TEST PLOTS FOR A LIGHT WEIGHT, LOW-COST, VEGETATIVE ROOF IN COMMERCIAL APPLICATIONS

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Abstract
In response to market pressures, we constructed green roof test plots to investigate critical technologies that can be applied to large commercial buildings (warehouse, big box retailer, etc.) with minimal additional costs. The project design addresses structural loading, propagation methodology, plant material, irrigation regime and maintenance costs. Each attribute is designed according to a "bare essentials" approach in an effort to demonstrate the effectiveness of a lightweight vegetative roof and its capabilities as a simple, cost-effective solution for stormwater management.

Testing Facility, March 2003

Project Description
The project consists of a series of eight test plots with varying configurations of growth media and drainage. Each plot measures 12.5 ft. x 38 ft. and slopes to a central drain point on the northern boundary of the plot. This design allows for drainage and stormwater runoff monitoring. The plots are delineated with aluminum flashing set on top of 4 mm reinforced EPDM rubber. The engineered system within each plot consists of three primary layers:

- Plant material
- Growth media and principal root zone
- Drain Layer

The planted testing area covers 4,000 ft2 while maintaining a constant plant composition and field-saturated rate of 10 pounds/ft^2 over the entire testing facility.

Plant Material

Five pounds of sedum cuttings (table 1) were evenly distributed by hand across each plot. In addition to the sedum plantings, a straw blanket with sterile (annual) rye seed was selected as the erosion control system. Installed across the testing facility, the system secured the growth media and minimized wind and water erosion. A manual dispersal propagation method was chosen for ease of replication, limited skill requirement, and low installation cost.

PLANT SCHEDULE	
Scientific Name	**Percent Coverage**
Sedum acre	17.5%
Sedum album "Laconicum"	15%
Sedum album "Bella d'Inverno"	16.25%
Sedum album "Balticum"	10%
Sedum moranense	12.5%
Sedum spathyphyllum. "Carnea"	3.75%
Sedum tschernokolevii	15%
Semprivium species (assorted)	10%

Table: 1

Substrate Composition

The individual test plots have a variety of substrate compositions, depths (from 2.5 to 6.5 inches) and drainage layers. The cost, ease of installation, weight and performance of each substrate is the primary focus of our research. The growth media of each plot is outlined as follows:

SUBSTRATE DESCRIPTION PER TEST AREA		
AREA	**SUBSTRATE NAME**	**DESCRIPTION**
A	Pro-Grow 3.2 (without drain mat)	Classic rooftop / planter light weight soil mix
B	Pro-Grow 3.2	Classic rooftop / planter light weight soil mix with drain layer
C	Pro-grow 2.1	Highly organic light weight soil mix with drain layer
D	Lando 1.1 (without drain mat)	Custom light weight soil with minimal organics
E	Lando 1.1	Custom light weight soil with minimal organics and drain layer
F	Geo-Soil 1.1	Geo-textile mat with organic compost mix
G	Rock Wool 1.1	4" (loose) rock wool insulation with drain layer
H	Cinder Rock 1.1	"3/4 minus" red cinder rock with drain layer

Table: 2

Once each plot was constructed, filled with the growth media and planted, site maintenance consisted of minimal watering for the first summer season. A temporary irrigation system was constructed out of PVC tubing, conventional spray heads and a programmable timer. Once the

plants have established a 90% cover, the irrigation will only be used during “dry periods” i.e. a 14 day period that receives less than ½” of rainfall.

Results

Installation Results

The installation methodology resulted in several favorable conditions. Most notable was the ease of installation. The entire 4000 ft^2 area was installed in an eight-hour period by an unskilled labor force (March 1, 2003). Second, there was little erosion by wind or water to the testing facility. This was especially important due to the large wind uplift typical of the facility’s location. And last, the plant growth was tremendously successful in the first 45 days of installation.

Propagation and Plant Establishment

Plant propagation was limited to cuttings and seed distribution by hand. This methodology work well for plant installation and the first 45 days of plant establishment. However, plant establishment to date has been slow to progress. An uncharacteristically dry, hot spring caused the succulents to prematurely stop additional root development and subsequently stall growth starting mid-April. Additional impacts to plant growth were caused by the erosion control methods used in the installation of the test facility. Table 3 documents plot-specific performance.

