Designing and Building Green Roofs

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Components

Green Roofs

Types

- Intensive- deep
- Extensive- shallow
- Intensive/Extensive- mixed

Weight

- The lightest can weigh about 10 PSF when fully saturated with water.
- The heaviest can be as heavy as a structure can hold.

Costs

- Given various assembly types and project descriptions costs can range from $15.00/ SF to 60$/SF or more.
- These figures include membrane through plants.

How they work

- **Structure**: membrane, drain mat, filter fabric, and detailing. These serve as hydrology, aeration, and physical separation elements.

  Biology: growth media, plants. These do the ecological heavy lifting.

How they can fail

- 1. Leak
- 2. Fall down
- 3. Clog
- 4. Blow away
- 5. Drain poorly
- 6. Bad microclimate analysis
- 7. Growth media collapse

How they can fail

- 8. Poor maintenance
- 9. Inappropriate growth medium for plant selection.
- 10. Inappropriate plant selection

Residential /Commercial

- 6-8 times more residential roof surface than commercial roof surface within city limits.
- This ratio increases as one moves away from the urban center.

Incentives

- 1. Quebec, Switzerland – direct subsidy
- 2. Portland – F.A.R. ratio break
- 3. 6-8 LEED points
- 4. Germany – rain tax
- 5. Impermeable surface breaks
- 6. Procedural incentives

Precautions:

- When asking about green roofs, ask how many this business has both designed and installed.
- Ask them to list all the parts and services they provide. (for example does their green roof system include the growth medium and plants).
- Ask them for references and documents of their past work.
- Ask them about professional credentials.

Precautions:

- But most of all, inform yourself first !
- www.greenroofs.com
- www.greenroofs.org
- www.ecobuilding.org
- www.cleanrivers-pdx.org/pdf/eco_questions.pdf
- www.hadj.net

Roof Gardens, history,design,and construction

by Theodore Osmundson. (Norton Press)

Planting Green Roofs and Living Walls

by Nigel Dunnett and Noel Kingsbury (Timber Press)

Example

Example

Example

Example

Example

Example

Example

Example

Example

Example

Green Wall

Green Wall

Green Wall

Varieties

Varieties

- Extensive green roofs are lighter, require less maintenance, less expensive, but have a narrower range of plants and a highly engineered growth medium. Paths and decks must be created for accessibility.
- Intensive green roofs can hold more water, have a wide range of plant varieties, require more maintenance, are easily accessible, and are heavier.

Local steep slope

Tilth Green House

Big

Varieties

- Larger still, Ford's Dearborn Plant, 3.8 acres of green roof.

Sub-Membrane

Sub-Membrane

- Provides a cushion for the membrane
- Usually a semi-adhered water-resistant or waterproof layer- not tar paper.
- Frequently a peel and stick modified bitumen and modified rubber sheet that rolls on.
- It also serves as a back up membrane as well as a temporary protection for the deck before the membrane is installed.

Membrane

Waterproof Membrane

- Usually a commercial grade waterproofing layer.
- Many varieties with various weak and strong points: modified rubber (EPDM), modified plastic(TPO), modified bitumen, and PVC.
- They come in many forms. Mop down, liquid applied, single ply.
- The seams can be waterproofed by heat welding, chemical adhesive, or hot applied bitumen, depending on the material in the membrane.

Geotextiles

Drain Mat and Filter Fabric

- Frequently combined together
- Filter fabrics are either non-woven, woven, or spun blankets. They function to prevent growth media from draining off the roof.
- Drain mats currently come in basically 3 designs; a dimple with drainage, a cup and dimple system, and a filament mesh.

Drain mats provide drainage and aeration for the plant roots and for the growth medium. They also aid in thermal efficiency of the green roof.

Growth Medium

Growth Medium: Biology

- Nematodes,Arthropods,Bacteria
- Mycorrhizal and Saprophytic fungi
- Amoeba,flagellates, and ciliates
- Plants, roots and above ground vegetation
- Air-borne visitors

Growth Medium

Growth Medium: Nutrition

- Range of trace minerals to match the needs of all the life forms in the growth medium
- Range of organics to provide plant nutrition
- Range of ingredients that provide for the general health of the biosystem
- pH appropriate for the biosystem
- Waste,residue, and metabolites from plants,animals,and microbes.

