# Simple Solutions for Complex Landscapes

## Design Details for Successful Green Roof Implementation

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### ABSTRACT

Despite the well known benefits of green roofs, there is a hesitancy to adopt them because their associated costs and perceived risks can be high. In order to improve adoption rates of these favorable architectural elements, they need to be made credible through the success of previously built projects. Practical evidence from the Potsdamer Platz project in Berlin, Germany serves as an excellent example from which we can establish guidelines for the design, installation, and maintenance of green roofs. This study focuses on the areas of green roof design and installation that are most prone to failure. From this study, guidelines were derived to help landscape architects produce more successful green roofs, thereby improving their credibility and adoption in future development.


### INTRODUCTION

Contemporary green roofs have the potential to minimize detrimental effects of urban and suburban development, but their adoption has been slow. The skepticisms voiced in the green roof debate are often the result of green roof developments that have exhibited failure. Through carefully studying the extermely successful 5 hectare Potsdamer Platz project in Berlin, a lot can be learned about the design and construction of functional and valuable green roofs. Germany not only has a rich history of green roof systems, but a project of this scale requires an innovative approach, the utilization of quality materials, and the proper installation to ensure success. By analyzing the photographs, CAD drawings, and descriptions by landscape architect Daniel Roehr, one can acquire a clearer understanding of the simple and elegant solutions that have been developed to combat the complex problems associated with green roofs. Although this case study will provide valuable insight for designing green roofs, it is not meant as a complete guide: One must always consider local climate, environment, and building codes, as well as the collaborative relationships required between all associated stakeholders in a green roof project.

### METHODOLOGY

Within green roof implementation, there are three major stages that occur:

1. Design
2. Installation
3. Maintenance

Major failures that can result from errors in any of these stages include the following:

A. Damage to users
B. Damage to vegetation
C. Damage to architectural materials

This paper focuses on the design stage of green roof implementation, using archived information such as photography and CAD drawings from the Potsdamer Platz project to analyze the design process. If the archived information showed failure elements or methods to decrease the likelihood of failure, they were noted and expanded on in this paper.

### DISCUSSING DESIGN

Designing a green roof requires collaboration between the client and associated professionals. Goals and objectives are determined in relation to a holistic design, priorities are assigned to aesthetic appeal, habitat, stormwater management, energy savings, and other goals, and the landscape architect determines if the desired green roof is suitable for the context with regards to cost effectiveness and sustainability. Using clearly defined goals and a list of objectives, the design process becomes streamlined. Once design is defined with an overarching concept, the details must be determined with reference to local building codes and standardizations.

*A. Damage to Users*

The prevalent causes of damage to users include structural failure of the green roof or building, associated health problems with mold, spread of fire, and hazards such as falling or flying objects and

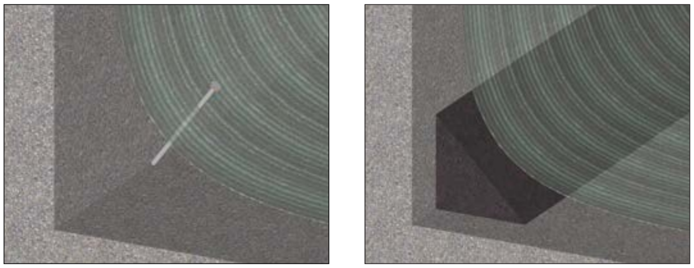

Figure 1. Designing for a durable waterproof membrane: finding weaknesses and minimizing them

tripping. Structural failure can be prevented by careful collaboration with the structural engineer whose job it is to ensure that the roof is not overloaded with dead or live weight at any time. The structural engineer will define areas on the plan which can be loaded with heavier objects, such as large trees or rainwater cisterns. Detailing two drains per area is also imperative to the structural integrity of a green roof. If one becomes blocked, the second will drain to remove water and avoid overloading during heavy rain events. Specifying green roof materials that are both rugged and durable can also serve to keep unwanted water damage from effecting the structural integrity of a green roof. Typical materials include:

