BREADTH ANALYSIS 3: INTEGRATION OF A GREEN ROOF

Overview of Green Roof Types

These systems range from less invasive systems featuring only 2" deep soil and 15 psf saturated weight supporting sedum plant species to most invasive systems featuring 9"+ deep soil and 54+ psf saturated weight supporting turf grasses and small trees. As systems become more intensive, weight when fully saturated with rainwater becomes more of a structural consideration, but improved energy efficiency and the possibility of creating inhabitable garden spaces may increase building livability in the long run.

Green roof systems were analyzed and compared to the existing system using model assemblies from Roofscapes, Inc., a green roof system provider located in Philadelphia. Consisting primarily of a thin plant layer, a growing media layer, and a drainage layer over a waterproofing membrane, these systems have been shown to

- Reduce runoff and erosion, improving water quality.
- Serve as a thermal and acoustic barrier to reduce energy usage.
- Increase the service life of the roof system.
- Improve the aesthetic environment for the building inhabitants.

While discussing Green Roof feasibility, structural, mechanical, acoustic, architectural, and cost considerations were analyzed in more detail.

Feasibility of a Green Roof

Selection of a Green Roof. Roofscapes, Inc. supplies data for four green roof systems ranging from non-invasive to large-scale. Weights and depths are summarized in Table 11.

System	Thickness/ Sat.Weight
Flower Carpet	2-3"/ 12-18 psf
Aromatic Garden	3-4"/ 18-24 psf
Savannah	4-6"/ 24-36 psf
Meadows	6-9"/ 36-54 psf

Table 11. Summary of Roofscapes Green Roof Types

For this analysis, all systems were considered both as a non-public space with merely the additional garden load, and as an accessible space, with the additional garden load and a 50 psf live load from limited walkways and patio areas. Composite steel designs assumed the same 3" composite deck with 3.5" slab used in the inhabitable office areas.

Structural Considerations. While the Flower Carpet System adds a relatively insignificant load to the building structure, a saturated Meadows system with public access places a 134 psf additional load on the roof structure, increasing steel and slab sizes beyond those of occupied office floors. Sizes are summarized in Table 12.

Garden Type	Concrete Structural System	Steel Structural System
No Garden	8" slab w/3.5" drops	W18x40 max girders
Flower Carpet	8" slab w/3.5" drops	W16x40 max girders
Flower Carpet with pedestrian access	9" slab w/3.5" drops	W21x48 max girders
Aromatic Garden	8" slab w/3.5" drops	W16x40 max girders
Aromatic Garden with pedestrian access	10" slab w/4.5" drops around column lines A and F, larger 20x24 interior columns	W21x50 max girders
Savannah	8.5" slab w/3.5"	W21x44 max girders
Savannah with pedestrian access	11" slab w/4.5" drops around column lines A and F, larger 20x24 interior columns	W14x22 composite girders, 3" deck with 3.5" conc slab
Meadows	9" slab w/4.5" drops around column lines A and F, larger 20x24 interior columns	W21x48 max girders
Meadows with pedestrian access	11" slab w/4.5" drops around column lines A and F, larger 20x24 interior columns	W14x22 max composite girders, 3" deck with 3.5" conc slab

Table 12. Approximate Structural Systems Under Roof Gardens

In addition to larger concrete slabs and supporting steel girders, a larger roof weight increases controlling seismic base shear:

- **Concrete Design**. From 354k to 386k for the Flower Carpet System and to 420k for the Meadows System.
- **Steel Design**. From 170k to 180k for the Flower Carpet System and to 200k for the Meadows System.

While the concrete moment frame design effectively reduces drift and will most likely be able to resist these larger lateral loads, the steel moment frame lateral system may need to be enhanced by shear walls or braced frames around the core area.

Mechanical Considerations. A key benefit to a roof garden would be enhanced R-values in the roof system, reducing heating and cooling loads. However, R-values for roof garden systems are still under evaluation, as soil type between systems affects thermal resistance as well as saturation level in differing climates and seasons. As can be seen in the roof sections in Figure 21, added layers of water distribution fabric, porous gravel fill, soil, and vegetation would contribute to greater thermal resistance.

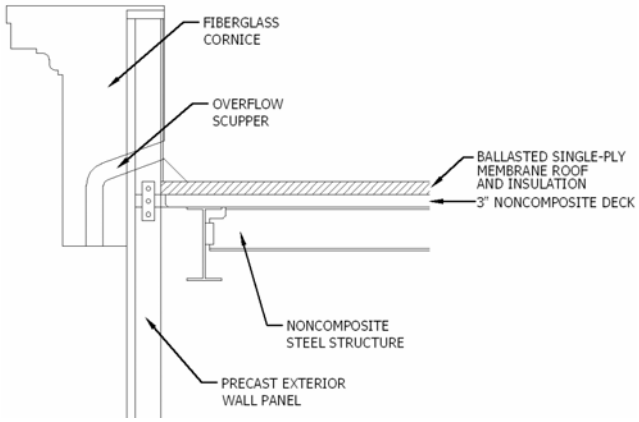

Figure 21A. Roof Section, Existing Steel System

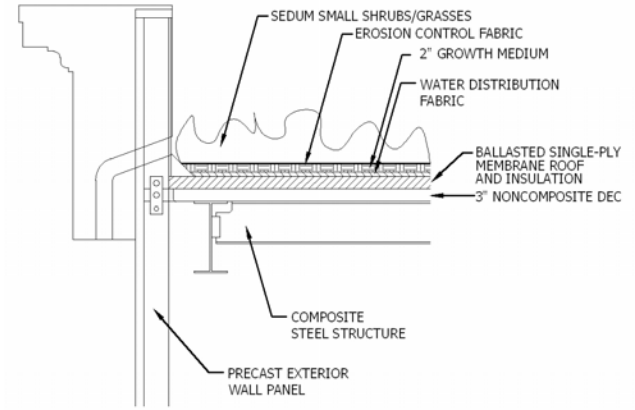

Figure 21B. Roof Section, Flower Carpet on Steel System.

