A Comprehensive Review on Green Roof Technology

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Abstract- *Here we have Studied various Green roof systems which are Smart Vegetated Roof System are used extensively in Europe and most of the countries to manage storm water, reduce energy consumption and for aesthetic appeal. They are gaining popularity in the United States especially in larger cities that are required to meet stringent requirements to manage storm water. Green roofs can be installed on new construction or retrofits to existing buildings as long as the facility has the necessary structural integrity (check with a structural engineer). There are variety systems available for commercial to residential applications. The two types of green roofs are: intensive and extensive. Intensive green roofs are typically more elaborate systems while extensive roofs can still be lush, but require less material.*

Keywords- Green Roof, Storm Water management, Rain Water Harvesting, Structural integrity

I. INTRODUCTION

As a result of rapid economic growth, many countries have been experiencing increased urbanisation. Due to this amplified urban population, tall buildings and other new developments are made at the expense of green areas. This resulted in the shortage of greenery which in turn causes a decrease in canopy interception and transpiration within the urban area leading to an increased temperature and decreased air humidity [1]. These problems can be partially solved by altering buildings' rooftop properties. The introduction of plants and soil to the unutilized rooftop surfaces are often regarded as a valuable strategy to convert buildings more sustainable [2,3]. Green (vegetated, eco or living) roofs are basically roofs planted with vegetation on top of the growth medium (substrate). The concept was designed and developed to promote the growth of various forms of vegetation on the top of buildings and thereby provide aesthetical as well as environmental and economic benefits. Green roofs generally comprise of several components, including vegetation, substrate, filter fabric, drainage material, root barrier and insulation. The role played by each component is well defined in engineered green roof system and type of each green roof component depends on the geographic location [4].Green roofs are broadly 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. Due to increased soil depth, the plant selection can be more diverse including shrubs and small trees. Therefore, typically require high maintenance in the form of fertilising, weeding and watering. On the other hand, extensive green roofs are characterized with thin substrate layer (less than 15 cm), 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. Of the three types, extensive green roofs are most common around the world due to building weight restrictions, 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 [1,5,6]. Many countries and municipalities understood these benefits and started to implement or even mandate green roofs in buildings. Consequently, more and more green roofs are established. Shortly, commercial green roof products started to appear in the market doing brisk business. However, it should be pointed out that the focus of green roof developers has been limited to achieving basic aesthetical benefits of green roofs [1]. Many other benefits of green roofs are just as achievable, but thus far the green roofs generally are not optimised to meet those [7]. This is generally due to lack of research on different aspects of green roofs and premature introduction of products into the market. Thus, there is a great need for green roof research. The objectives of this review are to understand the current scenario in green roof research, provide suggestions to select different green roof components based on requirements and strategies to develop practical green roofs to meet consumer needs. In addition, this review also summarizes the benefits of green roofs as well as recent trends in green roof technology.

II. HISTORY

Planting vegetation at the building rooftop is an old technique. The most famous ancient green roofs were the Hanging Gardens of Babylon constructed around 500 BC. In more recent times, peoples tend to cover their rooftops with sod for the purpose of insulation from extreme climates. Modern green roofs, therefore, may acquire their concept from ancient technique; however technological advances have made modern green roofs far more efficient, practical and beneficial than their ancient counterparts. Modern green roofs, in a larger scale being designed, developed and marketed by Germany [2]. Several investigations have been carried out with emphasis on biodiversity, substrate, roof construction and design guidelines [1]. Unfortunately, most of the early studies on green roofs was written in German and also not readily available to rest of the world [8]. However owing to the first initiative by Germany and subsequently by neighboring European countries, green roofs became popular in other parts of the world. Recently, green-roof coverage in Germany alone increases by approximately 13.5 million m2 per year [2]; whereby 10% of its buildings utilise green roof technology [9]. Currently, countries like USA, Canada, Australia, Singapore and Japan are making a strong initiative to install green roofs during construction of new buildings, and are retrofitting old ones so green roofs can be added in the near future. As a result of the regulations for new and renovated flat roofs, 15% of flat roofs in Basel (Switzerland) have been greened [10]. In Toronto (Canada), the green roof by-law mandates all newly established development with a floor area of Z2000m2 to include green roof on 20–60% of the roof area [11]. Similarly, Tokyo (Japan) accelerated the green roofing process by mandating that all new-construction buildings were to have green roofs. Private buildings larger than 1000m2 and public buildings larger than 250m2 must green 20% of the rooftop or pay an annual penalty of USD 2000 [11]. All new City-owned buildings in Portland are required to be built with a green roof that covers at least 70% of the roof [10]. There were approximately 2 acres (0.81 ha) of green roofs in Portland (USA) in 2005, with about another 2 acres committed to be built. In Hong Kong, governmental best practices for green and innovative buildings encourage construction of green roofs.

