



**GUIDELINES ON  
DESIGN AND CONSTRUCTION OF  
PITCHED GREEN ROOF**  
CS E08:2012

Guidelines on Skyrise Greenery



CS E: Skyrise Greenery

## **CUGE STANDARDS CS E08:2012**

# **GUIDELINES ON DESIGN AND CONSTRUCTION OF PITCHED GREEN ROOF**

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# **Design and Construction of Pitched Green Roof**

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The CUGE Standards will be reviewed every three years. Concurrently, CUGE also gathers new information continually through on-going research.

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# **Design and Construction of Pitched Green Roof**

## **SECTION 1 SCOPE**

### **1.1 INTRODUCTION**

This specification sets out the basic requirements for the construction of pitched green roof.

This shall not, in any way, replace, substitute or supersede, whether in whole or part, any existing and/or prevailing relevant statutory rules and regulations, including building codes and standards.

### **1.2 OBJECTIVE**

This specification is intended as a guide for the construction of pitched green roof.

It is intended to act as a reference point for quality assurance of pitched green roof design and construction.

The design and construction of pitched green roof shall comply with the relevant codes of practice and standards of the relevant authorities.

### **1.3 DEFINITIONS**

#### **Green roof**

Extensive green roofs are generally not designed for active recreational use. They are developed mainly for aesthetic and ecological benefits. Distinguished for being low in installation cost, lightweight ( $90\text{--}150 \text{ kg/m}^2$ ) and with shallow mineral substrates, minimal maintenance is expected. Inspection should be performed, at the minimum, once or twice a year. Plants selected are usually of low maintenance and are self-generative. Generally, extensive systems can also be placed on pitched roofs of up to an inclination of 30 degrees. With appropriate engineered stabilizing system and planting strategies, pitched green roof can incline up to 45 degrees! They are common in European countries, especially Germany and increasingly being installed in North American cities as well.



### Roof garden

Intensive green roofs, or roof gardens, are developed to be accessible. They are often used for recreation and other social activities. Hence they are associated with added weight, higher capital cost, more intensive planting and higher maintenance requirements. The plant selection ranges from ornamental lawn, shrubs, and bushes to trees. As they are designed for usage, regular maintenance such as mowing, fertilising, watering and weeding is required.



## 1.4 PERFORMANCE REQUIREMENT

The design and construction of pitched green roof should fulfill the following:

- The pitched green roof must not exceed the engineered load bearing capacity of the roof structure. Load and shear forces on the pitched green roof must be effectively distributed and safely transferred through building and to the ground.
- The pitched green roof must have adequate drainage capacity and efficiency for removal of excess rainwater during torrential tropical downpour.
- The pitched green roof should achieve 100% plant coverage by the end of the 12 month establishment period.

- The pitched green roof should be designed and constructed with provision for safe installation, operation and future maintenance work. Roof edge design and safety provisions, such as safety line, railing, terminal barrier, etc., must be in place, maintained and safely deployable to ensure objects and people on the pitched green roof do not fall off.
- Safety provision can be in the forms of:
  - A defined safety set-back distance from roof edge (This distance is site specific);
  - Safe access to the pitched green roof surface;
  - Provision of safety-railing to prevent worker from falling over the roof edge;
  - Provision of maintained Personal Protective Equipment (PPE), restraint-belt, fall-arrest system and life-line for ready deployment during site installation, operation and maintenance work;
  - Engaging only certified experienced installation, operation and maintenance workers.

## **SECTION 2 PITCHED GREEN ROOF DESIGN & INSTALLATION**

### **2.1 PITCHED GREEN ROOF INSTALLATION**

- 2.1.1 Green roof systems can be installed on pitched roofs and slope surfaces. Generally, most conventional extensive green roof systems can be safely and effectively installed on roof slopes of up to 10°.
- 2.1.2 Beyond the 10° slope threshold, green roof installation becomes significantly different from a typical horizontal green roof and requires different systems and/or design approaches for improved stability against increased shear forces. Roofs up to 45° pitch can be outfitted with specialized green roof systems.
- 2.1.3 The designed pitched green roof must be:
- Stable (against shear forces and loads);
  - Well-draining (capable of removing excessive rainwater);
  - Planted with suitable plant selection (which will improve substrate stability and green roof appearance.) and;
  - Holistically designed and planned for safe installation, operation and maintenance.
- 2.1.4 While experienced and credible green roof specialists provide the best advice and expertise, designers must have a clear understanding of all system interfaces, for optimal performance of the pitched green roof system and its site-work coordination.
- 2.1.5 Wherever the project allows, especially for large project, the selected green roof system and materials should be tried-and-tested through conducted field trials to ascertain suitability to the relevant roof inclination and site microclimate. The conducted field trial presents an opportunity to identify and shortlist plants suitable for the specific pitched green roof design and its site context.
- 2.1.6 The selected pitched green roof system should be soil-less.

### **2.2 STABILITY**

- 2.2.1 "Stability" of the pitched green roof system refers to the ability of the installed system in withstanding shear and sliding forces from dislodging the green roof system and its plants.

- 2.2.2 When designing a pitched green roof, the topmost priority is to hold the green roof assembly in place. These include the vegetation, substrate layer and the under-layers. The zone most likely to fail in a pitched green roof assembly lies just underneath the substrate. Extreme care and attention must be focused on the design and installation of this "potential failure zone".

