Chapter 7.6 - Vegetated Roofs

Rooftop vegetation provides three primary benefits: attenuation of stormwater runoff and peak flows, reductions in the heat island effects with significant improvements in building insulation, and a substantial increase in the life expectancy of the base roof material. As an added benefit, vegetated (or green) roofs absorb smaller storm events by minimizing peak and volume of stormwater runoff. The runoff from a flat roof may be detained and treated within a layer of filter media and vegetation and will meet the required treatment under the General Standards of Chapter 500.

There are two primary types of green roofs: extensive and intensive. The term "extensive" represents the practice of covering the entire roof area with a vegetative mat.
These systems are lightweight with only a few inches of growth media; and the vegetation is limited to various species of sedums or other similar arid plants. Due to the shallow media, the roofs have little organic substrate to retain potential pollutant loads.

The term "intensive" represents additions to the roof for access and use of the rooftop as open space for the building inhabitants. Intensive roof landscaping runs the gamut from small city parks to commercial use such as sidewalk cafes, etc. This type of green roof typically requires more growth media and significant additional weight loading to the roof structure; but it provides for more nutrient uptake and greater flow attenuation.

One point of consideration is that thin media green roofs provide little treatment. The initial flow from rainwater typically contains elevated levels of organic constituents such as nitrogen and phosphorus; and residual stormwater detention tanks with a pump back system can be used to recirculate rainwater for watering the media during dry periods, providing for additional uptake of first flush pollutants and summertime evaporative cooling. The inclusion of a containment structure significantly improves stormwater water quality and enhances the overall effectiveness of the green roof technology.

In summary, typical green roofs include the planting media, a protective geotextile liner, and a root barrier membrane that consists of an impermeable membrane. A structural engineer should be consulted to ensure the building can support the added weight from the planting media and vegetation.

Roof Design:

- *Roof Slope:* A minimum slope of 2% is considered normal for extensive and simple intensive greening. In extensive greening, controlled drainage will meet the basic needs of the vegetation. Roofs with less than 2% slope will require special measures. Extensive greening on roofs with less than 2% slope requires a drainage course to avoid water logging in the vegetation support course.
- *Roof Structural Strength:* The building and roof will need to be designed for the additional bearing load equivalent to 3 inches of water.
- *Design Loads:* The design load of the building is the critical factor in deciding what type of greening to use and how to cultivate the vegetation. All the courses must be considered, at maximum water capacity and including the surface load generated by the vegetation, as a component in the surface load. Spot loadings generated by large scale bushes, trees and structural components, such as pergolas, water storages and peripheral items, will need to be calculated separately.
- *Joints and Borders:* Joints and borders include joints with facades and other vertical structural components, joints where the roof is penetrated, and borders at roof edges. Damp-proof lining/root-penetration barriers should be brought up to 15 cm high for a roof slope of up to 5° and 10 cm high for a roof slope of over 5°. As a rule, a strip made up of slabs or gravel

should separate the vegetation area from the structural border with a minimum height of 10 cm high for a roof slope of up to 5° and 5 cm high for a roof slope of over 5°.

- *Wind Loads:* Wind can generate positive and negative pressure forces, or friction on the green roof. The strength of these forces is a direct function of wind strength and direction and of the shape and height of the building in question.
- *Protection Against Slipping and Shearing:* Where a roof slopes at an angle in excess of 2:1, structural anti-shear protection will normally be needed without creating tension at the point of contact with the damp-proof lining and the root-penetration barrier.
- *Lip Edge:* A lip will need to be provided at the edge of the roof to control drainage and to prevent the filter media from sliding off the roof.
- *Impermeable Roof Cover:* The roof will need to be protected with an impervious cover
- *Root Penetration:* Both intensive and extensive green-roof sites must have lasting protection such as protective sheeting or full surface treatment/liquid coating against root penetration. Damp-proof linings and root-penetration barriers on roofs can be protected against mechanical damage by protective non-woven fabrics, boards, sheeting or drainage course.
- *Underdrain Mat:* The drainage layer will consist of a mat that is covered with a filter fabric. This product is available through vendors of manmade erosion control measures.

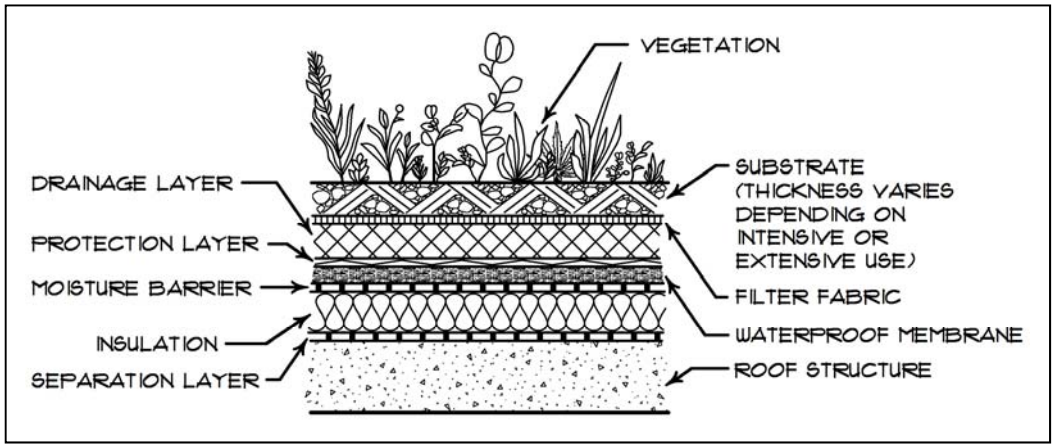

Figure 7.6.1 – Vegetated Roof Cross-Section

Growing Medium: The vegetation support course should accommodate a dense root stock and have all the physical, chemical, and biological properties needed for plant growth. Available materials include:

- Soil mixtures - improved top and underlying soil
- Aggregate mixtures - mineral aggregate mixtures with high or low organic content or with an open-pore granular structure with no organic content
- Substrate boards -boards made from modified foam materials or mineral fibers
- Vegetation matting - matting with mineral/organic aggregate mixtures. The organic content of the vegetation support course should be as shown on Table 7.6.1.

