

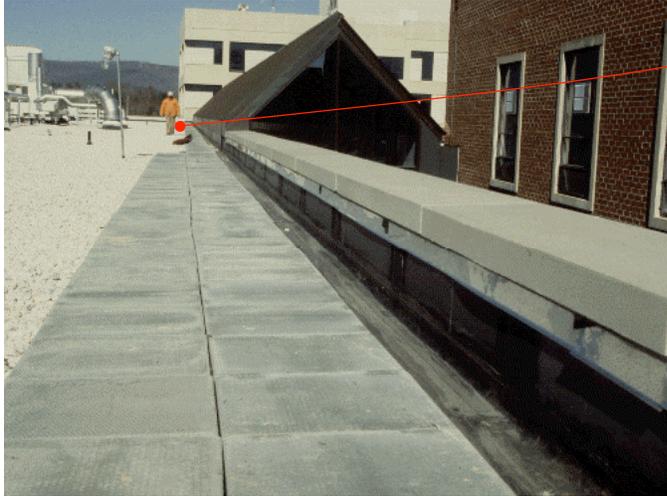
What hurts roofs

- Roof membrane durability is limited by a number of factors
 - U.V. Exposure
 - Thermal shock / thermal cycling
 - Mechanical wear and tear...golf spikes
 - Wind-induced abrasion/ballast oscillation
 - Standing water

Right side up and upside down

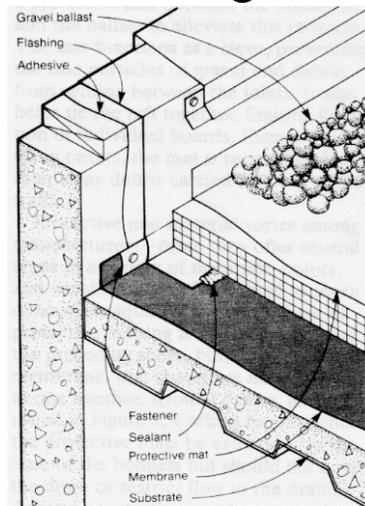
- Roof membranes are typically installed on top of the insulation boards. This keeps the insulation dry, but exposes the membrane to damage from the sun (ultra-violet radiation) and physical damage (maint. Crews wearing golf shoes)
- These “right side up” roofs are by far the most common installation, easier (cheaper) initially to install, drain, and flash