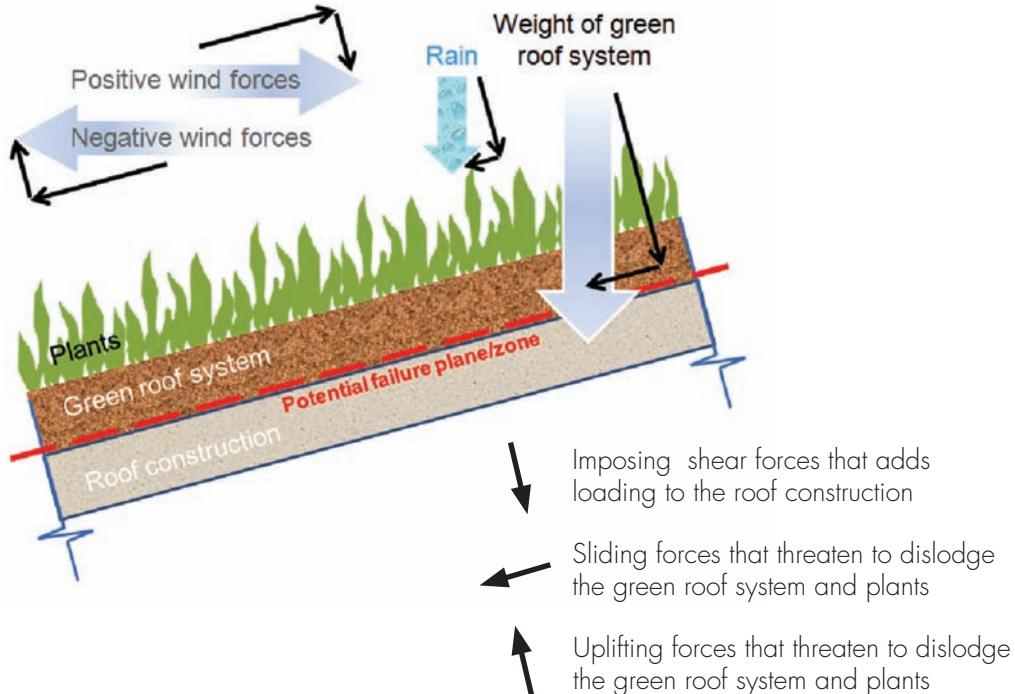


Fig 1:  
Diagram shows the forces that affect the stability of a pitched green roof.

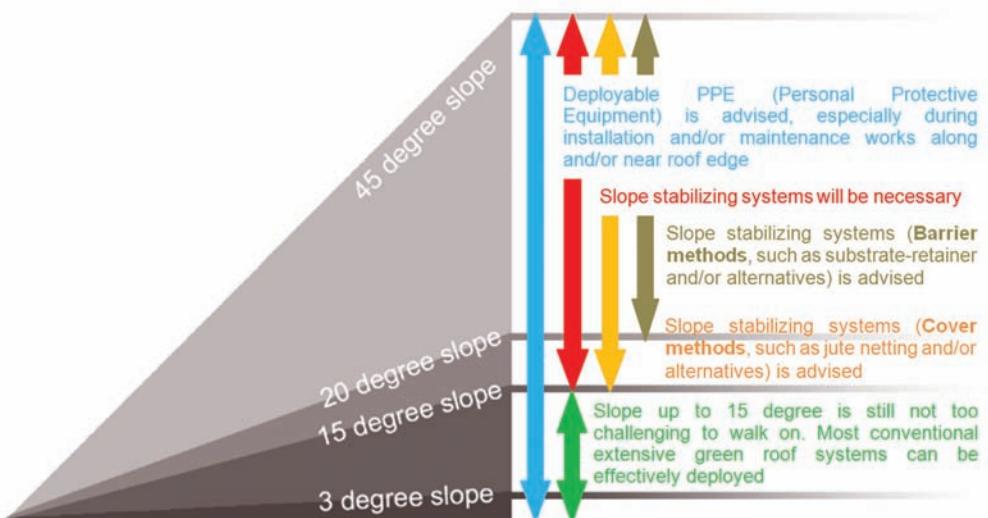


Fig 2:  
Pitched green roof angles and the relevant requirements

### 2.2.3 Green roof pitch more than 3°

- These are considered pitched. (Most flat roofs are in fact gently sloping.)
- For roof pitch more than 3°, waterproofing layer must not be loose-laid and must be fixed in place by product-specific mechanical means (i.e. use of appropriate adhesive, fixtures, etc, in accordance to system and/or product installation specifications.)

### 2.2.4 Green roof pitch less than 15°

- In general, pitched green roofs, of 10° to 15° pitch, are still adequately gentle to walk on. Most conventional extensive green roof systems can be installed on such pitch, subject to product's system-specifications.
- The selected pitched green roof system must be secured to the roof surface in accordance with the system specifications. Where necessitated by unique site conditions, the green roof system is to be installed in accordance with the specifications by the certified professional engineer to ensure safe transfer of shear forces and loads.
- It is possible for pitched green roofs, of less than 15°, to be stabilized by the rooftop vegetation alone. However, this is only true when the green roof is appropriately designed to site conditions and constructed to system specifications, with suitable materials, under-layers and roof edge details.
- At this slope, it is generally not too challenging for the green roof installers and maintenance workers to walk on such green roofs.

