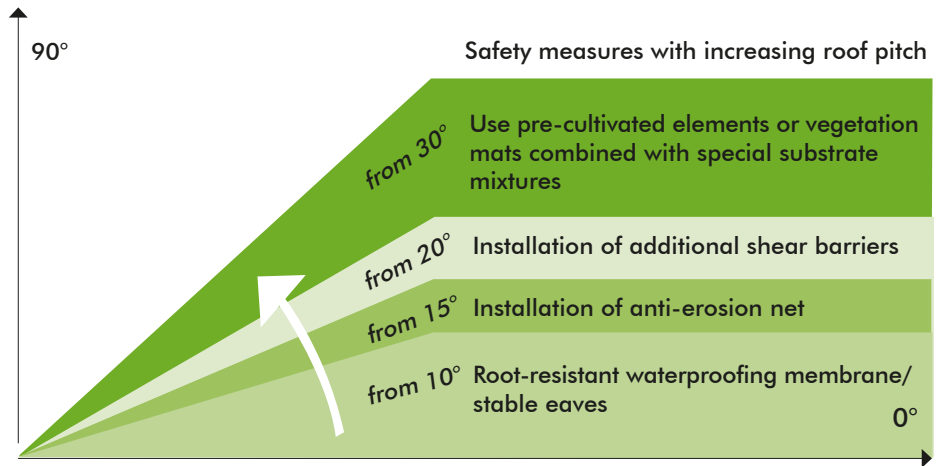
The use of solar energy is also possible on pitched green roofs. The issue as to how each system can be installed without penetrating the waterproofing, is addressed for each individual system.