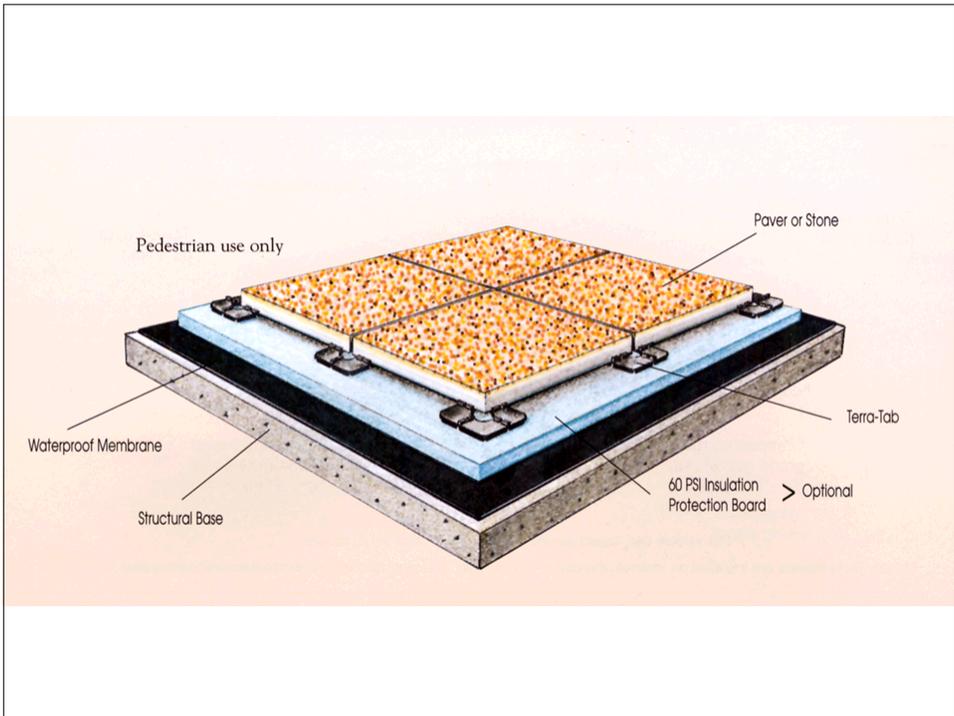
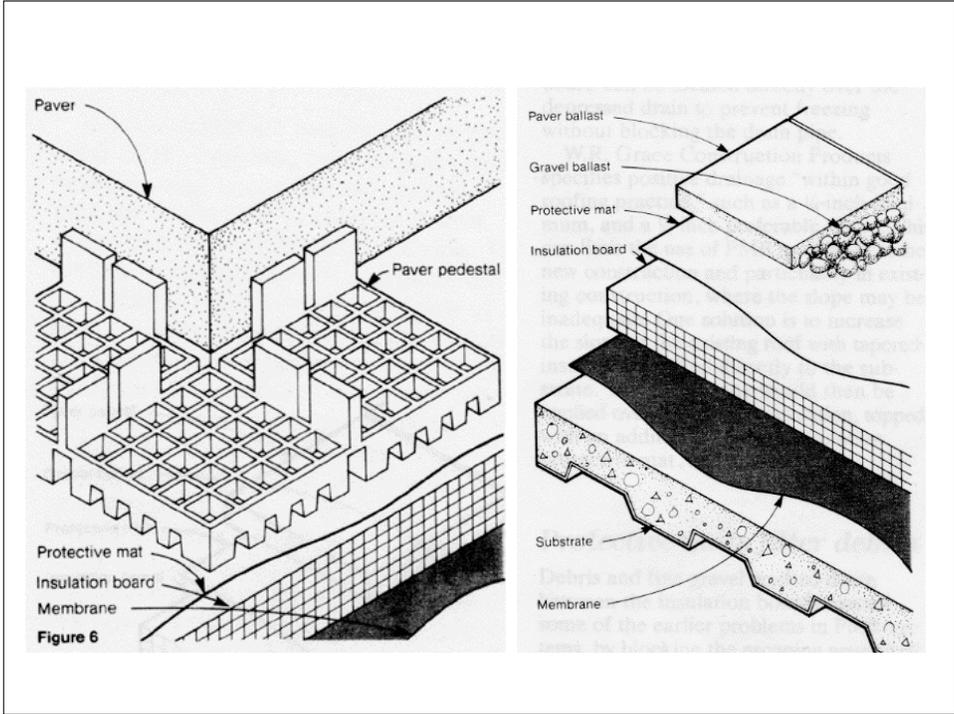
Protect the roof from foot traffic with pavers... (guy avoiding pavers)



Upside down for the long haul

- Protecting the membrane extends its life
 - It stays warm – goes through less thermal shock
 - Is protected from ultra-violet radiation (embrittlement)
 - Is protected from physical damage
- But requires special insulation, drains, and a geotextile filter.