### 2.2.5 Green roof pitch from 15° to 20°

- At this slope, the substrate layer and vegetation will need to be stabilized.
- Slope stabilizing system, such as the use of jute netting appropriately secured intermittently, can be deployed to improve substrate stability and mitigate substrate erosion. (Please refer to section 2.3.1)

## 2.2.6 Green roof pitch from 20° to 45°

- At this slope, the substrate layer and vegetation will need to be “compartmentalized”, for effective intermittent distribution of the shear forces and green roof loads across the roof surface. Suitable substrate-retaining systems will keep substrate and vegetation in place. (Please refer to section 2.3.4)

## 2.2.7 Shear stresses within the waterproofing layer

- Since green roof systems and solutions for pitched green roofs are intended to last a very long time (usually lasting for 10 to 20 years or more), designers should not solely rely on the bonding strength of adhesives between the layers of the green roof assembly. (This includes the bond between the waterproofing layer and the roof deck.)
- The shear stresses within the waterproofing layer arising from the pitched green roof assembly above should be kept minimal. Common approaches to achieve this include:
  - Degree of slope – Reduce the degree of slope or pitch of the green roof.
  - Materials – Select thicker and robust waterproofing material to withstand the anticipated shear stresses.
  - Separation / Protection layer – A layer of protective cement screed (or alternative) atop the waterproofing to withstand shear forces and loads, maintaining waterproofing integrity. Intermittent sheer-barriers along the gradient of the roof slope can also evenly distribute the loads and shear forces.
- Waterproofing performance must not be compromised by the selected slope stabilization system and its maintenance.

## **2.3 SLOPE STABILIZING SYSTEMS**

- The overall objective of slope stabilizing systems is to retain as much substrate in its original position as possible. In general there are two types of slope stabilizing systems, namely cover methods and barrier methods. Cover methods are suitable for pitched green roof steeper than  $15^\circ$ . For slope  $20^\circ$  or steeper, barrier methods are more suitable for improved slope stability. Please refer to figure 2.
- Cover methods - In general, pitched green roofs steeper than  $15^\circ$ , will need to address potential substrate erosion. Substrate erosion (of granular-type substrate systems) can be exacerbated by negative wind pressure on the leeward roof plane. This concern can be effectively addressed via cover method slope stabilizing systems, such as jute netting.
- Barrier methods - In general, for pitched green roofs steeper than  $20^\circ$ , possibility of green roof slope failure is a real concern, especially when there is continuous heavy downpour. This concern can be effectively addressed via barrier method slope stabilizing systems such as shear barrier, terminal barrier and substrate-retainer. Please refer to sections 2.3.2 to 2.3.4 for the design criteria.
- Should there be concern on the pitched green roof system stability, especially for slope steeper than  $15^\circ$ , barrier method is advised subject to the site context and microclimate.
- Please refer to sections 2.2.3 to 2.2.6, for recommendations on suitable slope stabilizing systems for pitched green roofs of different steepness.

### **2.3.1 JUTE NETTING (Cover method slope stabilizing system)**

- For low pitched green roof, less than  $20^\circ$  slope, substrate and vegetation can be stabilized by securing jute nettings over the substrate to reduce substrate movement and loss during tropical rainstorm and strong winds.
- Slope stabilization of a low pitched green roof, using jute netting, is to be advised by an experienced green roof specialist, with installation in accordance to the selected product specifications. The jute netting should be spaced and secured ('pegged'), as indicated in product specification, intermittently to keep the substrate and vegetation in place.

- To mitigate and/or prevent substrate erosion, ensure that:
  - The substrate is not exposed to direct sunlight, wind pressure and rain-drop impact. For example, applied jute net can protect area with exposed substrate.
  - The velocity of surface run-off down the pitched green roof is reduced to promote rainwater percolation into the substrate layer. By having a gentler roof pitch, velocities of surface run-off can also be reduced.
  - Selected substrate material should allow easy-draining of excess rainwater.



Fig 3:  
A close-up view of common jute net that can be used as a form of anti-erosion mat on a gentle slope.



Fig 4:  
A green roof that is over laid with jute netting.

### 2.3.2 **SHEAR BARRIER (Barrier method slope stabilizing system)**

- Beyond 20°, shear forces can be significant. Shear barriers, appropriately designed and constructed, are necessary for the safe transfer of shear forces and loads from the green roof system, the rain and the wind.

- In general, effective shear barriers are:
  1. Positioned perpendicular to the direction of the shear forces.
  2. Installed intermittently along the full gradient of the roof slope to achieve an even distribution of shear forces and loads across the roof surface.
  3. Installed without compromising the roof waterproofing system and its performance.
- Some proprietary green roof systems have accessorial shear barriers that can be retrofitted onto existing pitched roof surfaces. For new buildings, intermittent shear barriers can also be designed and constructed as integral parts of the roof structure right from the onset of the design phase. Design coordination between designers, engineers and green roof specialists are advised during the design phase to streamline construction and system performance.
- Intermittent shear barriers should be made of strength-bearing, corrosion resistant materials such as flexible polypropylene, treated-metal and/or even concrete.

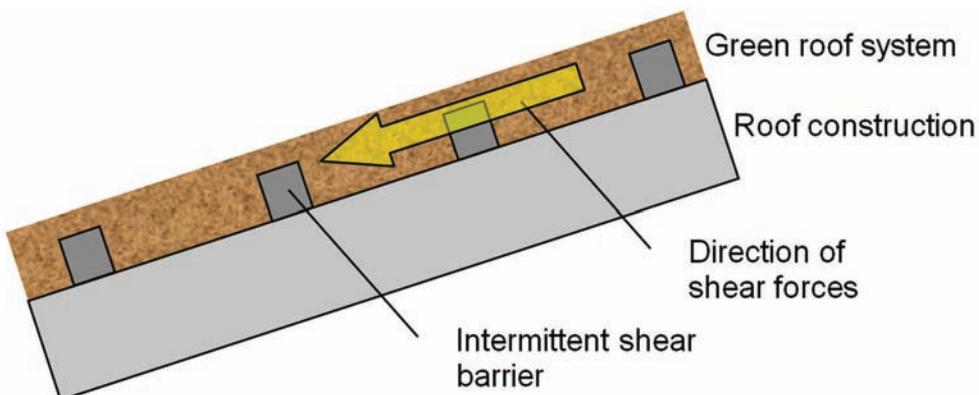


Fig 5:  
Intermittent shear barriers



Fig 6:  
"Protruding teeth-like" intermittent shear barriers as integral parts of the pitched green roof system.

