A Guide to Retrofitting an Existing Roof to a Vegetated Green Roof

Marc A. Loranger, P.E., LEED®AP    Richard Stewart
Associate    Buildings & Grounds Facilities Manager
Gale Associates, Inc.    Simmons College

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Why Green Roofing
Green Roof Benefits
Waterproofing Systems
Membrane Requirements
Conventional Advantages
Insulation Components
How Does it Work
Green Roof System Components
Leak Detection
Design Rules of Thumb
Case Study
Learning Objectives:

1. The elements of a Green Roof
2. How to select Green Roof types
3. Important technical issues
4. Maintenance issues
Green Roofing?
Seaport Area – Boston, MA
System Build-Up Mimics Nature

Vegetation Level
Growing Medium
Filter Sheet
Drainage Layer / Moisture Retention
Root Barrier
Waterproofing Membrane and Deck
Types of Green Roofs...

Vegetation
Growing Medium
Filter Sheet
Drainage Layer
Moisture Layer
Waterproofing Membrane
Extensive: Sedums
Extensive Green Roof

Maintenance

Park-Like

regular

periodic

Not-so Parklike

light

Weight

heavy

“Gardens and Parks”

“Pitched Sedum”

“Ornamental Sedum”

“Sedum Carpet”

“Moss-Sedum Green Roofs”
Intensive Green Roofs

Maintenance

- Regular
- Periodic
- Low

Weight

Light - Heavy

“Intensive Green Roofs”

“Moss-Sedum Green Roofs”

“Gardens and Parks”

“Recreational Park”

“Roof Garden”

“Perennial Garden”

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Why Green Roofs?
Rooftop Temperature Analysis

Source: Roofscapes
Roof Durability: Up to Triple Service Life
Energy Efficiency and Heat Reduction
Urban heat island reduction (study found 6% green roof coverage in Toronto would lower temperature by 1-2°C)
Stormwater Run-Off Impact

Runoff from Vegetated Roof Covers
(Depth: 3-14 inches)

Precipitation
Bare roof
Vegetated Roof Covers

Source: Roofscapes
Green Roofing Benefits
Economic Advantages of Green Roofing

- Greater energy efficiency
- Minimizes storm-water requirements
- Protects waterproofing membrane
- Lower life cycle costs
Potential LEED® Credits

- Storm water management – Green Roof 0 to 2 points
- Reduce Heat Island – Green Roof 1 point
- Water Efficient Landscaping – 0 to 2 points
- Optimize Energy Performance – 0 to 10 points
- Local / Regional Sources – Green Roof 0 to 2 points
- Innovation – 0 to 2 points

OTHER POTENTIAL CREDITS

- Tax Credits / Property Values / Drainage Credits
Environmental Advantages of Green Roofing

Create bio-diversity

Temperature regulation

Improve air quality

Stormwater Management
Community and Social Benefits of Green Roofing

- Aesthetics
- Noise Reduction
- Urban Agriculture
- Recreation Potential
- Public Education
- Therapeutic Stress Reduction
Waterproofing Systems
Built-Up Systems

- Coal tar pitch
- Asphalts
- Common Modified Bitumen
Single-ply modified bitumen
Torch-applied modified bitumen
Fluid-Applied Systems

- Rubberized asphalts
- Cold-applied asphalts
- Urethanes, PMMA
Adhered hot-applied rubberized asphalt
Cold-Applied Urethanes
Single-Ply Membranes

Thermoplastic

Thermoset
Loose-laid, single-ply thermoplastic membrane
Membrane Requirements
Must provide ability to prevent water from entering the building over occupied space
2.

Membrane must facilitate run-off and withstand hydrostatic pressure
Even minor defects in membrane can be catastrophic if subjected to ponding water
Minimum 2% slope strongly recommended
Membrane must resist fertilizers, roots, and mechanical damage
Waterproofing Design Options – Steel Deck

Vegetation
Grown Medium
Drainage Composite
Waterproofing Membrane
Separation Layer
Insulation
Thermal Barrier (as required)
Metal Deck
Conventional Advantages
1.

