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Performance of Building Roofs on Energy Efficiency- A Review

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Abstract

The steep increase in energy demand mainly during the summer season for tropical humid climates has gained significant importance in this scarce condition of fossil fuels. This paper presents a review on different roof technologies performed with an aim to reduce the cooling loads during summer thus helping in energy conservation. Firstly it deals with green vegetated roof carried out in regions of hot humid climates. The green roof performance was explored by evaluating its effect on temperature fluctuations and heat fluxes during summer. The results showed that the presence of plants led to a decrease in temperature in the presence of green roof. The water usage and tolerance to stress at times of prolonged drought were also assessed for several types of plants suitable for extensive green roof systems. Other cooling strategies are use of reflective paints also called cool paints. The impacts of the application of reflective paint on a standard bare roof were analyzed by mainly monitoring reduction of roof surface temperature at different case study locations. Further performance of three kinds of cool paints and even cool black paints are studied for going deeper into the facts of cool paint potentials and limitations. Eventually comparative analysis between these two solutions is assessed by taking into account the several parameters that affect the final energy performances.

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1. Introduction

The intensification of the urban heat island effect has led to development of issues like global warming, greenhouse gas effect etc. The building sector being directly involved to such effects and thus adequate solutions needs to be provided at energy and environmental levels. Roofs in particular are envelope components for which

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advanced solutions can lead to significant energy savings in any building with air conditioning facilities or improve indoor thermal conditions in buildings without such facilities. Green roofs are one such building element, providing various benefits where water availability does not restrict their implementation. Green roofs are generally classified into two major categories: (a) extensive green roofs, which may be established on a very thin layer of soil and are designed to require minimal maintenance and (b) intensive green roofs, which have a soil layer of 20 cm or more and can support a large variety of plants. On the other hand cool roof strategies are progressively drawing the attention of the scientific community and the market due to their effective role in reducing building energy requirements and also mitigating urban heat island effects. A cool roof technology generally consists of a roof system with a coating characterized by high solar reflectance and high thermal emissivity. When the roof is exposed to solar radiation, these two characteristics reduce the roof's external surface temperature. The same roof with lower reflectance and thermal emittance has a much higher roof surface temperature. Consequently in the former case, solar heating load entering the indoor thermal zone is decreased. This technique for improving thermal comfort inside the buildings is of low cost, much effective, easy to implement, energy efficient and helps in mitigation of Urban Heat Island (UHI).The necessity for cool non-white coatings arose because heat absorbing darker colours, which are often preferred from aesthetic point of view, contribute to UHI. This led to the development of cool paints of darker colours, but with special pigment that still reflected solar radiation. For aesthetic and energy efficient considerations, organic and complex inorganic black pigments with good spectral reflectivity have drawn attention. Complex inorganic pigments are less expensive and generally exhibit high durability properties like weathering, temperature, chemical resistance and UV scattering.

2. Green Roof

Natural cooling techniques have been used over the centuries. The introduction of mechanical air conditioning systems although came with a huge thermal comfort but it had to deal with a huge amount of energy expenditure. The benefits of green roof natural cooling system have not only shown huge potential in reducing the building energy consumption but also had been a large contributor in mitigation of the urban heat island effect. According to A. Niachou et. al. foliage protects the buildings from solar radiation, controls the temperature and humidity of the indoor building environment [1]. The plants for their biological functions such as photosynthesis, respiration, transpiration and evaporation absorb a significant portion of solar radiation. Moreover, the solar radiation, external temperature and relative humidity are reduced as they pass through the vegetated part covering the roof, hence protecting the integrity of the underlying bare roof. Selection of plant species plays an important role. Plant species exhibiting a strong ability to store water in their leaves and drought resistant are suitable for green roof plantation.

Green roof installation is characterized by a number of layers. According to A. Spala et. al. the lowest point before the original bare roof consists of a water proofing membrane in order to protect the building from leakages [2]. Similar scenario was also shown by Dominique et. al. where there were both a water proofing membrane and drainage layer and also other protecting layers summing up to a total depth of 120mm between the green roof (GR) and the bare roof surface [3].

2.1. Effect on roof surface temperature

Green roofs help to decrease the roof surface temperature significantly. According to Dominique et. al. the extensive green roof installed in Reunion Island which was mainly characterized by tropical humid climate, showed a significant decrease in temperature of the roof surface. While the maximum temperature of the reference bituminous roof surface reached about 73.5 ±1.4 °C, the roof covering the three succulent plant species namely *Plectranthus neochilus*, *Kalanchoe thrysiflora* and *Sedum reflexum* only reached an average maximum temperature of 34.8 ±0.6 °C. Similar things were reported by A. Spala et. al. where the green roof system in Athens, Greece showed a decreased temperature after its installation as recorded in the space thermograph. Similarly A. Niachou et. al. reported that lowest temperatures of the green roof ranged from 26°C to 29°C and were measured in places dominated by thick dark green vegetation. The highest temperatures were between 36°C and 38°C and were measured in spaces covered by sparse vegetation. While the temperature of green roof cover of insulated building varied from 28.7°C to 32.5°C at different positions, the temperature of green roof cover of non-insulated building