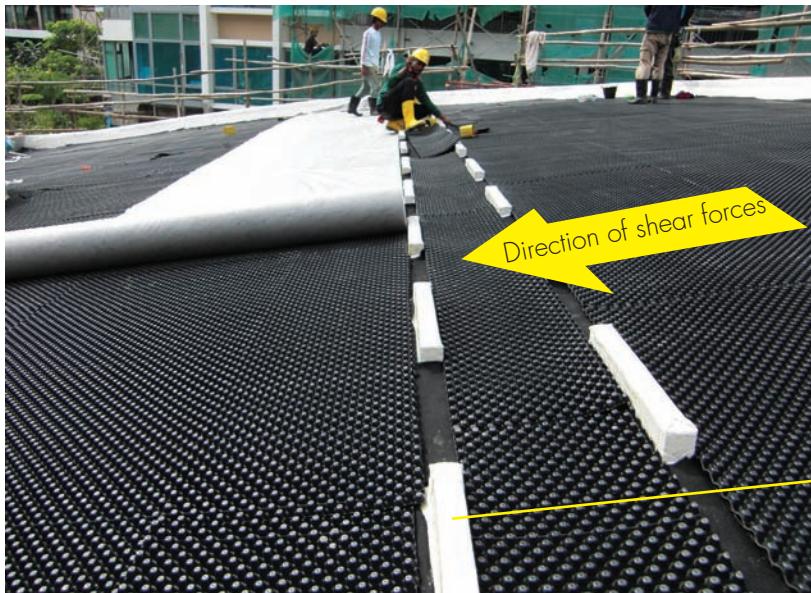


Fig 7:  
Intermittent shear barriers in the form of concrete kerbs constructed as part of the roof construction.

### 2.3.3 TERMINAL BARRIER (Barrier method slope stabilizing system)

- Terminal barrier must be designed, engineered and constructed to withstand the minimum loadings as prescribed in the loading code and green roof loadings. The following design code shall be complied with:

<http://www.bca.gov.sg/Publications/BuildingControlAct/others/Approveddoc.pdf>

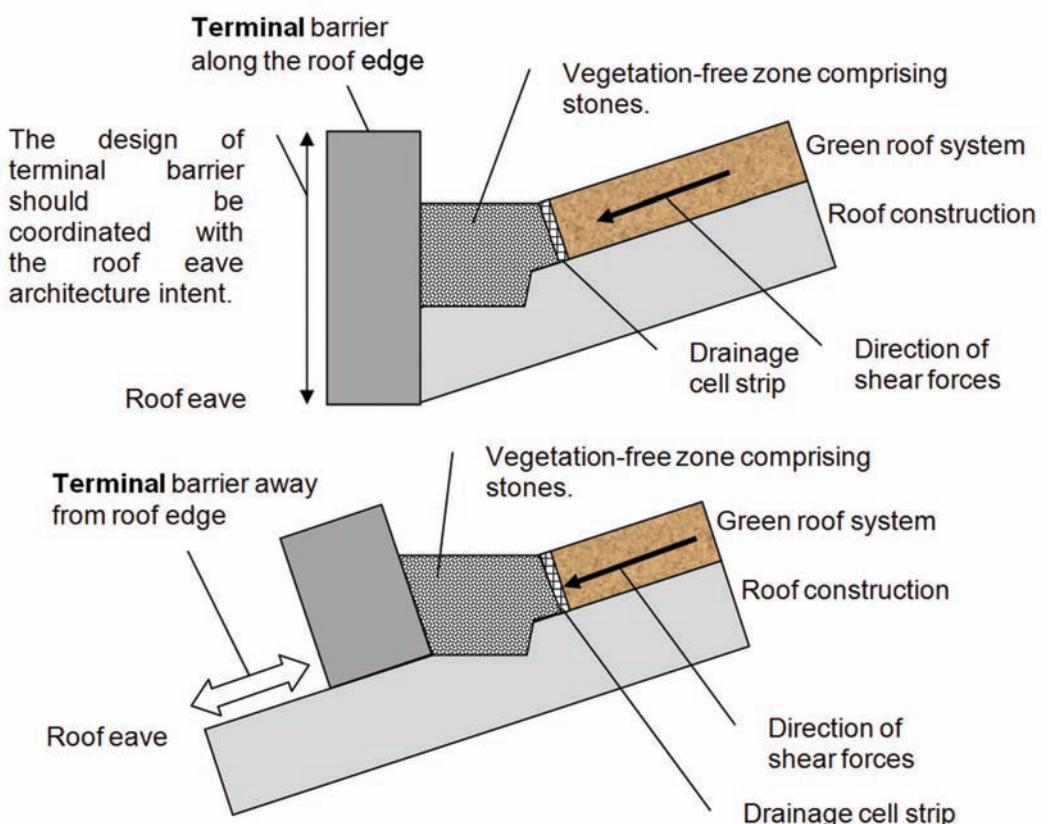


Fig 8:  
Examples of terminal barriers



Fig 9:  
A terminal barrier of a pitched green roof of significant slope

#### 2.3.4 SUBSTRATE-RETAINER (Barrier method slope stabilizing system)

- Substrate-retainer is suitable for steeper pitched green roof, of  $20^{\circ}$  to  $45^{\circ}$  slope. The substrate-retainer (typically of rigid, strength-bearing, interlocking plastic honeycomb-like grid structure, or the like) can effectively “compartmentalize” the substrate, allowing manageable transfer of shear forces and loads through its structure, onto the terminal barrier and the roof surface. This keeps the substrate in place.
- Some substrate-retainer systems may need to be structurally anchored to the roof perimeter with steel tendons. During installation, precautionary measures are necessary to avoid penetrating and damaging the underlying roof waterproofing.
- Some substrate-retainer systems are loose-laid and rely on the roof construction to hold the assembly in place. Installation of such non-penetrative system will require design and construction coordination between the designer, the engineer and the green roof specialist, to ensure optimal performance.