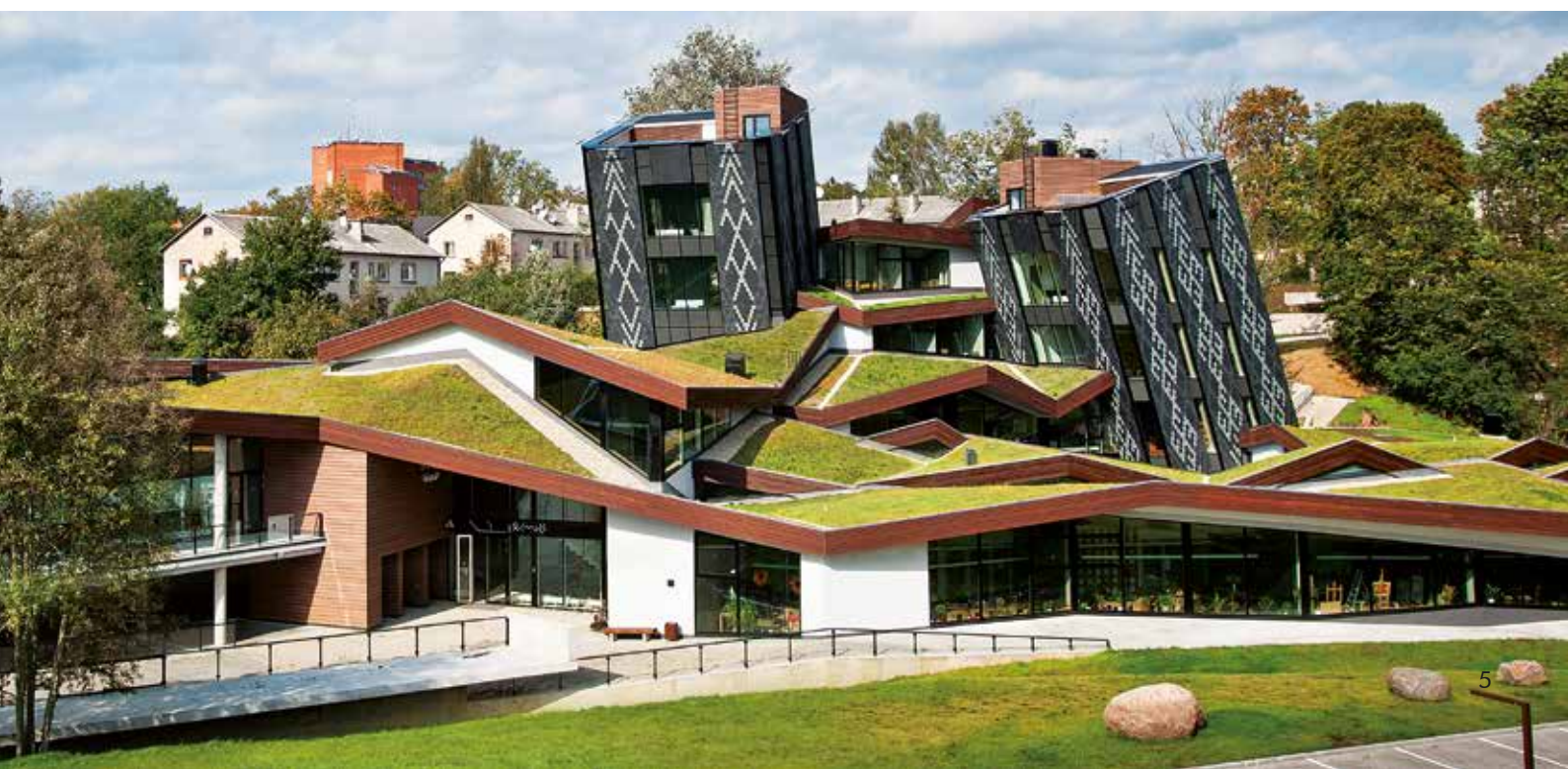
Shear Forces

The diagram on the right indicates which measures are generally required for which roof pitch.

It is also important to check if, in the case of the roof sub-structure, measures have to be undertaken to prevent the roof layer package from slipping down. This may already be useful for a roof pitch of less than 10°.



Roof pitch: Degrees	10°	15°	20°	25°	30°	35°	40°	45°
Per cent	15%	30%	45%	60%	80%	100%		
System Build-up for "Flat Roofs" (see Planning Guide "Extensive Green Roofs")	System Build-up for "Pitched Green Roofs" (see page 6)		System Build-up for "Steep Pitched Green Roofs" (see page 8)			Special solutions in consultation with ZinCo Technical Department		



Pitched Green Roof with Floraset® FS 75



Elegant finish included. A "slim" roof edge with a stainless-steel panel mounted on the Shear Fix LF 600.

- Tried and proven across thousands of square metres – a low-maintenance green roof build-up for root-resistant waterproofed roofs with a pitch of between approx. 10° and 25°.



- The Floraset® FS 75 elements installed across the entire roof surface interlock well with the substrate and prevent it from sliding off.

- These elements distribute the shear forces safely into the eaves upstand that has been dimensioned in line with structural requirements or into additional shear barriers.

- Additional anti-erosion protection thanks to the coarse-meshed Jute Anti-Erosion Net JEG for roof pitches > 15° or in the case of exposure to strong winds.

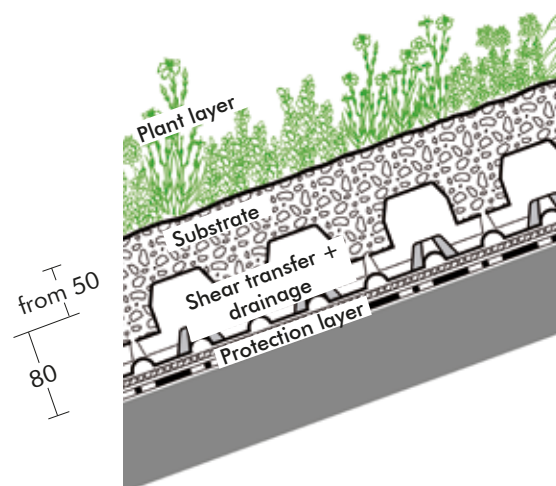
- The build-up can withstand sparks and radiant heat and is classified as a "hard roof" in compliance with the German standard DIN 4102, Part 7.





Weight kg/m ²		Depth mm
dry	saturated	
75	105	from 50 80
2	10	
77	115	

Depth
mm



Plug plants as per plant list "Pitched/
Steep Pitched Green Roof"

System Substrate "Rockery Type Plants"

Floraset® FS 75

Protection Mat BSM 64

A root-resistant waterproofing
membrane is required.