- Insulation with differing weights and insulation values such as Polyisocyanurate, extruded polystyrene, expanded polystyrene or fesco board
- Membranes such as EPDM, TPO, PVC, Built-Up Roofing, Modified Bitumen, liquid-applied membrane, or metal roofing
- Protection materials such as gypsum-based cover boards, fesco board or fabrics
- Moisture retention materials such as fabrics, Gel Packs and particles, eggshell/dimpled mats or filter fabrics
- Root barriers such as fabrics or thermal plastics
- Drainage layer materials such as aggregate, geo-textiles or combination core/root barriers

Mold can similarly be prevented in green roof design by ensuring the green roof system to be water tight from the building interior. Specifying products that are anti-fungal or low in organic composition can also prove effective. Roof drains that are the appropriate size and shape and which are protected by filter fabric allow water to flow while keeping growth media and plant materials from entering and damaging the plumbing (Snodgrass, 2010). Products such as plastic wire mat can also be used to assist with continuous air circulation to the many layers of the green roof (Roehr, 2004).

Fire hazard is the final avenue through which green roofs are concerned with causing damage to users. Although fire is a rare occurence, especially in Vancouver's climate, spread can be prevented by specifying a one meter wide strip of unburnable material every forty meters (Luckett, 2009). Building codes most often specify a minimum 0.43 meter wide strip of unburnable material against the edge of the facade of the building as well. Other general safety measures that can be taken on behalf of the users of green roofs include:

- Specifying a different colour or material to denote a significant rise in elevation. This helps prevent people from tripping on grade changes.
- Designing paths which lead users safely around the green roof, with parapets marking the edges.
- Specifying heavy pavers or anchoring things to buried concrete ballasts (that do not penetrate the waterproof layer) will prevent "uplift" of green roof layers from strong winds.
- Specifying plants with a good root structure will help stabilize the roof system.

*B. Damage to Vegetation*

Successfully designed green roofs will result in a product that will passively cool the building, beautify the roof, and require minimal maintenance. To keep vegetation healthy, however, there are a number of considerations that need to be made:

i. Local climate and rooftop conditions may call for native plants, shade-tolerant plants, or drought tolerant plants
ii. Juvenile plants are the most successful for establishing on a green roof and require close attention for the first two years.
iii. Placement of plants close to HVAC systems or other items that will drastically alter microclimates including the reflection off shiny materials can

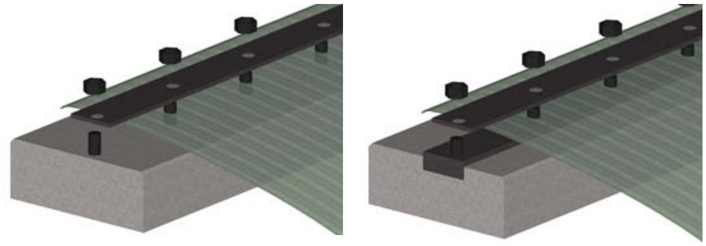

Figure 2. Watertight fastening for waterproof layer (left) vs. Waterproof fastening for waterproof layer (right)

cause heat damage to plants that are not tolerant to those conditions.

iv. Soils need to have the proper composition for your plant types. This includes the consideration of particulate size, organic matter percentage, and pH levels.

v. The proper plant sizes and density of plantings needs to be explicitly specified to ensure that plants can establish themselves within a relatively quick time period, making the roof more resilient quicker.

vi. Specify for plant diversity and allowing the roof to take a life of its own over time as plants find the most suitable area for themselves. This ensures a greater chance of establishment by the plants.

vii. Specify soil depth based on plant palette, rainfall, aridity, and desired stormwater performance. Deeper soil is not necessarily better for the plants, so be sure to collaborate with a trustworthy soil supplier and botanist.