2.1 Benefits of Green Roof Technology

Green roof can provide many benefits. They can be used as storm water management tool in which they reduce storm water runoff. They also could provide amenity space for the building user, grow vegetables, fruits and flowers, and filter air pollutants and carbon dioxide (CO_2) in air, filter pollutants and heavy metals out of rainwater. Plants on the roof may reduce urban heat island effect (which is city temperature warmer than the surrounding area) by providing shading and evapotranspiration. Green roofs can make the rooms under roofs cooler because of the absorption of radiant heat from the sun by moist substrates and plants, thus significantly contribute to energy saving in buildings. Green roofs can also be used as water retention or rainwater mitigation system in which they absorb some portion of precipitation and release it into the drains after a several hours delay, softened urban streetscapes, increased oxygen output and reduced impervious surfaces. The substrates also play a significant role in reducing annoying noise from outside.

Recent years witnessed new alternative applications and findings, which boosted the growth and reach of green roofs. Hybrid Photovoltaic (PV)-green roofs is a new trend that provides benefits of green roofs as well as improve PV electrical yield. It is well known that the efficiency of PV modules depends on the temperature of the modules and the surrounding ambient air temperature, i.e. cooler the temperature better the PV performance. Compared to gravel or other traditional roofs, the evapotranspirative potential of green roofs cools the surface and ambient air which in turn improve the performance of PV cells. PV panels also counter help green roofs by shading the parts of surface and thereby reduce the sun exposure and high evaporation rates normally experienced on green roofs. In Spain, Chemisana and Lamnatou performed experiments using pilot-scale PV green roofs and found out an increased efficiency of 1.29% and 3.33% for PV-gazania and PV-sedum green roofs, respectively, compared to PV-gravel roof. Hui and Chan conducted a case study for a PV-green roof installed on an old building in Hong Kong and observed that the integrated approach generates 8.3% more electricity than the stand-alone PV cell. Considering that PV is a mature technology and widely used in several countries, green roofs can act as an important accessory to create more sustainable buildings. Nevertheless, more research is needed especially the effect of different plant species on the performance of PV cell as well as seasonal variations and structural loading. Green roofs could utilise grey water as an irrigation source domestic wastewater production, which originates from laundry, bathroom and kitchen activities. Application of grey water also solves water requirement of green roof and also enables to select more vegetation species apart from succulents. Grey water from kitchen applications usually rich in nutrients hence minimise fertilization requirement of green roof. Unfortunately, very few studies explored this possibility and the results are not encouraging. Ouldboukhitine et al applied simulated grey water to pilot scale periwinkle- and ryegrass-green roofs; and the results indicated that grey water irrigation reduced thermal resistance by 30% and produced noticeable physiological harm especially to periwinkle plants. In another study, short term testing of grey water on a green roof has shown that levels of BOD in the grey water were significantly reduced by passing it through a green roof substrate prior to its discharge. So a green roof may serve as a filter for grey water; however the authors expressed uncertainty whether the plants can effectively utilise grey water. Considering that the contents of grey water vary with several unknown factors and activities, it is not easy to generalise the outcome. Other option to reduce the impact of grey water on the plant growth is to collect and treat grey water using sand- or bio-filter before application to green roofs. Green roofs offer provision to harvest rain water, although the volume will be much reduced and possible presence of some contaminants in the runoff compared to traditional roof. Also, potential of green roof to turn the rainwater brownish may also be a concern. For this reason, it is recommended that the collected water could be used for activities outside building such as irrigation of ground plants or treat with sand filter for other non potable purposes. A typical green Roof for storing water from our perspective is illustrated in Fig.1. In an attempt to simplify the design and practicability, green roof modules are designed and developed. The modules made of high strength polymeric materials comprises of water storage element and space for other components. In most cases, the modules are preinstalled with substrate and vegetation. Thus, it can integrate well with old and new buildings. Also, it offers flexibility to replace part of green roof for roof repair and can be moved to any part of the roof or other buildings. However the cost and eventual disposal of modules should be considered.

Fig 1.Schematics of proposed green Roof for Storing of water.