Fig 10:  
Plastic substrate-retainer rigid structure that is appropriate for steep slopes of  $20^{\circ}$  to  $45^{\circ}$ .

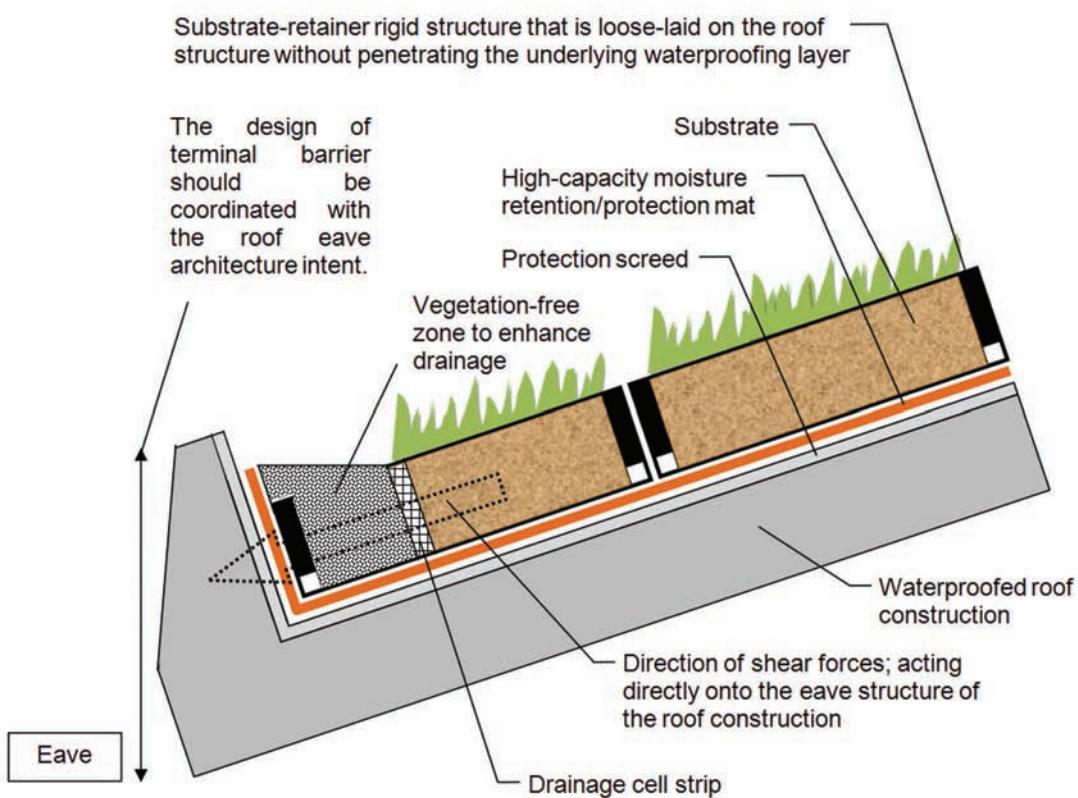


Fig 11:

An illustration of how a non-penetrative substrate-retainer rigid structure engages the roof construction to hold the green roof system on steep slopes. The shear forces are directly transferred onto the eave's upstand, which acts as a terminal barrier.

## 2.4 PLANT SELECTION

- 2.4.1 Sloped roofs are challenging horticultural environments. Slopes can compromise substrate stability and moisture retention, affecting vegetation growth. Selection of plant species and specimens should be congruent to the sloped rooftop environment.
- 2.4.2 The area near the ridgeline (highest point of the sloped green roof) is usually hot and dry, while the lower green roof edge can be comparatively moist. Closer to the ridgeline, select plant species that are comparatively more drought and heat tolerant than those along the lower green roof edge. It is advisable to seek professional horticultural recommendations from experienced green roof specialists.

- 2.4.3 Most pitched green roofs are extensive, with access restricted for maintenance activities only. Gentle pitched green roof can be designed to accommodate human traffic and other activities. Plant selection must be appropriate in accordance with the design intentions.



Fig 12:  
Marina Barrage, Singapore. This gently pitched iconic green roof, planted with 15,000 m<sup>2</sup> of cow grass (*Axonopus Compressus*), is designed for public access as an outdoor picnic and activity space.



Fig 13:  
Singapore Botanic Gardens, Singapore. The vegetation is a mixture of shrubs and ground-covers, irrigated by an automatic system. This pitched green roof is only accessed during periodic maintenance. There are safety life-lines along all four hips of this roof.

- 2.4.4 The choice of plants and selection criteria for the pitched green roof is similar to that of conventional green roof:

- Plants that are hardy, drought-tolerant, self-generating and ground-hugging, with emphasis on achieving lush coverage.
- Plants that root well to help retain the substrate layer and reduce chances of substrate erosion.
- Plants that can collect water at the axils should be avoided, to prevent mosquito breeding.

## 2.5 SUBSTRATE (Moisture retention)

- 2.5.1 Water can be stored in a number of ways within various components of the pitched green roof system:

- **Substrate layer**

Water storage in the substrate layer can be improved through the use of water-retentive materials. However, water retention boards or mats, such as rock-wool and foam boards, are NOT commonly used for pitched green roofs because such items may increase the risk of green roof sliding off if not properly designed and/or installed.