Allows installation over lighter weight structural decks; steel or wood deck.
2. Allows the installation of thin extensive vegetative covers (<12 lbs/sf) without concern of displacement by insulation during significant rain event
3. Allows installation over tapered insulation
4. Allows installation of stormwater retention/detention collection system
5.

Allows installation of ponding water irrigation system, also water features
Intensive Green Roof
PMA Design

Waterproofing Design Options – Concrete Deck
Insulation Options

- Polystyrene (extruded & expanded)
- Isocyanurates
- Spray foam or fiberglass
Extruded polystyrene (20-100 psi)
How Does it Work?
Shading Effects

Foliage absorbs radiant energy and reduces the amount of UV reaching the surface of the growth media
Evapotranspiration

Vegetation absorbs water through their roots and emit it through their leaves - transpiration

Evaporation occurs from vegetation and surrounding moist growth medium

Evapotranspiration cools the air by using heat from the air to evaporate water

Roof top temperatures are reduced through evaporative cooling

Effects are greatest in summer versus winter
Water Storage ...
... Drainage
Air Quality

- Reduces airborne pollutants
- Reduces ground-level ozone
- Photosynthetic converts carbon dioxide to oxygen
- Improves storm water management
Components of Green Roofing
Green Roof Trays and Modules

- Self-contained plants
- Growth media separation fabric
- Drainage layer root barrier (as needed)
Green Roof Trays and Modules

- More expensive than built in place
- Provide less design flexibility
- Less healthy for plant communities
- Provide less protection for waterproofing
- May be installed by inexperienced labor
Components of Green Roofing

• Hardscape
Components of Green Roofing

- Hardscape
- Soil confinement / curbs
Components of Green Roofing

- Hardscape
- Soil confinement / curbs
- Water retention layers
Components of Green Roofing

- Hardscape
- Vertical soil separation / curbs
- Water retention layers
- Drainage / filter methodology
Filter Material

- Geotextile fabric to prevent soil fines from migrating into drainage components.
- Sometimes combined with water retention qualities for improved planting.
Accessories of Green Roofing

- Hardscape
- Vertical soil separation / curbs
- Water retention layers
- Drainage / filter methodology
- Irrigation
Components of Green Roofing

- Hardscape
- Vertical soil separation / curbs
- Water retention layers
- Drainage / filter methodology
- Irrigation
- Root barrier
Components of Green Roofing

- Hardscape
- Vertical soil separation / curbs
- Water retention layers
- Drainage / filter methodology
- Irrigation
- Root barrier
- Protection board
Components of Green Roofing

- Hardscape
- Vertical soil separation / curbs
- Water retention layers
- Drainage / filter methodology
- Irrigation
- Root barrier
- Protection board
- Fall protection
Growing Medium

- Inorganic
- Air and Water
- Nutrient Cycling Capacity

- Organic
- Capable of Drainage
- Weight (saturated)
Plant Materials

- Aesthetics/program
- Maintenance/access requirements
- Soil requirements
- Wind load
- Water needs
- Roof pitch
Planting Considerations

- Climate/hardy plantings/elevation
- Air intake locations/allergies
- Planting establishment size and method
- Irrigation
- Exhaust locations – plant burn
- Fire hazard/codes
Vegetation Free Zones

- Typically 12 to 18 inch minimum
- Creates passage/access
- Reduce wind scour
- Assists in fire prevention
- Restricts root growth
- Segment large green areas
Leak Testing
Inspection Procedure

1. Start with substrate inspection
2. Visual membrane inspection
3. Visual flashing inspection
4. Repair visual deficiencies
5. Proceed to leak detection testing
Flood Testing
Disadvantages of Flood Testing

- Difficult and costly with sloped decks
- Not possible after overburden installed
- Delay in schedule if retests required
- Weather restraints (rain/freezing temps)
- Difficult to find exact defect location
A Better Way to Find Leaks

- First developed in Europe, Electronic Leak Detection redefines the process of finding leaks in commercial roofing and waterproofing systems.