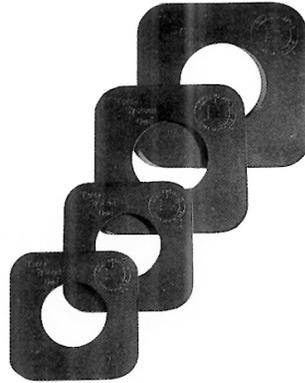




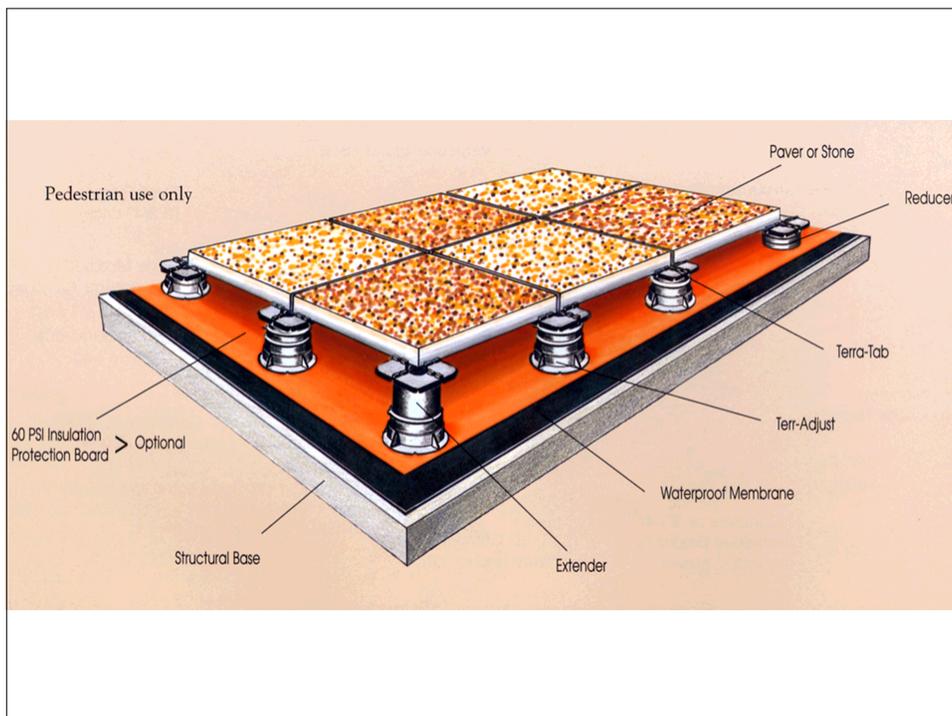
Terra-Tabs

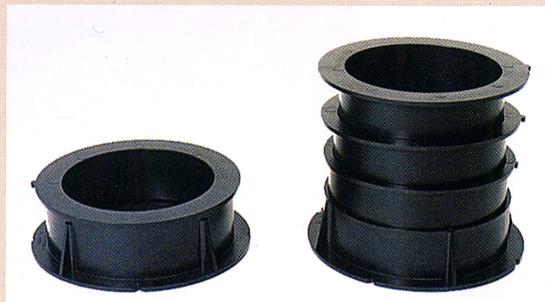


Terra-Shims



Spacing tabs on Terra-Tabs provide 3/16" joint between pavers to provide air circulation, drainage and precise alignment. Tab # 5A and # 6A are available with a 1/8" spacer tab. Terra-Shims adjust pavers where minor leveling is required.





Standard Terr-Adjust Pedestals

Minimum adjustment 2" Maximum adjustment 5 1/2"
Outside base diameter 6 1/8" Base contact area 29 1/2"



Extender

Used with Terr-Adjust pedestals to extend heights from 5 1/2" to 10"

Terra System One Mix

Specially formulated concrete is used to fill the Terr-Adjust cavity after adjustment to desired height and slope. Supplied in 100 lb. bags, one bag fills an average of 20-25 Terr-Adjusts. The preblended dry concrete mix meets ASTM C387-99 specifications.



Earth roofs . . . protect the membrane!

- The upside down roof idea is a natural direction for earth covered roofs.
- Instead of ballast on top of the insulation, put a drainage layer of sand/gravel, then topsoil.
- Make sure you let your structural engineer know you're doing this, wet soil is very, very, heavy.



Old green roofs from Le Corbusier at La Tourette



Literally millions of acres of roof are ready to be transformed into roof gardens, protecting roof membranes, reducing the heat island effect in cities, slowing urban flash floods, filtering particulates from the air, and making gardens

<http://www.cityofchicago.org> search for rooftop garden



Contouring on the south side of the roof.



Completed planting on the north side of the roof.



Contouring on the south side of the roof.



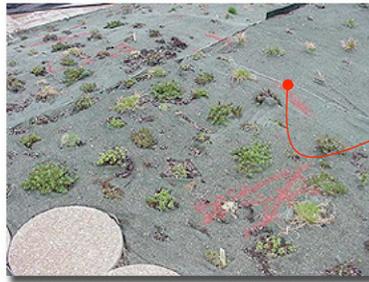
Plants begin to grow on the north side of the roof.



Completed planting on the north side of the roof.



Rooftop plants continue to grow.

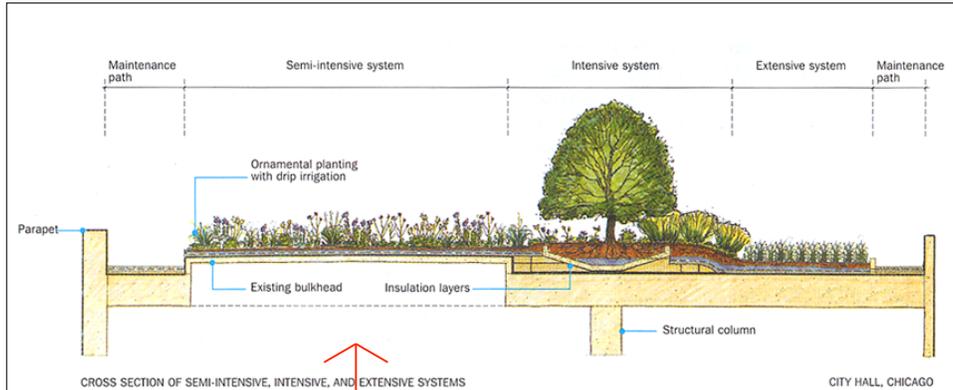


Plants begin to grow on the north side of the roof.