2.2 Review about Green roof Technology

2.2.1 Green roofs: A critical review on the role of components, benefits, limitations and trends, K. Vijayaraghavan, 2015,740–752, issue 57

This Paper shows Gap between Literature studied in this research uptodate, liimitation of Green Roof System, unaware about the Green Roof System Objective of this paper that it is showcasing different techniques of Green Roof System and come up with optimum solution. In this Research they have used Extensive Green Roof Technique in Which they have used layer such as Vegetation Growth substrate Filter fabric Drainage element Protection layer Root barrier Insulation layer Water proofing membrane Roof deck. Green roofs could utilise grey water as an irrigation source, Rey Water Can Also Be Treated by Green Roof System, They have Shown Schematics of proposed green Home.

2.2.2 Environmental impact of Green roofing: the contribute of a green roof to the sustainable use of natural resources in a life cycle approach, Caterina Gargaria, Carlo Bibbiani, Fabio Fantozzi, Carlo Alberto Campiotti, 2016,646 – 656, issue 8

This paper aims to evaluate the variation of the overall impact in hot climates where insulation is less strategic than heat capacity. This Literature objective was to compare Different types of Green Roof Using Life Cycle Assessment For better Result and Bring into local Practice. In this research they have taken a case Study on single floor Social Housing Building in PISA. They have studied different kinds of Scenarios like Production Face, Transport Face, and End of life face. The key Findings of this paper was that if we used Green Roof System By using Recycle Tile then it is more Beneficial, Low Maintenance cost for clay roof as no Replacement of tiles are needed

2.2.3 The capacity of greening roof to reduce stormwater runoff and pollution, Qianqian Zhang, Liping Miao, Xiaoke Wang, Dandan Liu, Liang Zhu, Bing Zhou,Jichao Sun, Jingtao Liu,2015 142–150, Issue no 144

This paper shows Major Problem neglected from previous study was the Quality of Runoff from Green Roof System. There objective was to check the Quality of Storm water and reuse, also to calculate the retention of stormwater runoff. The carry out methodology of Monitoring of a school by analysing the Annual Temperature and Rainfall for 5 Years for Storm water Management. This paper examining these rainfall events, by which they found that the retention rate ranged from 35.5% to 100%, with an average retention rate of 77.2%. The retention rate varied with the rainfall intensity, with retention of nearly 94% for small rainfall events (<10.0 mm), >72% for medium rainfall events (10.0–24.9 mm), >67% for large rainfall events (25.0–49.9 mm) and nearly 39% for storm events (>50 mm).

2.2.4 Importance of Different Vegetation Used on Green Roofs in Terms of Lowering Temperature and Water Retention, Zuzana Poorova, Frantisek Vranay, Mohammed Salem AlHosni, Zuzan Vranayova, 2016, 39 – 44 issue no 162

This paper reviews that in open air there is huge temperature difference which affects the vegetation. Main problem is to plant which type of vegetation at different temperature. There objective was to plant different type of vegetation at lower temperature and Also maintain the water retention and analyse the temperature variation. There Methodology was that they have installed 2 types of sensors used before plantation and after plantation for analysing the Lower temperature and water retention. And analyse the temperature variation. after analysing the Author finds the best plant which gives the effective cooling effect.

2.2.5 Green roofs and facades: A comprehensive review, ahmet B. Besir, Erdem Cuce, 2018,915–939, issue 82.

This study States that in U.S 67% of Population will migrate to Cities so there increase in urban heat, Pollution and less Vegetation. So To Build Energy Efficient Building and reduce Urban Heat Island I New York City, To Control the Pollution In Urban Area by planting More Green Roof Vegetation. In this paper the author have compare all the Green roof techniques such as Intensive, Extensive and Semi Intensive Green Roof ,The Researcher have used both Green Roof and Green Wall which help him analyse the different type of Temperature Controlling results. After Comparing both green roof system author Defines new Technique which can be Implement in urban area using small spaces, Heat penetration from the building roofs in summer can be mitigated by about 80% via green roofs, The temperature difference between conventional and greens roofs in winter is found to be about 4 °C, whereas it is about 12 °C in summer.

III. CONCLUSION

From literature reviews it has been proven that green roof could provide numerous benefits such as storm water management, Reduce air pollution, new technology of Rain water Harvesting also increase the environmental performance However, in context of India that it is not commonly practice in India. Therefore, a progressive effort should be induced among the Indian researchers to conduct more research on green roof technology.

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