Table 7.6.1 – Growing Medium

Type of Greening	Substrate Density	Organic Content
Intensive Greening	< 0.8 > 0.8	< 12% by mass < 6% by mass
Extensive Greening		
Multiple-Course Construction	< 0.8 > 0.8	<8% by mass < 6% by mass
Single-Course Construction	N/A	< 4% by mass

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- *Treatment Filter:* The filter media will meet the specifications of the media for underdrained soil filters with equivalent organic material and with a porosity of 30%. The filter bed must be a minimum of 3 inch thick with between 4 and 7% fines (passing #200 sieve).

Vegetation: A perennial plant or grass that is draught resistant and flood resistant will need to be selected for vegetation cover. The most appropriate plants are the one that need low maintenance and are prolific. The best plants will have a thick shallow root mat Acceptable options may be found in the sedum family and are shown on Table 7.6.2.

- *Additional Watering:* Green-roof sites are designed to depend chiefly on precipitation for their water supply. Additional watering may be provided through the use of a spray or dip type hose, hose and sprinkler, an overhead irrigation system, or automated water systems controlled by a timer.
- *Plant Compatibility*: Materials must not contain any components which are harmful to plant life and which are capable, over a given period, of finding their way out into the environment.

Table 7.6.2 – Roof Top Vegetation Type

Objectives	Course Depth (cm)	Form of Vegetation	% Water Retention Annual Average
Extensive Vegetation	2-4 >4-6 >6-10 >10-15 >15-20	Moss-sedum greening Sedum-moss greening Sedum-moss-herbaceous plants Sedum-herbaceous-grass plants Grass-herbaceous plants	40 45 50 55 60
Intensive Vegetation	15-25 >25-50 >50	Lawn, shrubs, coppices Lawn, shrubs, coppices Lawn, shrubs, coppices, trees	60 70 >90

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Drainage: Drainage must be available through the layered superstructure and off the surface. Excess water may be drained within the vegetation area, outside the vegetation area, or through separate drainage facilities for areas which have undergone greening and those which have no vegetation. Regardless of the size of the roof surface, roofs with drainage facilities located within the vegetation area must have at least one run-off facility and at least one emergency overflow.

- *Drainage System:* The drainage system should collect the overflow from the drainage course, and surface water from the vegetation support course. Materials include roof outlets, guttering, downpipes, and emergency overflows.
- *Overflow:* An overflow measure must be provided for the runoff from larger storms.
- *Filter Course:* The filter course should prevent fine soil and substrate components from washing out of the vegetation support course into the drainage course. Nonwoven geotextile fabrics are typically used as filter courses.
- *Drainage Course:* The drainage course should contain sufficient voids to uptake any excess water. Course materials and dimensions will depend on construction requirements and objectives for the vegetation. The drainage course may be constructed of:
  - Aggregate-type materials - gravel and fine chippings, lava and pumic, or expanded clay and slate
  - Recycling aggregate-type materials – brick hardcore, slag, or foamed glass
  - Drainage matting - textured nonwoven matting, studded plastic matting, fibre-type woven matting, or flock-type foam matting
  - Drainage boards - boards made from foam pellets, studded rubber boards, shaped rigid plastic boards, shaped plastic foam boards
  - Drainage and substrate boards – boards made from modified *foam*

- *Water Retention:* The annual water retention on green roof sites should be a function of the course depth is provided in the table below.

Water Storage: Water may be stored in the vegetation support and drainage courses:

- Storage in the vegetation support course through the use of substances which retain water for vegetation substrates or prefabricated substrate boards
- Storage in the vegetation support course and in the drainage course, through the use either of open-pore type aggregate materials in graded granular sizes or of prefabricated draining substrate boards
- Storage in the vegetation support course and in the drainage course, by allowing a water supply to build up in the aggregate over the entire area or by using pre-formed drainage boards with partial retention characteristics
- An underdrain layer is needed to drain the filtrated water. Stored volume needs to fully drain within 24-48 hours. To meet the General Standards requirements (treatment of 1 inch of runoff), a minimum storage capacity within the filter layer is needed to allow the treatment of one inch or greater of runoff.

MAINTENANCE CRITERIA

A green roof needs to be maintained like any other soil filter structure. The maintenance activities for filtration BMPs listed in Chapter 7 of the BMP manual apply equally to this type of structure. Replacement of the vegetation will be required if it is found to be unhealthy, dying and with soil showing though.

- *Vegetation Upkeep:* The more complicated and intensive the green roof, the more maintenance associated with caring for the vegetation, whereas an extensive roof planted in sedums can represent little or no maintenance other than a periodic feeding during the first year of operation.