“Wind blanket” an loosely woven biodegradable sheet, holds growth media until root mass is mature



20,300 square feet of low maintenance plantings for an effective barrier to the heat shock and UV forces that reduce a roofs life. Owners might see a roof last 40 years instead of 10....but we have to work on the landscape of these mechanical systems!



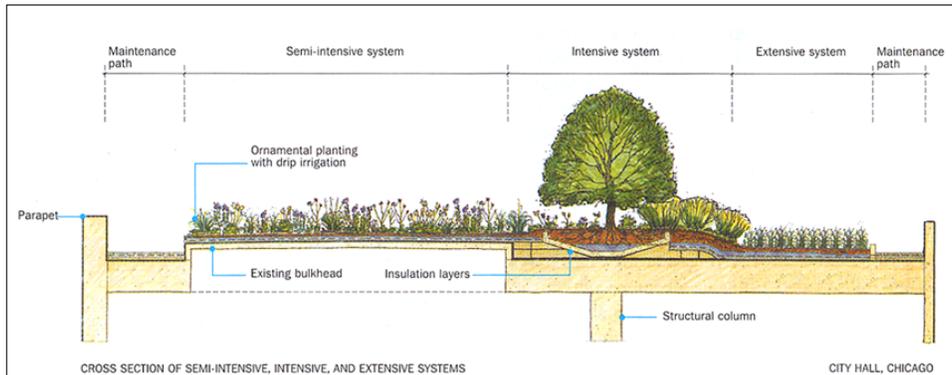
Veneer landscape

- Emphasizes horizontal root spread instead of vertical
- Uses three layers
 - 1 - topsoil - rich in organic material
 - 2 - sandy subsoil
 - 3 - fractured rock



- Can hold a 1 inch rainfall
- Penthouse roof collects water to supply part of the drip irrigation needs

	Extensive Soil		Intensive Soil		Drain Material
	one layer	multi layered	soil mixture	bulk material mixture	
PHYSICAL PROPERTIES					
Water retention (compressed condition)	min. 25 %	min. 35%	min. 50%		min. 15% (without water damming)
Water permeability (compressed condition)	min. 60 mm/min	min. 0,6 mm/min	min. 0.3 mm/min		min. 180 mm/min
Air content (fully saturated)	min. 25%		min. 15%	min. 20%	
Weight (density) (fully saturated)	0.8-1.4 g/cm ³	1.0-2.2 g/cm ³	1.4-2.2 g/cm ³	1.0-1.8 g/cm ³	0.8-1.8 g/cm ³ dependent on the material
CHEMICAL PROPERTIES					
pH-value	6.5 - 9.5	6.5 - 8.0	6.5 - 7.5		6.5 - 8.0
Salt content of water extract (recommended, if possible)	max. 1 g/liter				
Initial organic matter	3-8 %		3-6 %	6-12 %	
Nitrogen (N) slightly	max. 60 mg/liter		max. 60 mg/liter		



- Intensive - deep root systems, deep media 12-18 inches - **over columns only**
- Semi Intensive - shallow end of intensive 6 to 8 inches - over former skylights
- Extensive - horizontal extent over vertical 4 to 6 inches can occur over most of roof capable of supporting 30 pounds per square foot.

Wind exposure requires drought tolerant plants

The Chicago City Hall Project used many native prairie plants and grasses as they have drought and wind resistance.

Yarrow	Poppy	Russian Arborvitae
Wild Onion	Foxglove	Snowberry
Pasque flower	Prairie clover	American Bittersweet
American Columbine	Sand phlox	Boston Ivy
Silver Mound	Prairie buttercup	Gro-low sumac
Butterfly weed	Pasture rose	
Whorled milkweed	Sweet black eyed Susan	
Sky blue aster	White sedum	
Milk vetch	Stonecrop sedum	
Ox-eye daisy	Hen and chicks	
Coreopsis	False Solomons seal	
Purple Coneflower	Early goldenrod	
Showy sunflower	Cockspur Hawthorne	
Daylily	Prarie Crabapple	
Path rush	Dwarf Honeysuckle	
Blue hair grass	Sea Green Juniper	

Additional Resource:

For detailed guidelines on growth media characteristics for green roofs:
Forschungsgellschaft Landschaftsentwicklung Landschaftsbau e.V.
(www.fl.de)

Chicago City Hall Green Roof Project:

<http://www.cityofchicago.org/env/rooftopgarden/index.html>

Penn State Green Roof Research Center

http://hortweb.cas.psu.edu/research/greenroofcenter/about_ctr.html

Insulation

- Below most low sloped roofs is an insulation board of some kind.
 - Phenolic resin board
 - Perlite board
 - Mineral board
 - Expanded polystyrene board
 - Extruded polystyrene board
 - Polyisocyanurate board

Metal eating insulation

- Phenolic resin insulation trapped gas in bubbles surrounded by the resin. Over time, the phenolic resin reacted with galvanized metal decking in the presence of water...so a leak could make the decking corrode fast.
- It's still in buildings, but not sold here anymore.