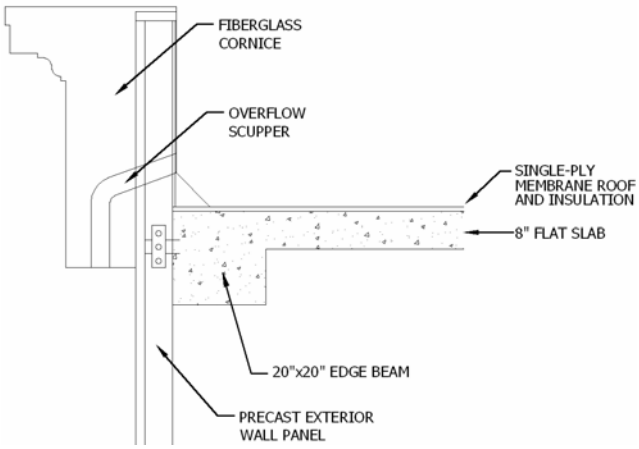

Figure 21C. Roof Section, Concrete System

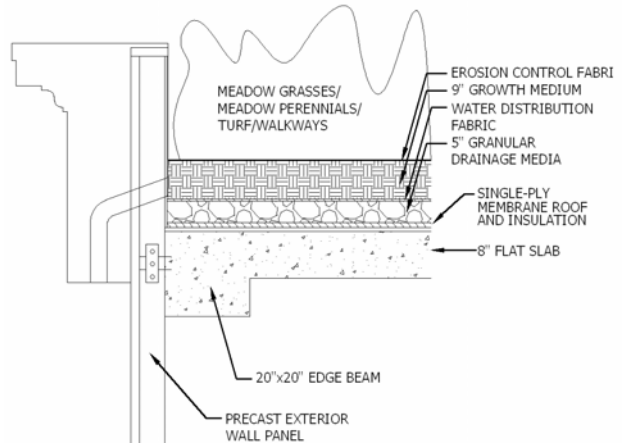

Figure 21D. Roof Section, Meadows on Concrete System.

Acoustic Considerations. Another benefit cited by green roof manufacturers are reduced sound transmission through the roof structure. Soil, as a solid and flexible material, would provide increased sound isolation over a regular system. As soil mass increases from the Flower Carpet System to the Meadows system, the STC rating will increase, though in less dramatic increments. Additional membranes and drainage layers would increase mass and therefore transmission loss through the roof system as well.

Architectural Considerations. Besides the structural, mechanical, and construction-related considerations of installing a green roof, the architectural implications of creating a green space on the roof of an office building present a unique opportunity to suburban architecture. Where the Centreville Road corridor through Manassas hosts a myriad of fast food restaurants, big-box stores, strip malls, car dealerships, and light industrial complexes, there are few green areas designed completely for pedestrian use, as shown in Figure 22. Therefore, the people who inevitably work in the Signal Hill Professional Center will not have any immediate areas to enjoy the outdoors.

Figure 22. Adjacent Green Space Along Liberia Avenue

The Roofscapes garden systems also include pavers for patios and walkways to pedestrianize their roof gardens, and by extending stairway access to the roof, those working inside the building only need to walk upstairs to enjoy the outdoors above the busy surrounding suburban area. Zoning regulations provided by the city of Manassas do not mention roof gardens; however, they do impose a 55'-0" height restriction to all B-1 rated office buildings. Since this building is currently 53'-4" tall, floor-to-floor heights would need to be reduced on each floor to allow an 8'-0" tall enclosure at the top of each stairwell.

To further improve the aesthetic of the roof garden and to disguise the functionality of the stairwells and rooftop air handling units, the same architectural precast panels used throughout the exterior façade could be implemented in a coordinated manner.

Cost Considerations. Cost information supplied by Roofscapes, Inc. indicates that it would cost $10-13 per square foot to install a 5" deep system. Further, maintenance to weed, fertilize, and replant roof gardens as necessary should require 4-6 man hours per 1000 square feet per year. Therefore, a 9000 square foot Savannah roof garden system would cost $90,000 to $117,000 to install and roughly $720 to $1,080 per year to maintain. In addition to roof garden installation, larger structural sizes under this system will increase structural construction costs by roughly $17,500 for the steel system and $30,000 for the concrete system.

However, reduced thermal loads through greater R-values in the roof system and increased productivity from a more livable work environment may offset these costs for the owner. Further, since more than 50% of the roof area would be vegetated despite air handling units, stairwells, walkways, and patios, this building would be eligible for one point under the LEED Green Building rating system (Heat Island Effect: Roof, Credit 7.2). However, given that 26 points are required for LEED Certification, further revision of all major building systems would be necessary.