Roof pitch:		10–15°	15–20°	20–25°	
Build-up height:	ca.	130	140	150	mm
Weight, saturated:	ca.	115	130	145	kg/m ²
Water storage capacity:	ca.	38	40	44	l/m ²

Steep Pitched Green Roof with ZinCo Georaster®



The System Build-up “Steep Pitched Green Roof” based on the ZinCo Georaster® system, as presented here, is suitable for greening roof areas with a pitch of over 25°. The Georaster® elements are 540 x 540 mm in size, 100 mm high and made of recycled polyethylene (HDPE). No tools are required to attach them to each other. The result is a stable and continuous unit.

An area on which these grid elements have been installed is safe to walk on and can be filled with system substrate.

Thanks to the low volume of the Georaster® elements themselves, a relatively large space remains for root development. The choice of plants must, of course, be suited to the extreme location of a steep pitched roof, where exposure to the sun can be extreme and rainwater flows off quicker than on a flat roof.

In order to avoid gaps in the vegetation that could also be the start of erosion, irrigation should be considered as an option, even though it may only be needed in critical times. With the System Build-up

“Steep Pitched Green Roof” it is important to ensure that any occurring shear forces can be diverted to stable eaves upstands and, if necessary, additional shear barriers.

In addition to their use on pitched roofs, Georaster® elements can also be used as a reinforcement for gravel lawns, for creating pathways, when securing embankments etc.

Steps to Creating a Steep Pitched Green Roof:



The roof area to be greened is sealed with rolls of waterproofing membrane that have been tested for their root-resistance in line with FLL procedures.



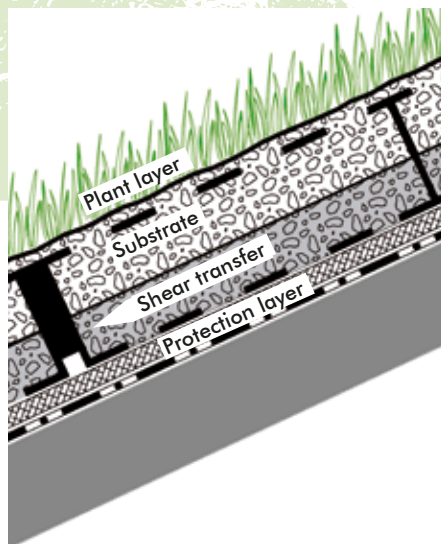
Once the area has been covered with the Protection Mat WSM 150, the Georaster® elements are installed, starting from the bottom up.



The system substrate “Heather with Lavender-light” is, e.g. delivered in a silo tanker. It is then blown onto the roof until the Georaster® elements are filled and covered up to about 10 mm over their upper edge.



Weight kg/m ²		Depth mm
dry	saturated	
89	155	120



Dense planting in line with the plant list "Pitched/Steep Pitched Green Roof"*)

Filled with system substrate "Heather with Lavender-light" (up to approx. 10 mm over the top of the Georaster® elements)

Georaster® elements
Protection Mat WSM 150

A root-resistant waterproofing membrane is required.

Build-up height: from 120 mm
Weight, saturated : from 155 kg/m²
Water storage capacity: from 64 l/m²

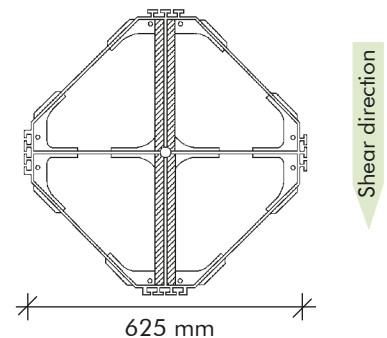


Finally, the roof is densely planted with various Sedum species and other perennials.



Even after only one vegetation period the plant coverage is largely complete. The roof area in this example is drained by means of an outer-lying gutter into which the three water spouts carry any excess water.

Georaster® element



*) Georaster® elements are generally planted with at least 28 plug plants per m². Therefore, there are at least 2 plants in each field of the element. Additional perennials for visual highlights as per the plant list "Pitched/Steep Pitched Green Roof" are possible. We recommend using vegetation mats or EcoSedum® elements for roofs of approx. 30° and upwards.