For most of the growing season the straw blanket and annual rye grass erosion control system worked well to minimize erosion and create beneficial shading to the underlying sedum plants. However, in the fall of 2003, the erosion control blanket created a wet, tightly packed thatch layer on top of the soil. This has caused the sedum to rot, resulting in an estimated 30%-40% mortality rate. It should be noted that the thatch has been removed from 50% of each test plot to better facilitate sedum growth. Furthermore, growth patterns appear to be more evenly distributed and generally healthier on substrates with drain mats.

In review, one can conclude that the best performing substrates for plant propagation and establishment are those that have coarse, well-drained soils without the accumulation of surface debris. The inclusion of erosion control is beneficial, yet should not impede long-term plant growth, and the addition of a drain mat increases overall plant distribution.

YEAR 1 PLANT PERFORMANCE PER TEST AREA		
AREA	**PLANT GROWTH**	**OBSERVATION**
A	Moderate	Growth is best at the top of the slope where it is most well drained. The bottom and drain (flat) areas have minimal sedum cover and compete with the reoccurrence of annual rye
B	Moderate	Growth is best at the top of the slope where it is most well drained. The bottom and drain (flat) areas have minimal sedum cover and compete with the reoccurrence of annual rye

C	Moderate - Low	Growth is slow and somewhat consistent in coverage. This soil appears to have compressed slightly.
D	Moderate - High	Growth is best at the top of the slope where it is most well drained. Limited growth at bottom and drain areas is less than Area E possibly due to the absence of a drain mat.
E	Moderate - High	Growth is best at the top of the slope where it is most well drained. Limited growth at bottom and drain areas is slightly larger than Area D possibly due to the inclusion of a drain mat.
F	Moderate - Low	Growth is consistent throughout the upper slope areas as a result of very good drainage coupled with the annual rye grass' inability to grow in this medium. The sedum exhibits signs of stress and has limited surviving varieties. The drain area has the highest rate of sedum loss (rotting) compared to all other plots
G	Absent	Growth is absent due to the medium's inability to absorb and maintain water. This was most evident throughout the summer. In addition, the annual rye could not survive in this medium. (This medium is being replaced)
H	High	Growth is consistent throughout area as a result of very good drainage coupled with the annual rye grass's inability to grow in this medium. Note that this test area does receive minimal shading (1 hr. / day).

Table: 3

Substrate Performance for Stormwater Management*

All soil profiles are currently working to mitigate stormwater regardless of the plant growth. However they are only providing a minimal contribution to annual storm events. We are expecting better performance upon complete plant coverage.

Early testing (during the first year) has required a series of trials to best obtain data collection. The testing has not provided a clear set of findings. However it has provided several valuable tools for designing future systems. The greatest results may be the observed surface run-off from thatch and debris accumulation. Our erosion control methods have produced a re-enforced surface for the water to run across, making it difficult to penetrate when dry. However, when this top layer is saturated, moisture retention occurs over a longer period of time. Surprisingly, the cinder substrate (Area H) has proven to have similar absorption characteristics to that of soil mixes. The inclusion of a drain mat appears to have little affect on saturation levels aside from the filter fabric-specified ratings.

*Testing of the various substrates has been performed by Portland State University in April-May of 2003. Further testing will occur over the next four years.

YEAR 1 SUBSTRATE PERFORMANCE		
AREA	**SATURATION** (rate: 8 gal. / min)	**OBSERVATION**
A	7.11 min.	Surface run-off on “thatch” and perimeter channeling skews actual saturation rates
B	12.05 min.	Surface run-off on “thatch” skews actual saturation rates
C	8.35 min.	Surface run-off on “thatch” skews actual saturation rates
D	15.20 min.	Soil saturation appears to be consistent
E	14.55 min.	Soil saturation appears to be greater than “D”, but perimeter channeling skews actual saturation rates
F	3.20 min.	Water saturation occurs immediately due to the lack of vegetation cover and geotextile nature of the substrate.
G	+25.00* min.	Simultaneous water run-off and absorption. After 3-4 min., surface run-off stops and absorption continues. Rate of saturation is extremely high, coupled with initially high run-off
H	20.75 min.	Water absorption is surprisingly long

Table: 4

Continuing Research

The research project has currently concluded its first year and intends to continue to provide our results over the next four years. Our focus will continue to examine propagation methodology, plant material, irrigation regime and maintenance costs and their capabilities as a simple, cost-effective solution for stormwater management. Future results can be obtained by request at the following address:

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