- **Drainage layer**

In addition to the substrate layer mentioned above, storage of water can be increased through the drainage layer where either open-pore aggregates of graded granular sizes or prefabricated drainage boards are used. Care must be taken to ensure that sliding forces have been adequately addressed.

- **Drainage-cum-reservoir layer**

In addition to the substrate layer mentioned above, storage of water is increased through the use of reservoirs within the aggregates or by using pre-formed drainage boards that have partial water retention features. Similar to the above, when preformed drainage-cum-reservoir boards are used, care must be taken to ensure that sliding forces have been adequately addressed.

- **Protection layer**

Some protection materials are felt-like and are water-absorbent, allowing additional water storage capacity.

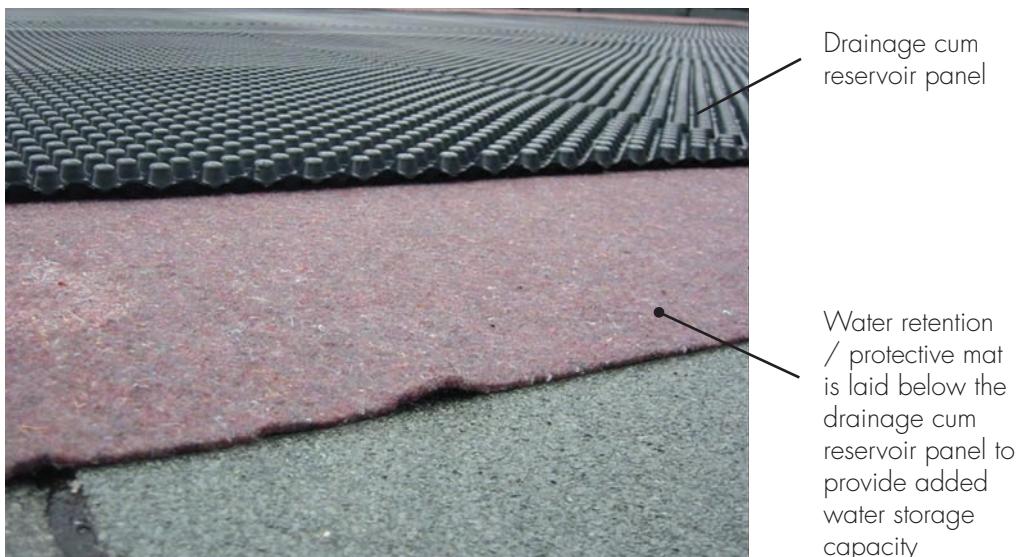


Fig 14:  
Water retention / protection layer

## 2.6 DRAINAGE

- 2.6.1 Excess water on a pitched green roof is drained as:
- Surface run-off – This is highly discouraged because surface run-off will cause substrate erosion that will lead to loss of substrate volume and plants.
  - Sub-surface drainage – This characteristic should be conceived and designed for in pitched green roof system.
- 2.6.2 Excess water is drained from the pitched green roof through:
- Surface drains
  - Weep holes
  - Rainwater downpipes
  - Gutters (peripheral drains)
  - Spouts
  - Boundary edgings
- 2.6.3 Drainage is a critical factor especially for pitched roofs of significant size, because the amount of water moving through such green roofs during a tropical storm can be significant in volume. It is thus crucial for pitched green roof system to drain excess water quickly, efficiently and safely.
- 2.6.4 The most effective drainage path for rainwater is to go through the substrate layer rather than as surface run-off. Improve rainwater drainage by:
- Having a gentle green roof slope. A gentle gradient, coupled with lush vegetation slows water flow, giving time for the rainwater to percolate into the substrate, reducing surface run-off and substrate erosion.;
  - Selecting substrate products that allow water to percolate readily. This can reduce the volume of surface run-off during a torrential tropical downpour;
  - Having intermittent drainage provision, along the slope of large pitched green roof, to prevent excessive rainwater built-up within substrate that may increase shear forces;
  - Formulating a holistic drainage strategy, that looks into the locations, distribution and the numbers of rainwater downpipes required to drain excessive rainwater effectively.

2.6.5 The following are relevant publications:

- CSE 03: 2010 Guidelines on Substrate Layer for Rooftop Greenery
- CSE 04:2010 Guidelines on Filter, Drainage and Root Penetration Barrier Layers For Rooftop Greenery

2.6.6 **Gutter**

- In Singapore, roof gutters, whether open or concealed, are not allowed to be installed along the perimeter of the roof for any new developments with effect from 1 Nov 2005. This is part of the nation-wide effort to curb mosquito breeding. However, for situations where gutters are necessary, the Qualified Person (QP) has to apply for a waiver and ensure that there is provision of a safe and permanent access to the rooftop so that regular inspection and maintenance can be carried out. For example, the open gutter system is used at the sloping green roof at the Cashew-Senja Community Club along Bukit Panjang Road (see figure 15).
- It is advisable that roof gutters, if any, be netted to prevent potential accumulation of plant debris clogging the drainage downpipe. Maintenance of such gutters should ideally be conducted at least once a week to clear stagnant water.
- Gutter, where implemented, must be designed and constructed to withstand loading, such as that from wind, based on relevant codes or standards as prescribed in Building Control and Regulations.



Fig 15:  
Open gutter at the sloping green roof at Cashew-Senja Community Club.