Technically Sound Detail Solutions for Enduring Success with Your Pitched Roof



Roof Perimeter with Drainage into Outer-Lying Gutter

Very often with pitched green roofs, an outer-lying gutter is the drainage option of choice. With this option, the shear force created by the green roof build-up has to be transferred to the roof structure via an eaves profile with drainage slots and an eaves support bracket. This allows for excess rain water to drain away unobstructed.

Support brackets and steel angles must be arranged in line with structural requirements. We recommend a loose-fixed flange construction for securing the eaves support bracket.



Eaves Profile
TRP 80 / 140



Additional Shear Barriers

As the system substrate interlocks well with the Floraset® elements, shear forces occurring with roof pitches of up to approx. 20° can usually be distributed to the eaves upstand.

However, where the roof pitch is greater and/or the roof is longer, additional shear barriers must be installed. Up to now, wooden shear barriers were generally used here. They were anchored to the roof sub-structure and sealed separately.

Given the loose-fixed flange construction, the same detail can be used as with the eaves. This achieves a vegetation which is visually not interrupted.

The shear force taken up by the eaves upstand or the shear barrier depends on

the build-up weight (incl. snow load), the pitch of the roof ($\sin \alpha$), the shear length and the coarseness of the waterproofing layer. For safety reasons, the latter should not be taken into account.

In our experience, if there are no project specific calculations, the following shear barrier distances should not be exceeded:*)

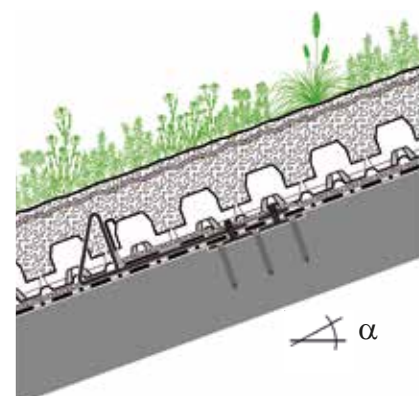
System Build-up "Pitched Roof":

20° pitch: approx. 10 m

System Build-up "Steep Pitched Roof":

25° pitch: approx. 8 m

*) These distances must be reduced in the case of snow loads above 75 kg/m². Please consult a structural engineer!



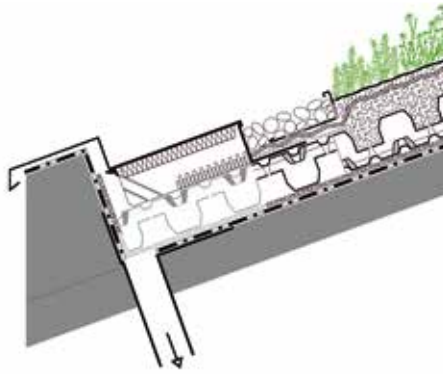
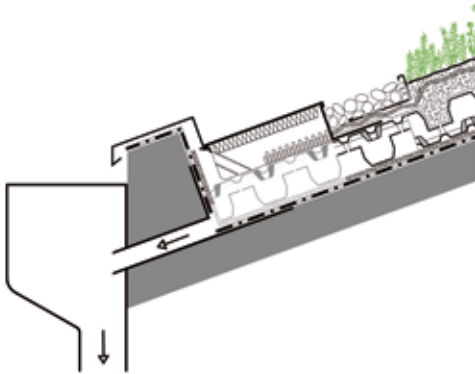
With the Loose-fixed flange construction of the Shear Fix LF 300 and the Eaves Profile TRP 80 even shear barriers within the green roof area can be realised.



Traufe mit Wasserspeier und Rinnenkessel

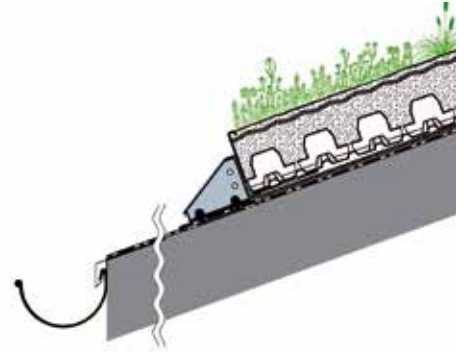
A pitched green roof can be built like a "tilted" flat roof. But to do this, the upstand around the eaves must be sufficiently high and stable. Excess rainwater can be drawn off by water spouts into the gutter and the attached downpipes. The channel system of the Floraset® elements provides for the necessary lateral distribution of the water. Additional drainage pipes are not required.