Mineral and Perlite insulation

- Mineral boards (expanded slag – a by product of steel making) and perlite (naturally occurring lightweight mineral) were common forms of roof insulation through the 1960's.
- They were substantially inert, didn't degrade when wet, and could withstand the temperatures of molten bitumen during BUR roof installation.

Expanded polystyrene

- Expanded polystyrene – polystyrene beads formed into boards under heat and pressure, is the least expensive of the foam plastic insulation boards used in roofing.
 - R value 3.5 per inch
 - Can hold water – reducing insulation values
 - Fairly soft – use large washers below screw heads when attaching to roof deck.
 - “melts” when exposed to solvents used to chemically weld membrane joints



Extruded polystyrene

- A closed cell foam (won't hold water) available in various densities to support wheel loads under plaza's.
 - R value 5.0 per inch
 - Middle of cost categories for foam plastic insul.
 - High interior shear strength – when anchored to the deck roof membrane can be adhered directly to the insulation

Polyisocyanurate

- Highest R value (7.5 per inch)
 - Most expensive of foam plastics
 - Won't hold water
 - Gases used to expand the foam cells changed from CFC gas to HCFC gas in 1999. Industry plans to replace HCFC gas in the next few years.

Get the water off!

- These membranes (included BUR) are generally considered to make a water *resistive* roof...not water *proof*!
- Because of this, we must get the water off the roof expeditiously.
 - Slope 1/4" per foot of run
 - Scuppers at roof edge
 - Interior drains

Drainage strategies

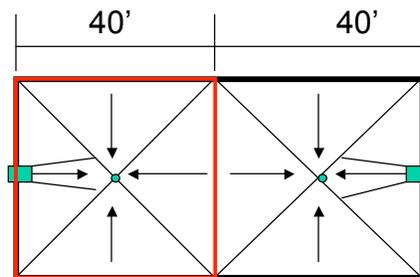
- Choosing a drainage (& insulation) approach requires an understanding of the architectural intentions
- A parapet 'hides' the thickness of insulation
 - allowing the use of inexpensive EPS
 - Making a precisely level line where wall meets sky
 -

Drainage

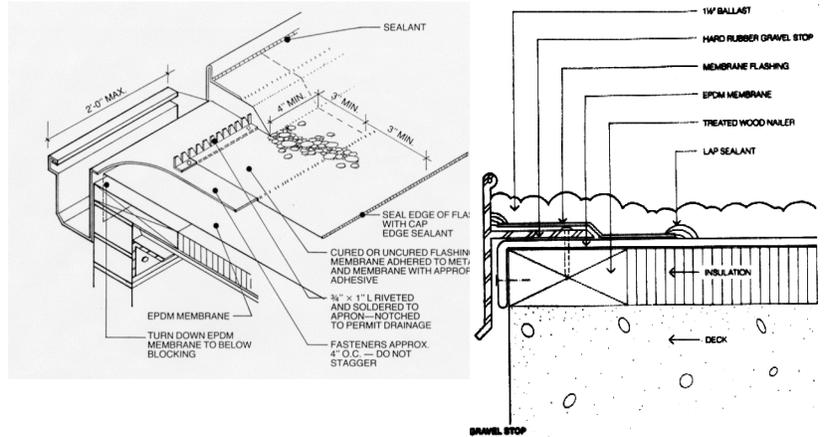
- The absence of a parapet saves height and money, but
 - Can make a wiggly line at the sky mapping the roof drains
 - Lets water run off the roof edge...needs a gutter / downspout

Slopes for a dry roof, insulation for energy efficiency

- This roof would require at least 5" of insulation at the red line in order to provide a slope of $\frac{1}{4}$ " per foot to the drain in the center. Allowing an inch or two at the drain would make the high points 7 inches thick... R 24.5 in expanded polystyrene, R 35 in extruded polystyrene and R 52.5 in polyisocyanurate!
- If this roof deck were flat, the slope would be made with a pre-tapered insulation board



2D or 3D... which is clearer?



The good guys



NRCA manual of roofing & waterproofing

