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Green Roof, A Review of History and Benefits

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ABSTRACT

Green roofs, also called "vegetated roof covers" or "living roofs," are comparatively thin layers of living plants installed on top of expectable roofs. Green roofs back to the Hanging Gardens of Babylon, which provided a green oasis for royal family. Ancestors to the modern green roof, such as sod roofs, have been used in many cultures for centuries. Green roofs provide many ecological, aesthetic, and financial benefits, including Conserving energy, Controlling storm water runoff, erosion, and pollution, Improving the aesthetic environment in both work and home settings, Creating wildlife habitat, Reducing sound reflection and transmission, Improving water quality, Mitigating urban heat island effects, cooling and cleaning the air. The study has been conducted on the basis of literature survey with Library, Journals, Internet, Various seminar papers, reports of research organization.

Keywords: Green Roof, Benefits, Intensive, Extensive

I. INTRODUCTION

Green roofs are generally classified into intensive, semi-intensive and extensive green roofs. Intensive green roofs are characterized with thick substrate layer (20–200 cm), wide variety of plants, high maintenance, high capital cost and greater weight. Because of increased soil depth, the plant selection can be more diverse including shrubs and small trees. Typically require high maintenance in the form of fertilizing, preparing and watering. Extensive green roofs are characterized with thin substrate layer, low capital cost, low weight and minimal maintenance. Owing to the thin substrate layer, extensive roofs can accommodate only limited type of vegetation types including grasses, moss and few succulents. An extensive green roof system is commonly used in situations where no additional structural support is desired. Semi-intensive green roofs accommodate small herbaceous plants, ground covers, grasses and small shrubs due to moderately thick substrate layer. These roofs require frequent maintenance as well as sustain high capital costs. Between three types, extensive green roofs are most common around the world due to building weight limits, costs and maintenance. Green roofs present numerous economic and social benefits in addition to more obvious environmental advantages such as storm water management, decreased energy consumption of buildings, improved water and air quality, decreased noise pollution, extended roof life, reduced heat-island effect and increased green space in urban environments (Berndtsson, 2010; Getter, 2009; Niu, 2010). Many countries and municipalities understood these benefits and started to device green roofs in buildings. Commercial green roof products started to appear in the market doing impatient business. It should be pointed out that the focus of green roof developers has been limited to achieving basic aesthetical benefits of green roofs (Berndtsson, 2010). Many other benefits of green roofs are just as attainable, but thus far the green roofs generally are not optimized to meet those (Vijayaraghavan, 2014). Green roofs are progressively being built to provide a varied range of environmental benefits. These include energy conservation through improved building insulation and energy efficiency (Sailor, 2008), mitigation of the urban heat island effect (Bass and Baskaran, 2003), noise attenuation (Van Renterghem and Botteldooren, 2009), biodiversity habitat providing (Brenneisen, 2006) and urban storm water management (Berndtsson, 2010; VanWoert et al., 2005). Green roofs are constructed profiles made up of layers including water-proofing, drainage and substrate layers in which plants are grown. Weight loading limitations on buildings limit the depth of substrate (often <20 cm) on equipped green roofs. This makes green roofs difficult environments for plant growth and survival as water availability fluctuates dramatically between rain events (Nagase and Dunnett, 2010). Consequently, survival during drought periods determines plant species suitability for green roofs (Bousselot et al., 2011), especially in hot and dry climates. Survival on green roofs is determined by substrate depth and physical properties, particularly water holding capacity. Drought tolerance of Sedum species in response to substrate depth has been widely investigated, with increased survival in greater depths (Durhman et al., 2007; Getter and Rowe, 2009; VanWoert et al., 2005). There has been little comparison of species performance under drought conditions in different substrates with different physical properties. Green roof substrates need to balance a number of competing and contrasting properties. Good aeration and low bulk density are needed to confirm the substrate is free draining, lightweight and facilitates plant respiration, yet this must be balanced against sufficient water preservation for plant growth and survival (Nektarios et al., 2004; Rowe et al., 2006; Thuring et al., 2010). These properties can be achieved with light weight components; many components, particularly organic materials, shrink and decay over time, therefore green roof substrates are largely mineral based. Mineral based substrate composition differs according to local availability and cost, and many include recycled or waste products to maximize the environmental benefits of green roofs (Molineux et al., 2009).