In principle, drainage is possible using roof outlets. However, they have to be positioned directly in front of the eaves upstand. A clearance of 300 mm, as is generally specified in the German Flat Roof Guidelines for roof penetrations etc. is not best practice here.



"Thinner" Roof Edge Desired

For reasons of visual appearance – in particular with monopitch roofs – great importance is attached to a "thin" roof edge. This is achieved by moving the Eaves Support Bracket back from the edge and not greening the front part of the roof. However, it is important to ensure in this case that the waterproofing membrane is protected or that a suitable weather-resistant waterproof membrane is applied.



Stainless Steel Profile secured with an Support Bracket LF 600.

Shear-Fix LF 300 / LF 600 / LF 150

Shear retainer LF 300 and LF 600 for use on sealed pitched roofs to prevent the green roof build-up from slipping. To be installed in connection with Eaves Profile TRP 80 or TRP 140 at the eaves or as shear barrier on the roof area.

The base plate is fixed with 5 corrosion-protected screws on the supporting structure. It is sealed according to German DIN 18195-9 with the sealing material used for the roof as a loose flange/fixed flange construction.



Shear Fix LF 300, made of solid stainless steel, replaces wooden shear barriers in connection with ZinCo eaves profiles. Perfect for roofs with a lesser slope. Load bearing capacity: 300 kg/shear retainer.



The Shear Fix LF 600 is also made of stainless steel and is designed for loads of up to 600 kg per bracket. It offers considerable added value thanks to the fixing options.



Shear Fix LF 150

The two-part screw anchor LF 150 made of stainless steel is used where the load is only around the 150 kg mark per stopping point. Ideal for fixing gravel retainers using a retaining plate.

Green Roof on Barrel Roofs – the Basics

If there is a stable eaves upstand available, the System Build-up “Pitched Green Roof” can also be used for barrel roofs. If the roof area is extremely curved, the Floraset® elements should perhaps be divided in the middle, as was done with the former fortress “Lunette” in Rastatt, Germany.



There is no standard solution for barrel roofs. However, solutions specific to your building can be worked out in conjunction with the ZinCo Technical Department, as seen with the roofs of apartment blocks



in Pfäffikon in Switzerland (photo above). As gravel edge strips cannot be used for roofs with an extreme pitch, grass pavers ensure a solid and location-stable option for eaves drainage.

In the picture on the right, the System Build-up “Steep Pitched Roof” with Georaster® elements is installed in the steep, lower area. The elements distribute the shear forces into smaller portions and help to keep the erosion stretches very short. The transition to the System Build-up



“Pitched Roof” in the upper area with a lower pitch is possible thanks to the Eaves Profile held against it. The drainage element Floraset® FS 75 interlocks well with the substrate.

Particularly Significant for Pitched Green Roofs: the Correct Choice of Plants

In order to prevent erosion, the vegetation layer on a pitched roof should be permanently covered. As these roof areas are generally visible, a pitched green roof should of course be visually very appealing. However, a pitched roof is different in many ways to a flat roof: water runs off more quickly and is not as easy to retain.

In the case of a steep pitch and an orientation to the sun, these differences are particularly accentuated. For structural reasons it is often not possible to increase the depth of the substrate. Without additional irrigation, therefore, the choice of plants is considerably limited.

On the one hand, considerable attention must be paid to shear forces, and on the other hand, there has to be sufficient water retention in the system build-up. Generally speaking, the vegetation picture on the south side is different to that of the north side. For example, on the sunny south side grass is probably more likely to survive.



Pitched roofs require special measures to safeguard the vegetation.

From 20–25°, additional irrigation must be possible during dry periods. Depending on precipitation levels, even at a lower pitch.