Growth Medium

Growth Medium: Structure

- Heavy enough not to percolate or blow away
- Durable enough not to collapse or grind to dust
- Porous enough to provide habitat and water space
- Varied enough in size to allow for good hydrology and aeration
- Provides enough texture and pores to absorb and hold water

Growth Medium

Table 1. General Media Characteristics

	Typical Grain-Size Distribution	Max. Water Content	Moisture at Field Capacity	Volatile Fraction
D	Coarse Gravel	Low	Low	N/A
SE	Gravelly Texture	Moderate	Moderate	Less than 5%
DE	Coarse to Fine Mixture (silt less than 15%)	Moderate to High	High	Less than 8%
I	Sandy Texture (silt less than 20%)	High	High	Less than 12%
T	Sandy Texture (silt less than 10%)	Moderate to High	Moderate	Less than 5%

Plants

Plants:

- Low growing
- Fibrous roots
- Drought tolerant
- Non-spore reproduction
- Wind and sun tolerant
- Balanced biomass production of system
- Perennial &/or self-seeding annual

Moss

Economics

Economics

- By reducing the total volume of storm water and by pre treating what storm water it does release, a green roof saves municipalities money in treatment expenses and in storm water infrastructure construction.
- By reducing CSO's a green roof saves the cost of cleaning up the pollution they cause.
- By reducing he urban heat island effect and by saving on cooling costs, both utilities and their customers save.

Mistakes

Mistakes can cause….

- The obvious is to leak or to come apart.
- The plants can drown on too flat of a slope
- The plants can suffocate if a crust develops on the surface of a poorly designed growth medium.
- Fines in a bad medium can clog up a filter fabric.
- A poor growth medium can blow away.
- A poor growth medium can compress over time.
- Poor maintenance can kill the plants.
- An inappropriate plant selection may necessitate replacement.

ASTM Standards

- Astm: Saturated water permeability
- Astm: Max dead load analysis
- Astm: Water capture and media retention
- Astm: dead loads and transient water live loads

ASTM Standards

- Membranes
- Geotextile permeability
- Geotextile compressive strength
- Drain mat flow rates
- Sub-soil durability
- Irrigation
- Erosion resistance, shear strength

FLL Standards

- Growth media grain size
- Growth media compressive strength
- Growth media pH and other chemical properties.
- Proportionate growth media elements

Soil Biology

- Aerobic bacteria species counts
- Endo-Mycorrhizal fungal counts
- Interface with growth media elements in terms of habitat.
- Bio-inventory.

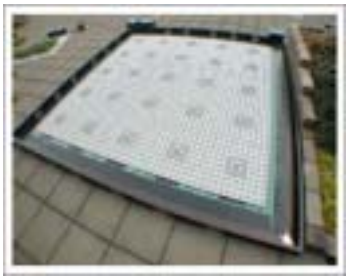
Plant Biology

- Root analysis
- Chlorophyll metabolism
- Crassuleaic Acid metabolism
- Malic Acid metabolism
- Growth rates
- Symbiotic plants and animals
- Nutrient profile

Assembly-1 sequence

Assembly-1 sequence

Assembly-1 sequence



Assembly-1 sequence

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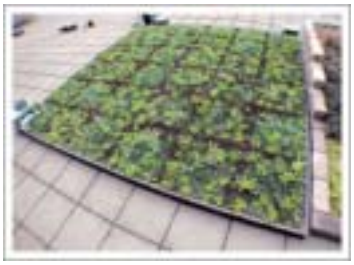