Storm Water Reduction

Green roofs are known to retain rainwater and delay peak flow, thereby reduce the risk of flooding (Mentens, 2006; Chen, 2015). When rain water enter green roof, a portion of water will be absorbed by growing substrate or retained in the pore spaces. It can also be taken up by the vegetation and either stored in plant tissues or transpired back into the atmosphere (Nagase, 2012). Vijayaraghavan and Joshi (Vijayaraghavan, 2014) utilized a commercial drainage element and the authors claimed the storage potential of drainage module played a significant role in reduction of runoff volume. Several studies correlated water retention capacity of green roofs with rain fall size, intensity and previous dry periods (Berndtsson, 2010; Carter, 2006). Villarreal and Bengtsson (Villarreal, 2005) found that water storage capacity of green roof strongly depends on the intensity of the rain event and slope of green roof. For a rainfall with an intensity of 0.4 mm/min, 62%, 43% and 39% of the total precipitation were retained in the green-roof having slopes of 2°,8° and 14°, respectively. For rain intensity 0.8 mm/min at slopes of 2°,8° and 14°, the retentions were 54%, 30%, and 21%, respectively.

Thermal Benefits

Green roofs are attractive option for energy savings in building part. They reduce building energy demand through improvement of thermal performance of buildings (Saadatian, 2013; Hashemi, 2015). A study in Greece revealed that green roofs reduce the energy utilised for cooling between 2% and 48% depending on the area covered by the green roof, with an indoor temperature reduction up to 4 K (Niachou, 2001). Improvement of thermal performance is basically due to increment of shading, better insulation, and higher thermal mass of the roof system (Saadatian, 2013). Urban heat island (UHI) effect i.e. to decrease Green Roof, Benefits, intensive, extensive ambient air temperature in urban areas. Several densely populated and intensely urbanized areas in the world suffer from UHI problems and the worst urban eco environment (Wong, 2013). Green roofs are tools that combat UHI and increase the albedo of urban areas (Saadatian, 2013); Kolokotsa, 2013). Berardi et al. (Berardi, 2014) indicated that albedo of green roofs ranges from 0.7 to 0.85, which is much higher than the albedo (0.1–0.2) of bitumen, tar, and gravel roofs. In his review article, Santamouris (Santamouris, 2014) compared several mitigation technologies to minimize UHI effect and recommended that large-scale application of green roofs could reduce the ambient temperature from 0.3 to 3 °C. Green roofs impact both humidity and temperature. High temperatures are responsible for urban heat islands. Average summer temperatures in major North American cities have been on the rise over the past decade. High temperatures necessitate more electricity for air conditioners and increase pollutants, such as ground level ozone. Such conditions can result in heat exhaustion, heatstroke, and even death. Green roofs can dramatically lower temperature. For example, on a recent hot day in Minneapolis, Minnesota (90 degrees Fahrenheit), a reading on the green roof of the Minneapolis Central Library building registered 92 degrees Fahrenheit, while a neighbouring conventional roof registered a temperature of 170 degrees Fahrenheit (Dramstad, 1996). Even when the air is clean, dry air can put a draining on a person's breathing during periods of high temperatures. Green roofs capture and hold precipitation in the plants, thereby increasing humidity and easing breathing difficulties.

Water Quality Improvement

Green roofs buffer acidic rain (Teemusk, 2007; Vijayaraghavan, 2012) and theoretically retain pollutants thereby produce good quality storm water runoff. However, there exists a difference in opinion among the research studies on runoff quality from green roofs (Berndtsson, 2010; Vijayaraghavan, 2014). In Toronto, Van Seters et al. (Van Seters, 2009) examined runoff samples from an extensive green roof for pH, total suspended solids, metals, nutrients, bacteria, and PAH (polycyclic aromatic hydrocarbons). The author's identified that concentrations of most pollutants were lower from the green roof relative to the conventional roof with the exception of Ca, Mg, and total P. Similarly, Rowe (Rowe, 2011) reviewed several research articles on green roofs and concluded that green roofs can have a positive effect on water quality. Discharge of nutrients from green roofs can also be directly associated with the usage of fertilizers (Malcolm, 2014; Razzaghmanesh, 2014), particularly conventional fertilizers cause higher nutrients concentrations in runoff than the controlled release fertilizers (Emilsson, 2007).

