The Energy Efficiency Analysis of the Planting Roof Building

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Abstract. The rapid development of urbanization and the construction industry in our country, and the urban environment has been severely tested. The Planting roof is a good research direction, and greatly improve the residents' living and working environment, such as urban heat island. The planting roof at home and abroad have been greatly the development and application of the modern building an ecological components of concern. This paper analyzed the planting roofing heat insulation mechanism, it help to spread planting roof technology of building energy efficiency and improve the urban ecological important role and value, the planting roofing can also contribute to the popularization and application of planting roof technology in China.

Introduction
Along with the rapid advance of urbanization, new built every year in our country urban and rural housing construction area of 2 billion m$^2$, due to the low level of building energy efficiency in China, in 2008, the building energy consumption accounts for the total energy consumption almost one-third$^{[1]}$. According to the measurement, 20 years later, the proportion will reach 40%. Building energy efficiency has become a key project of our country's energy conservation and emissions reduction work. At the same time, a lot of hard roof, changed the thermodynamic characteristics of city underlying surface, intensify the urban heat island effect, reduces the city comfort$^{[2]}$.

The planting roof can be seen as a kind of ecological construction, basic structure mainly includes: vegetation, planting soil, filter layer, water layer (storage), resistant to root puncture waterproof layer, the common waterproof layer, leveling layer, heat preservation heat insulation layer and structure layer. For different climate division of building thermal requirements, by optimizing the structure, can realize the unique characteristics of summer heat insulation and winter heat preservation and good thermal stability, is one of the important link, reduce building energy consumption is of great significance for building energy conservation. At the same time, because there is no land costs, planting roof is the most cheap way of greening, urban can adjust urban climate, relieve urban heat island effect; absorb the harmful gas in air and reduce dust in the air, purify the air; Effectively intercept rain, relieve urban waterlogging, is an important part of ecological low carbon city.$^{[3,4]}$

Summer Heat Insulation Mechanism Analysis
The planting roof insulation mechanism and there is essential difference between conventional insulation materials, conventional thermal insulation material is in the water, humidity, response to climate wet isolation to participate in climate, climate action is just a simple heat transfer process. Planting roof with moisture absorption, water absorption, evaporation, open to the wet climate features, climate effect is not a simple heat transfer process, heat transfer, but the wet phase coupling and complex process, the heat insulation performance is not only based on the temperature and solar radiation characteristics of hot climate action as a result, and is characterized by rain wet climate effect$^{[5]}$.

The Vegetation Layer Heat Insulation Effect
Summer and longest building roof by solar radiation, maximum intensity, vegetation layer of plant leaves, canopy cover on the solar radiation and reflection, and transpiration and photosynthesis can
effectively adjust the heat and moisture balance of the environment, reduce the roof net radiation, reduce indoor heat gain. The basic factors that affect plant solar radiation absorbing ability include: the sun incidence geometry structure, plant, leaf area index and the optical properties of the plant itself.

Research data show that sunny summer, when the moderate soil water, planting roofing heat dominated by solar radiation, can amount to more than 90% of the calories, proportion of convection heat gain is less than 10%. In the way of energy dissipation, transpiration and soil evaporation of evapotranspiration role played a decisive role, accounting for more than 50% of the total heat release. Second canopy net longwave radiation cooling can be accounted for about 40%; net photosynthesis in plants accounted for about 8%, only 2% of the quantity of heat through the roof to the indoor[6]. Therefore, under the condition of incident conditions must be in the sun, to improve plants and soil moisture loss rate is to optimize an effective way of planting roof insulation performance.

Planting Soil Heat Insulation Effect

Soil is a typical porous material, on the roof laying planting soil, artificial or natural precipitation in water pouring water storage in the future. When the solar radiation and outdoor hot air in hot-work unavailable, moisture in the material will gradually migrate to material layer on the surface, evaporation latent heat of vaporization. This thermal process effectively curb the solar radiation or atmospheric temperature on the roof of adverse effect, achieve the goal of evaporative cooling roof. At the same time, the soil heat storage coefficient, high thermal inertia index, improve the thermal stability of the roof, has good temperature attenuation and time delay effect[7].

The Winter Heat Preservation Mechanism Analysis

Cold region in winter, heating room temperature is relatively stable, and compared the difference between the relative to the room temperature and outdoor temperatures, outdoor air temperature fluctuation amplitude is relatively small. In addition, the winter vegetation withering, metabolic function is weak, small rainfall, planting soil natural drying. Therefore, winter planting roofing heat transfer according to the steady state heat transfer, heat preservation performance mainly depends on the roof of each layer thermal resistance, heat resistance, the greater the heat preservation performance is higher.

Natural dry winter plants, altered planting soil and the surface properties of atmospheric exposure, the lower surface of the natural wind speed, reduce the effect of surface heat transfer.

Planting soil coefficient of thermal conductivity is dry density, water (ice) and a function of temperature, amount of winter planting soil in natural drying condition, show the thermophysical properties of porous body, smaller thermal conductivity coefficient, and is advantageous to the roof insulation. After the temperature below freezing temperature, along with the formation of frozen soil structure, the thermodynamic properties of the soil has changed. This is mainly because of the liquid water in the soil into solid ice, liquid water unit mass becomes solid ice, the coefficient of thermal conductivity will increase 3 times, 1 times the volume heat capacity reducing, the coefficient of thermal conductivity of the soil dry density grows a logarithmic form or exponential curve. This is due to the density increases, the number of minerals in the unit volume of soil skeleton, porosity decreases, and the coefficient of thermal conductivity of fossil skeleton is greater than the coefficient of thermal conductivity of gas phase fillings. The coefficient of thermal conductivity of the same dry density, and the total water content increases. Therefore, cold and wet climate regions should adopt planting roof protection measures in winter.