Growth medium delivery

Bare deck

Gravity erosion

Gravity erosion

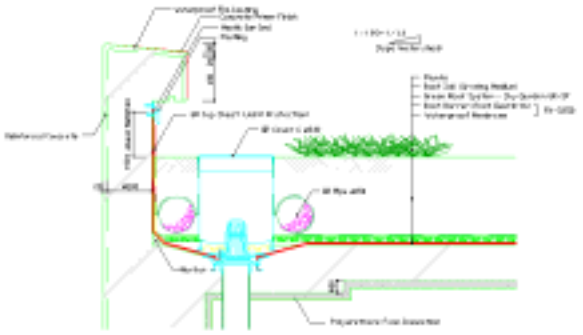
Wind Erosion

Wind Erosion

Drain mat and filter

Protection fabric

Detail-1



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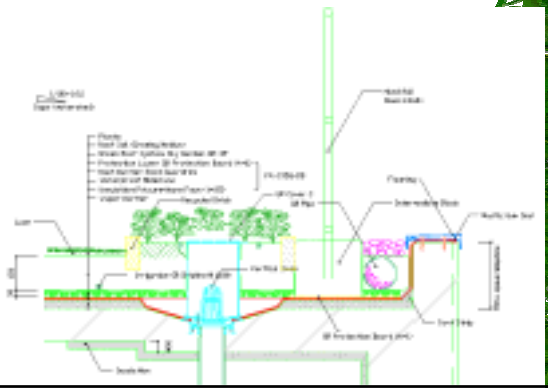

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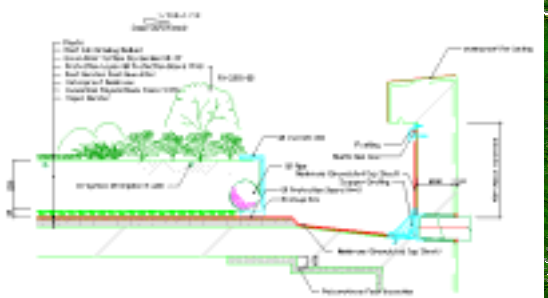

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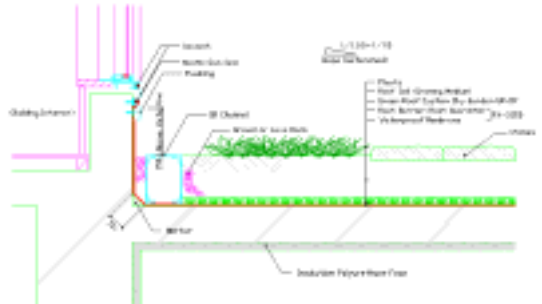

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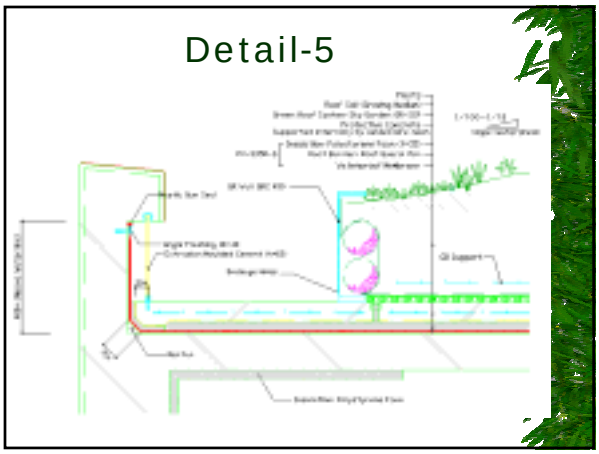

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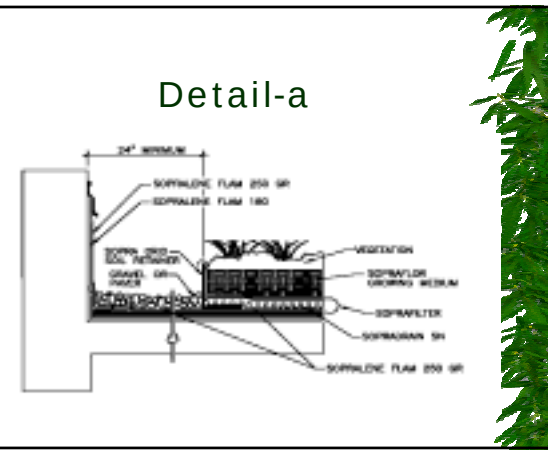

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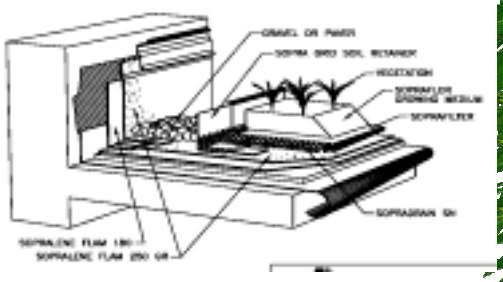