*C. Damage to Architectural Materials*

When considering potential damage to architectural materials, it is important to understand the difference between watertight and waterproof. Watertight is the condition most commonly seen on green roofs, where the waterproof layer is fixed to the parapet, fastened by one metal plate and bolts. Waterproof is the condition seen for water features, where the waterproof layer is fixed between two metal plates and bolts and inset into the building material. Waterproof connections to architectural elements are considerably more expensive than watertight connections and should be used only where necessary (Fig. 2). Where possible, pitch should be designed into architectural elements to provide drainage, noting of course where the water is draining to: the preference is toward the green roof and away from the facade in order to avoid staining or water damage on the face of the building (Fig. 3). Architectural damage can also be prevented by avoiding plants with aggressive root systems. These can damage the roof structure, HVAC systems, or even the building facade. If such plants must be used, the design should include appropriate barriers and precautions. Metal edging is commonly used to help contain vegetated areas of roof from spreading into the nonvegetated areas (Fig. 4).

## A BIT ON INSTALLATION AND MAINTENANCE

The successful design of green roofs means very little if the installation and maintenance is not consistent with the intention of the designer. Thus, a knowledgeable project manager must be on site throughout the installation process, and maintenance practices must be accounted for before a project begins. These strategies have been

Figure 3. Inverted roof configuration (left) vs. warm roof configuration (right)

developed to mitigate the risk of error throughout the installation and maintenance phases of green roof implementation:

i. Keep the work site organized and uncluttered
ii. Large scale projects are easier to coordinate and safer to install when using the inverted roof model. The inverted roof protects the waterproof layer and can be walked on by developers. If damage occurs to the surface of the insulation, it can easily be replaced (Fig. 3).
iii. Schedules should be coordinated to install the vegetation the day of arrival on site. This minimizes the chances of plants being dried out or stacked in palettes for extended periods.
iv. Protective boards and sheets can be utilized to guard architectural elements during the installation of the green roof.
v. The membrane needs to be protected from Ultraviolet radiation and heat from the sun, therefore must be completely covered and unexposed.
vi. Drains need to be blocked and the roof flooded to check for leaks during the installation process.

*Maintenance often makes the difference between a thriving green roof and a failed one*

(Snodgrass, 2010)

The definition of 'low maintenance' is highly variable. The landscape architect needs to make it known to the client that maintenance is an added cost and that the budget can't be spent entirely on design and installation. Good maintenance is preventative rather than reactive. By anticipating problems and taking measures to avoid them, long term maintenance costs are decreased. Watching for signs of stressed, damaged and diseased plants can alert maintenance personel to a dysfunctional component of the roof. Clogged drains due to biomass buildup need to be regularly monitored and cleared accordingly (Fig. 4).

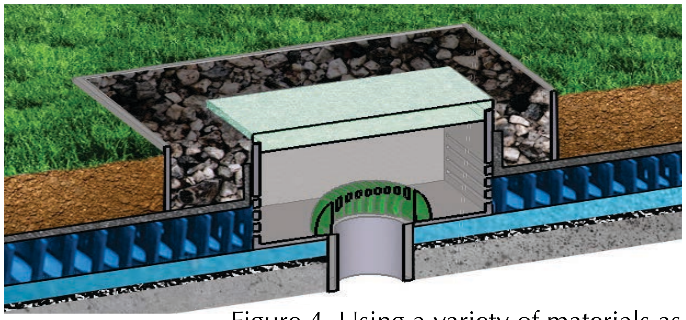

Figure 4. Using a variety of materials as barriers to drain (to avoid blockage)

## SIMPLE SOLUTIONS, COMPLEX LANDSCAPES

German Architect Ludwig Mies van der Rohe claimed that "less is more" and "God is in the details". These two aphorisms can be used as guiding principles for green roof designers to produce more resilient and beautiful projects.

**"Less is More"**

Through maintaining a holistic design approach and establishing consistent methods of detailing even the most complex green roof can become manageable. With the objective being to reduce the number of technical failures, this paper advocates for the landscape architect to be involved in all phases of design development, finding simple solutions to grand scale problems.

**"God is in the Details"**

Specifying the design intricacies of a project is required to fulfill the designer's vision. Without highly specific details, the potential for failure increases in a design.

Using the simple solutions outlined in this paper, the complexities of green roofs can be reduced to a number of simple solutions found in the details of a project. This type of problem solving can, in turn, improve the credibility of green roof projects thus increasing their level of acceptance and adoption.

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