## 2.6.7

### **Spouts and weep-holes**

- Spouts and weep-holes may be designed into the terminal shear barrier to facilitate water drainage. Weep holes should only be used where the discharge cannot be seen from public areas and must not spill onto paved and/or decked surfaces. Weep holes from one planting area to another are acceptable.
- The size and spacing of the spouts (or weep-holes) depend on the following factors:
  - Captured rainfall
  - Degree of slope
  - Required drainage efficiency and capacity of the installed pitched green roof



Fig 16:  
Spouts along the shear barrier of the pitched green roof.

- It is good practice to have a vegetation-free zone or buffer of about 200 – 300 mm wide along the lower roof edge to enhance drainage. This zone or buffer should comprise of granular, stable and inorganic mineral stones such as granite, gravel or pebbles.

## 2.7 FIRE SAFETY AND PROTRUSION

2.7.1 All protrusions beyond the top surface of the substrate at a pitched green roof should be surrounded by a vegetation-free zone that comprises of granular, stable and inorganic mineral stones such as granite, gravel or pebbles.

- To enhance drainage
- To enable better identification
- To prevent the potential interference of the vegetation with the protrusion

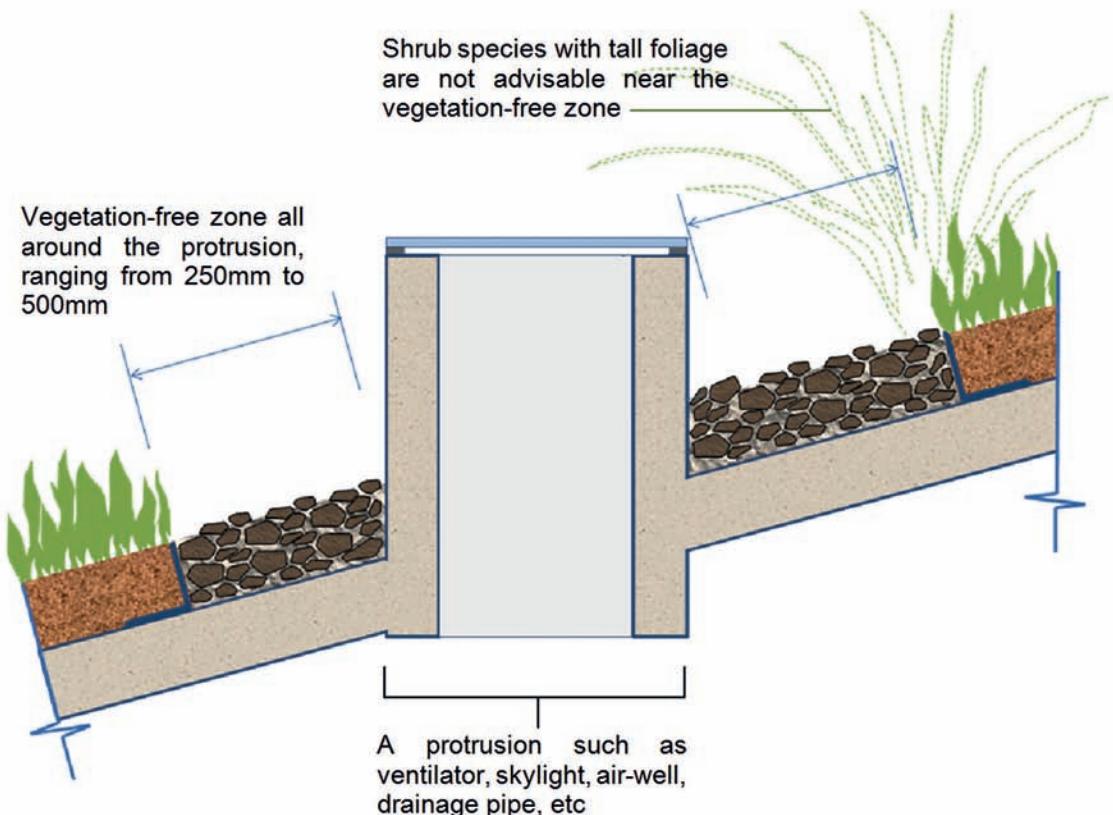


Fig 17:

Diagram explains the vegetation-free zone or buffer around the protrusion at a pitched green roof.



Vegetation-free zone around the air exhaust outlets allow the facility to be easily identified, accessed and maintained without the interference of vegetation.

Vegetation-free zone around the fire sprinkler pipes allow the pipes to be easily identified, accessed and maintained without the interference of vegetation.

Fig 18:  
Vegetation-free zones allow easy identification, access and maintenance.

- 2.7.2 The fire safety works at the rooftop shall comply with the requirements stipulated in the Fire Safety Act, "Code of Practice for Fire Precautions in Buildings" and its relevant codes of practices.
- 2.7.3 If necessary, the Qualified Person can consult Singapore Civil Defense Force (SCDF) on the fire safety provisions at the rooftop.

## **2.8 LIGHTNING PROTECTION**

- 2.8.1 Lightning protection for rooftop greenery must be designed and installed in accordance with the requirements of the latest BCA (Building and Construction Authority) Building Control Act and Regulations. Please refer to relevant web-link: <http://www.bca.gov.sg/Publications/BuildingControlAct/others/Approveddoc.pdf>
- 2.8.2 The design of the lightning and earthing protection system is to be endorsed by a Professional Engineer.

## **2.9 PROTECTION FROM FALLING**

- 2.9.1 Falling from a height is a major cause of injury and fatality at workplace. On a pitched green roof, while it is not likely to avoid working at height, work at roof edges should be minimized

wherever possible.

2.9.2 Where it is not possible to remove the need to work at height and/or near roof edge, features that reduce or eliminate the risk of falling should be introduced.