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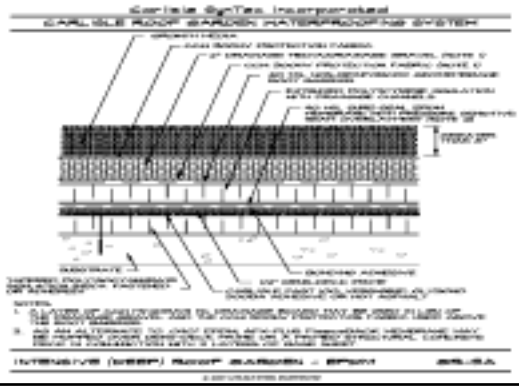

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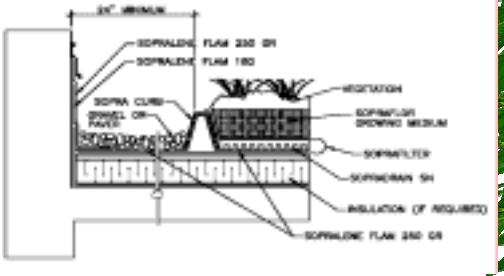

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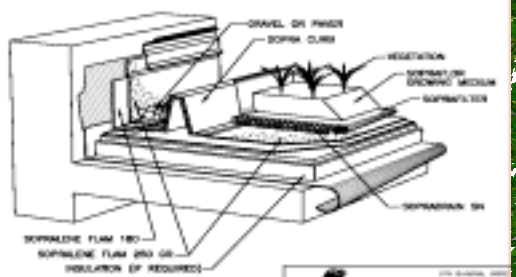

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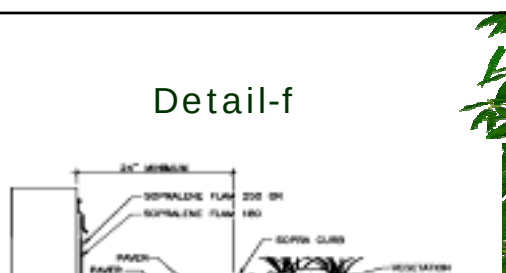

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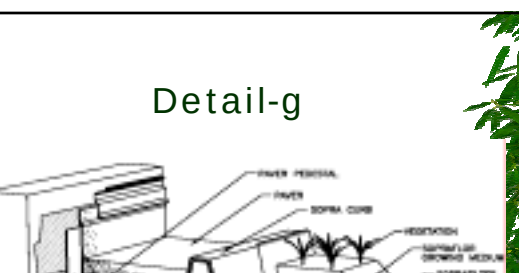

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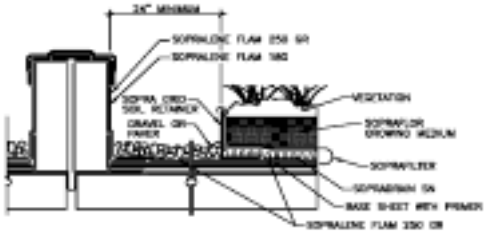

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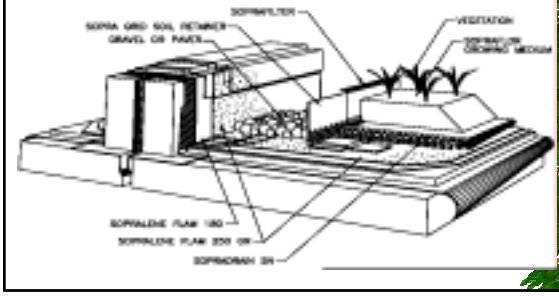

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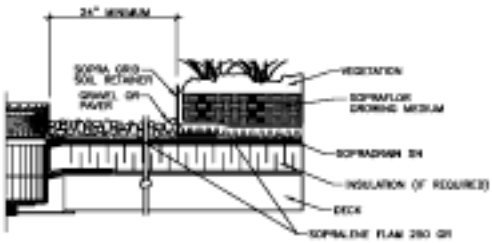