Noise Reduction

Considering that green roofs are constructed boundary between the natural exterior and indoor environments, they generally reduce noise pollution in urban spaces arising from road, rail and air traffic (Van Renterghem, 2008; Yang, 2012). Sound can be minimized by a green roof in few ways, viz. providing increased insulation of the roof system and by absorption of sound waves diffracting over roofs (Van Renterghem, 2011). However, research studies on the acoustical benefits of green roofs are rather limited. Connelly and Hodgson (Connelly, 2013) performed field experiments on green roofs of varied substrate depths, water content, and plant species; and results indicated that the transmission loss of vegetated roofs was greater than that of non-vegetated reference roofs by up to 10 and 20 dB in the low and mid frequency ranges, respectively. Van Renterghem and Botteldooren (Van Renterghem, 2008) studied both extensive and intensive green roofs for their potential over sound propagation. They observed good overall efficiency from extensive green roofs (15–20 cm); whereas intensive green roofs (greater than 20 cm) produced no further positive effects. It is also worth noting that the performance of green roofs in sound insulation is more pronounced in low rise buildings, owing to the fact that growing layer should be exposed to the direct urban sound field to be an effective absorptive surface (Rowe, 2011). Controlling noise is another reason to choose green roofs. Soil, plants, and the air layer trapped between the green roof assembly and the building surface provide sound insulation. The substrate blocks lower frequencies, while the plants block higher frequencies. This can mean a reduction in indoor sound levels of as much as 40 decibels, an important difference to those who live near airports, major highways, or other forms of industrial related noise pollution. Additionally, wind moving through the stems and leaves on green roofs can provide masking noise or create a beneficial soundscape.

Air Pollution

The green roof system is a popular approach that could help to mitigate air pollution in urban environments. Urban air often contains elevated levels of pollutants that are harmful to human health and environment (Mayer, 2008). Yang et al. (Yang, 2008) quantified a total of 1675 kg of air pollutants was removed by 19.8 ha of green total of 1675 kg of air pollutants was removed by 19.8 ha of green roofs in one year with O (27%), PM10 (14%), and SO3 2accounting for 52% of the total, NO (7%). On the other hand, Johnson and Newton (Johnson, 1996) estimated that 2000 m 2 of uncut grass on a green roof can remove up to 4000 kg of particulate matter. Rowe (Rowe, 2011) further added that one square meter of green roof could offset the annual particulate matter emissions of one car. It is also worth noting that the potential of green roofs to minimize CO concentration was studied (Li, 2010). The vertical building massing of downtown areas often inhibits ventilation, reducing wind speed and trapping pockets of heat. Pollutants can remain suspended for long periods of time. Green roofs absorb carbon dioxide, a major automobile emission, through foliage, naturally cleansing the air.

Regaining Waste

Green roofs have the capacity to capture waste and convert it to useful product. A Belgian factory that manufactures biodegradable laundry products has two acres of native grasses and wildflowers on its roof. By products of their manufacturing process are treated in an onsite sewage pond and then filtered through the green roof, simultaneously acting as irrigation and a nutrient source for the plants (Scholz-Barth, 2001).

Initial Costs versus Life Cycle Costs

Regardless of the many benefits of green roofs, their limited use is attributable to their higher first costs. Typically, a conventional roof costs $10-$12 per square foot; the initial cost for a green roof can be up to twice that much. A life cycle perspective, however, reveals the economic benefits of green roofs. Because they protect the roofing membrane against ultra violet radiation, extreme temperature fluctuations, and puncture or physical damage from recreation or maintenance, the green roof prolongs the life expectancy of the roof up to three times longer than a conventional roof. As an example, a London department store that installed a roof membrane under a planting in 1938 found the membrane still in excellent condition fifty years later. In England's rain soaked climate, most conventional flat roofs have an average lifespan of only 10-15 years (Peck, 1996).

Energy Savings

Additional cost savings come from the insulating properties of green roofs. By trapping an air layer within the plant mass, the building surface is kept cool in summer and warm in winter. By covering the roof with vegetation, the summer heat is prevented from reaching the building's skin; in the winter, the internal heat is reflected or absorbed. This interprets into year round lower energy consumption and lower corresponding costs. Green roofs make sense, both in ecological and economic terms (greenroofs.org).

II. METHODS AND MATERIAL

The study has been showed on the basis of literature survey. Library , Internet, Various seminar papers, taskforce reports of research organization, journals and some periodicals on history and benefits of Green roof have been surveyed for the purpose of accumulating information.

III. RESULTS AND DISCUSSION

Green roofs can also be viewed as a tool to enhance aesthetic appeal of any building. Compared to bland and utterly boring flat roofs, green roofs are more pleasant to experience or view from other buildings. Green roofs also aid to restore biodiversity that have been lost due to urban development. Green roofs offer a safe place for birds, insect and other plants to grow. Green roofs protect roof membrane from extreme heat, wind and ultra violet radiation. Due to the presence of vegetation and thick substrate layer, the daily expansion and contraction of the roofing membrane can be avoided.

The benefits of green roofs include:

- Storm water management
- Air quality
- Economic benefits
- Thermal benefits
- Noise reduction
- Social benefits
- Energy Savings

IV.CONCLUSION

Green roofs provide many ecological, aesthetic, and financial benefits, including Conserving energy, Controlling storm water runoff, erosion, and pollution, Improving the aesthetic environment in both work and home settings, Creating wildlife habitat, Reducing sound reflection and transmission, Improving water quality, Mitigating urban heat island effects, cooling and cleaning the air.

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