- Electronic Leak Detection uses Vector Mapping to pinpoint membrane breaches by tracing the flow of an electric current across the membrane surface.

- Can pinpoint locations of leaks during service life even with overburden in place.
Isolation Loops
Pulse Generator Supplies 38 Volt DC Current to Trace Wire
Electricity finds ground connection “breach” and is “pulled” towards it.
Water “conductor” applied to surface to allow for ground connection (breach)
Small electrical impulses are directed onto the membrane. The electricity is searching for a ground connection (vector).
Plaza Deck Waterproofing
Advantages of EFVM Testing

- Exact pinpointing of membrane breaches
- Membrane defects can be repaired and retested without delay to the construction schedule
- EVFM® can be performed during inclement weather
- Eliminates unnecessary removal of the overburden to locate a membrane breach
- Membrane performance can be monitored during its lifespan through the overburden
Other Testing Methods

- Infrared (IR) thermal imaging
- Nuclear metering
- Capacitance testing
- Moisture sensors

None?
Vegetated Roofing “Rule of Thumb”
Design Considerations
1. Determine major design objectives such as structural capacity, environmental considerations and aesthetics
2. Waterproofing adhered to concrete deck preferable
3. Perform controlled leak testing before and after covering membrane
Only use systems with proven track records
5.

Show all connections, corners, and any detail with multiple components and/or trades
6.

Consider having full-time monitoring/inspection
Accessibility for ease and safety during installation, maintenance and visitors
Accessibility for ease and safety during installation, maintenance and visitors
Using a Life Cycle Cost Analysis might help shed some light over the long-term benefits of installing a green roof
ASTM Standards for Green Roofs

- E 2396: Saturated Water Permeability of Granular Drainage Media
- E2397: Determination of Dead Loads and Live Loads
- E 2398: Water Capture and Media Retention of Geocomposite Drain Layers
- E2399: Maximum Media Density for Dead Load Analysis
- E2400: Selection, Installation and Maintenance of Plants
- WK7319: Use of Expanded Shale, Clay or Slate (ESCS) as a Mineral Component in Growing Media
Design Standards for Green Roofs

- Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau (FFL) Guidelines
- Green Roofs for Healthy Cities (GRHC)
- FM Approvals – Approval Standards for Vegetative Roof Systems
- FM Global Property Loss Prevention Data Sheet 1-35
- ANSI/SPRI RP-14
- Whole Building Design Guide, Section 07 33 63 – Vegetated Roof Coverings
- Denver, CO: The Urban Drainage and Flood Control District T-04
Warrantees – Beware Of:

- Exclusions for ponding water
- Tray manufacturers who warrant the tray only and not the media and vegetation for 20 years
- Off-the-shelf growth media supplied by roofing manufacturers

Note: All warranties require maintenance programs and a FULL SYSTEM WARRANTY that includes membrane and overburden, including plants
Maintenance: Key to Meeting Client Expectations

Should Be a Minimum of Three Maintenance Visits Per Year
During Two-Year Establishment Period

have this ahead of them for the weekend...
What Tasks Should Be Executed During Maintenance Visits

- Remove invasive species
- Inspect roof drainage
- Inspect penetrations/roof edges
- Clean biomass from roof
- Dead-head
- Spread cuttings and new plants to fill bare areas
- Add nutrients (as needed)
- Soil analysis (yearly)
- Mow roof if extensive (yearly)
- Written / photo documentation
Common Problems

- Unmaintained for extended period of time leading to undesirable plants taking over and choking out desired plantings
- Poor drainage
- Full sun plants planted in shady areas
- Wind scour
- Trampling of plants by other trades
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