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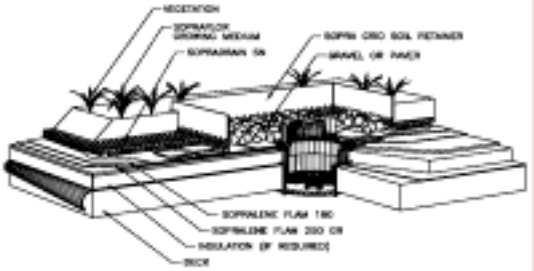

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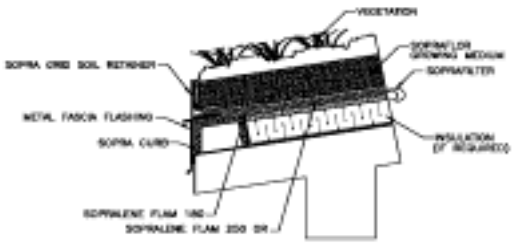

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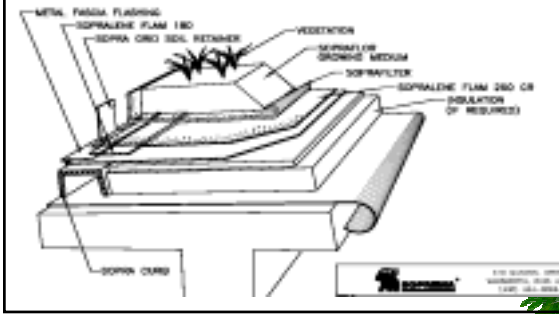

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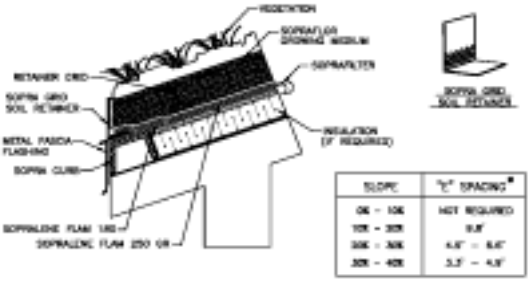
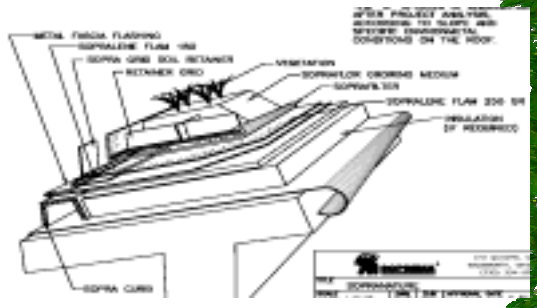


SLOPE	"L" SPACING*
0% - 10%	NOT REQUIRED
10% - 20%	9.8'
20% - 30%	6.6' - 8.4'
30% - 40%	3.3' - 4.9'

Detail-o



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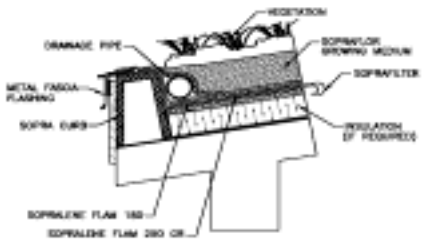

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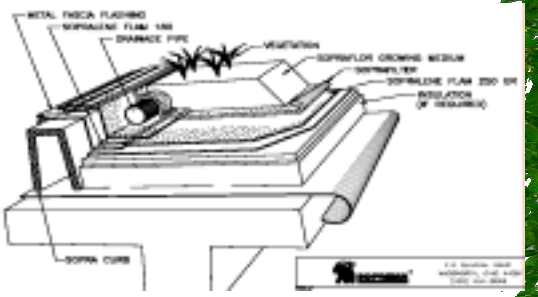

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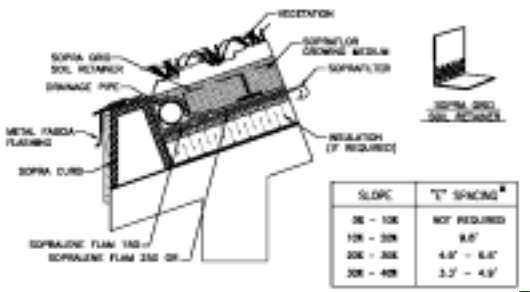

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