Planting Roof Thermal Evaluation

The planting roof as a form of ecological design, due to its heat insulation performance influence factors, involves many physical properties of the materials and the determination of meteorological parameters, calculation is difficult. And with the continuous improvement of building energy saving
standards, building energy efficiency design is deeply rooted in the hearts of the people, with more attention paid to the planting roofing heat preservation and heat insulation effect. Therefore, clear planting roof thermal parameters and planting roof thermal price method, to promote engineering design and application of planting roof is crucial.

The planting roof surface temperature, indoor temperature, heat flux, the equivalent thermal resistance, cooling (insulation) thermal parameters, such as efficiency, is planting roof thermal evaluation, building energy saving research of commonly used parameters. Most studies are usually aimed at the specific climate area and specific roof construction.

Abroad, in 1984, the German scholar Kohler is pointed out that planting roof can achieve lower half of the roof peak temperature effect. In 1991, the Japanese scholar onmura measured that the planting roof with the planting roof surface daily maximum temperature, maximum difference at 30 °C, planting roofing heat can reduce 50% of the incoming. In 2001, Wong test show that the largest planting roofing roof outside surface temperature 30 °C, planting roof can reduce cooling load in summer 17%[8].

Domestic, Ding-guo Zhao tested a light planting roofing insulation performance, compared with the ordinary roofing, planting roof can effectively reduce the external surface of the roof temperature 16 °C, reduce indoor temperature 2 °C[9]. Xue-lian Bai's research shows that summer in the roof surface average temperature 1.32 °C, the inner surface temperature amplitude is about 1/7 of the common roof, planting roof cooling efficiency is 1.45, the winter roofing insulation efficiency up to 65.5%[10]. Zhu at idle tests, planting roof in the highest surface temperature and the inner surface temperature fluctuation amplitude was significantly lower than ordinary roof, at the same time, planting roof surface temperature of the highest temperature appears in time than ordinary roof delay 3 hours[11, 12]. Tang to let through the measurement and calculation analysis, it is concluded that the equivalent thermal resistance of a planting roof area Chongqing is 0.56 m². The K/W. Tang planting roof summer let tested a building heat insulation performance, it is concluded that the roof 3 °C, reduced the average surface temperature in the inner surface temperature amplitude reduced more than 80%, the roof to indoor heat flow reduced by more than 70%, the equivalent thermal resistance of 1.0 m2. The K/W[13, 14]. Qing-lin Meng on a light planting roofing heat transfer process of the simulation test and energy balance equation, it is concluded that the planting roof equivalent thermal resistance is 0.41 ~ 0.63 m². The K/W[15].

Ecological Function Analysis of Planting Roof

**Beautify the Urban Environment, Improving Urban Ecology**

The planting roof, can effectively reduce the roof temperature and temperature change, not only promoted the building energy efficiency, also has protective effect for building roof, prolong the service life of buildings. At the same time, the landscape design of planting roof, enhanced the close combination of ecological greening and building, and build the urban vertical greening, beautify the urban environment, improve the urban ecological, enhancing the ecological development of the harmony of man and nature.

**Purify Air, Reduce Noise and Light Pollution**

Vegetation photosynthesis can absorb carbon dioxide, into a lot of oxygen is released, can adsorption dust, smoke particles in the air, and such as SO2, HF, CL2, NH3, and other hazardous substances, and can make the adsorption material with raindrops come together.

The planting roof can reduce light pollution and noise: planting roof by green plants on the absorption of optical radiation reduce light pollution in the urban construction. High-rise living or working people looking down, landscaping planting roofing formed a multi-level urban greening system, has the effect of soft, rich and full of vitality, avoid dazzle of low-rise roof reflection light and the sun radiation caused by light pollution.
Save Water, Relieve Urban Waterlogging

In today's water aggravate tension, as the important freshwater resources and non-traditional water, construction of roof rainwater accumulation and utilization is an important measure to realize the construction of water-saving. Roof runoff pollution due to the lighter, the water quality is good, a little treatment or no treatment that can be used to irrigate green space, build a water landscape.

Without green roof runoff, about 80% into the underground pipe network, roof greening, can make the roof rainwater emissions reduced to 1/3 of the original, while the remaining two-thirds of storage was on the roof, effectively reduce the workload of underground drainage pipe network to alleviate urban waterlogging. Exist at the same time, the accumulation of rain on the roof, and gradually by evaporation and plant transpiration diffusion into the atmosphere, which can adjust urban climate[16].

Summary

The planting roof, it is a kind of ecological construction, can largely improve the thermodynamic characteristics of city underlying surface, has a unique mechanism of heat insulation and heat preservation. At the same time, planting roof, but also has improve urban microclimate, beautify the urban environment, purify air, reduce noise and save water, relieve urban waterlogging ecological functions.

The building energy conservation is an important energy conservation project in China, because China's geopolitical vast, the climate characteristics of various thermal partitions and different thermal design requirements. According to different thermal zones, therefore, research on different structure forms of planting roof thermal evaluation and research, is the important way to realize building energy efficiency. At the same time, the implementation of green building and ecological construction, improve the urban ecological environment is of great significance, also contribute to the accumulation and application of planting roof technology practice in our country.

References