Recommended Plants for Pitched Green Roofs	
Ground cover perennials	Recommended proportion
<i>Sedum album</i> in varieties	approx. 0–10 %
<i>Phedimus floriferum</i> 'Weihenstephaner Gold'	approx. 30–40 %
<i>Phedimus hybridus</i> 'Immergrünchen'	approx. 15–20 %
<i>Sedum kamtschaticum</i>	approx. 15–20 %
<i>Phedimus spurius</i> 'Pink' and 'White'	approx. 15– 20 %
Small group perennials	
Plant list "Pitched/Steep Pitched Green Roof"	in addition to the above 4–5 pcs/m ²
Plant density (incl. small group perennials)	up to 15°: at least 20 pcs/m ² up to 20°: at least 24 pcs/m ² up to 25°: at least 28 pcs/m ² up to 30°: at least 34 pcs/m ²

Choice of Plants

Plug plants from the plant community "Pitched/Steep Pitched Green Roof" can be used on pitched roofs. Sedum is generally the main type of vegetation used while the other perennials on a pitch of approx. 20° offer additional flowering, above all in the shady and less exposed areas. Generally speaking, they should only be used occasionally in groups of 3 or 5 (or maximum 7).

Upwards of a pitch of 25°, the perennial "proportion" should be reduced, as Sedum is more capable of thriving with a low water supply and ensuring protection against erosion.

limited to 1–2 m². The above-mentioned Sedum species will provide for stable vegetation with good ground coverage if the recommended proportions are adhered to.

It is best to use only Sedum for green roofs with a pitch of 30° and upwards. It is worth noting that the individual space for a Sedum species should generally be

Grass on the Roof

As mentioned previously, a lawn can be established permanently on pitched roofs. However, it is important to take into consideration that the lawn has to be mowed regularly and that the cut grass has to be brought down from the roof. With a low build-up depth, the water supply must be ensured by means of a perfectly functioning irrigation system.



An alternative to a conventional lawn is drought-resistant grass vegetation such as the plant community "Grassy Pasture" or "Country Colours". The result is a roof with "wild meadow character" in which a variety of species will be maintained when mowed once a year.

For Special Applications



Roof pitch over 30°: Pre-cultivated Sedum Vegetation Mats should be used for this and greater roof pitches and in exposed ridge or roof edge areas.

Solutions for a **roof pitch over 35°** and building-specific plant recommendations are available from our ZinCo Technical Department.

Golfclub, Wilsdruff



The clubhouse roof has various forms and pitches.



A new club house was built at the existing golf course in Wilsdruff in the Herzogswalde part of town. This included a restaurant, sauna, fitness area, lounge and an apartment with roof terrace. The building with its extraordinary roof form fits perfectly into the hilly landscape. The clubhouse, an extensive green roof installed across the entire roof merges superbly into its surroundings.

upward-facing studs prevent the substrate slipping and the overlying plant mats ensure a quick full coverage and immediate protection against wind shear and erosion.



The Irrigation and Protection Mat BSM 64 was used in the green roof system build-up, and was fully covered by Floraset® FS 75 elements that were developed specially for pitched roofs. The large,



Project data

Area:	ca. 2000 m ²
Architects:	zanderarchitekten, Dresden
Contractor:	Thomas Ruppricht Specialist roofing contractors, Dresden
System build-up:	“Pitched Roof“ with Floraset® FS 75

Springdale Library, Brampton

The Springdale Public Library and the adjacent Komagata Maru Park are in Brampton, a suburb of Toronto.

The triangular, single-storey library building and the surrounding green areas with terraced gardens, a water playground and also a triangular pavilion have won numerous design prizes.

Various sustainability strategies were implemented in order to achieve LEED Gold Certification.

These include a grey water system, a geothermal heating and cooling system, book-like solar-responsive windows, e-car charging stations and, last but not least, a green roof to strengthen thermal insulation.

The green hill creates a domed roof over the reading room below. It is visible from a distance and connects the architecture with the landscape. Particularly when seen from the side, the organic roof form merges perfectly with the sloping ground.



Project data

Area:	ca. 650 m ²
Architects:	RDH Architects
System build-up:	"Steep Pitched Green Roof" with Georaster®



System Technology Provides for a Permanent and Perfect Green Roof!

This Planning Guide aims to answer any queries you may have about pitched green roofs.

Our engineers will be glad to help you work out the details for your own particular project; from the planning stage right through to creating the required specification texts.



ZinCo GmbH · Lise-Meitner-Strasse 2 · 72622 Nuertingen · Germany
Phone: +49 7022 6003-0 · info@zinco-greenroof.com · www.zinco-greenroof.com