2.9.3 Some pitched green roofs have no parapet. Such spaces are not intended for access, except during periodic maintenance. On such parapet-free roof surfaces there must be provision for safety features:

- Safety features, such as travel restraint belts, safety harnesses, harness-railing/rings and permanent anchors and fall arrest system can be incorporated to safeguard against falling during site work.
- The anchors for maintenance safety harnesses and restraint belts must be coordinated with structural requirements and design of the pitched green roof.

2.9.4 Please also refer to:

- CS E02:2010 – Guidelines on Design for Safety on Rooftop Greenery.
- Workplace Safety and Health Council (WSHC) Code of Practice for Working Safely at Height: [https://www.wshc.sg/wps/themes/html/upload/cms/file/Code\\_of\\_Practice\\_For\\_Working\\_Safely\\_At\\_Height.pdf](https://www.wshc.sg/wps/themes/html/upload/cms/file/Code_of_Practice_For_Working_Safely_At_Height.pdf)

2.9.5 Pitched green roof installation, operation and maintenance must comply with the relevant Workplace Safety and Health Council (WSHC) regulations, standards and guidelines.

## **2.10 PITCHED GREEN ROOF MAINTENANCE**

2.10.1 The following is a guide for the management of site-works. It is to be noted that the list is not exhaustive, nor is every item relevant to every project. It is advisable to consult Workplace Safety and Health Council (WSHC).

### **Guide for site-work management**

#### **1. Risk assessment to be conducted**

Before any site work can commence, Safety and Health Risk Assessment has to be conducted. Risk Assessment with proper Fall Protection Plan (please refer to WSHC guidelines) must be conducted. Potential hazards are to be identified. Strategies and solutions shall be formulated to mitigate the identified risks and hazards.

## **2. Proper briefing**

Before any work starts at the site, the site supervisor has to first and foremost conduct a site-work-briefing with the work team. This is necessary to achieve clarity of work scope, risk assessments, precautions, etc;

## **3. Adequate supervision**

There must be adequate supervision at the site. Should there be rooftop greenery installation and/or maintenance, there must be appropriate supervision at ground level.

## **4. Redirecting of traffic**

Redirect ground level traffic, if any. The affected area, including the ground level directly below the affected roof edge, must be cordoned off. At times, barricading of work areas to prevent unauthorized entry by members of the public is necessary.

## **5. Proper means of communications**

Clear communication between the workers at the rooftop and workers at the ground level is essential for effective and safe work. Should the instruction and communication cannot be verbally transmitted effectively and clearly, appropriate communication equipments will then have to be effectively deployed.

## **6. Proper execution of site-work procedures**

Site supervisor has to oversee and ensure that proper work procedures are safely carried out and equipments are utilized correctly and appropriately.

Workers need to be in teams or groups. In no case should one worker be on a roof without the presence of others. Workers must deploy the Personal Protective Equipment (PPE) with compliance to the regulations and requirements of the Workplace Safety and Health Act from the Ministry Of Manpower (MOM).

## **7. Proper use and maintenance of equipments**

Appropriate equipments must be used for the relevant site-work scope. Equipment must be properly checked before use, and adequately maintained after usage (and appropriately stored).

## **8. Adequately qualified workers**

The workers must have appropriate qualifications and certifications to assure suitability to work scope. Proper documentation of qualifications can facilitate future deployment of workers.

## **9. Promote a culture of safety on worksite**

Promote safe practices within the team. Every member on site must maintain vigilance of one another. Rooftop work must be carried out with vigilance of the ground level conditions adjacent to the relevant roof edge.

## **10. Proper use and provision of equipments**

There must be provision of necessary equipment and proper safe access to the relevant worksite. It is to be noted that improper access to work-site is a cause of many work-site accidents and fatalities.

## **11. Protection from falling**

Depending on the work environment, workers are to don appropriate PPE such as properly deployed safety harness to prevent falling from heights.

Workers at heights must have safe means of access to and egress from suitable working platforms with safety guardrails.

The construction operation must be in accordance with the WSHC – Code of Practice for Working Safely at Height.

## **12. Safe deployment of Personal Protective Equipment (PPE)**

Prior to accessing the actual work space and surface, the worker must don and deploy the PPE while on a safe secure landing space and surface. (This is especially necessary when working near roof edge and/or on steep pitched roof.)

The relevant work surface must have adequate load-bearing capacity to support loads from equipments, plants, landscaping and other system materials that are needed during the site works.

For all works at heights, please refer to and comply with the latest relevant regulations and requirements of the Workplace Safety and Health Act from the Ministry Of Manpower (MOM).

## **13. Prevention of equipment falling from height**

Equipments and relevant materials (i.e. plants, landscape materials, plant debris, etc.) have to be properly secured and/or contained to prevent dropping from a height. Workers must be properly educated on executing safety measures.

## **14. Appropriate notification during maintenance**

The rooftop can be a highly isolated part of the building. Therefore maintenance of rooftop greenery can commence only after the building management is duly notified with issuance of maintenance-work permit by the building management.

## REFERENCES

**Germany FLL** – Guidelines for the Planning, Construction and Maintenance of Green Roofing – Green Roofing Guidelines 2008 edition

**CP 79:1999** - Code of Practice on Safety Management System for Construction Worksite  
The Workplace Safety and Health Act by the Ministry Of Manpower (MOM)

**Workplace Safety and Health Guidelines** – Landscape and Horticulture Works  
(WSH Council)

**CS E02**:2010 – Guidelines on Design for Safety on Rooftop Greenery

**CS E03**:2010 – Guidelines on Substrate Layer for Rooftop Greenery

**CS E04**:2010 – Guidelines on Filter, Drainage and Root Penetration Barrier Layers for Rooftop Greenery



