Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 205 (2017) 1469–1476

Procedia Engineering

www.elsevier.com/locate/procedia

10th International Symposium on Heating, Ventilation and Air Conditioning, ISHVAC2017, 19-22 October 2017, Jinan, China

Simulated study on the potential of building energy saving using the green roof

Linfang Zhang[a,b,c], Ming Jin[d], Jiying Liu[a,b,c,*], Linhua Zhang[a,b,c]

[a]*School of Thermal Engineering, Shandong Jianzhu University, Jinan 250101, China*
[b]*Key Laboratory of Renewable Energy Technologies for Buildings, Ministry of Education, Jinan 250101, China*
[c]*Shandong Key Laboratory of Renewable Energy Technologies for Buildings, Jinan 250101, China*
[d]*Shandong Huake Planning Architecture Design Co. LTD, Liaocheng 252000, China*

Abstract

With the expansion of the scale of urbanization, a large amount of energy consumption and human activities seriously affected the outdoor thermal environment and air quality. The study of green roof has been greatly taken into account by reducing the building energy consumption. This paper mainly introduces the influence of green roof on exterior surface temperature taking a residential area in Jinan as an example. This study analyzes the heat transfer model of a building, uses the PHOENICS software to establish 3D building model and simulates thermal environment under the different green conditions. The results show the differences of building surfaces temperature under the different conditions of green roof. It proves that green roof can reduce building energy consumption. It provides a theoretical basis for energy-saving design in hot-summer and cold-winter zone.

Peer-review under responsibility of the scientific committee of the 10th International Symposium on Heating, Ventilation and Air Conditioning.

Keywords: PHOENICS; building model; thermal environment; green roof

Nomenclature

ρ	the density of fluid, kg/m^3
t	time, s
k	turbulent kinetic energy of turbulence
u_i	component velocity, m/s

* Corresponding author. Tel.: +86-150-9873-6935.
E-mail address: jxl83@sdjzu.edu.cn

1877-7058
Peer-review under responsibility of the scientific committee of the 10th International Symposium on Heating, Ventilation and Air Conditioning.
10.1016/j.proeng.2017.10.369

ε	turbulent energy dissipation rate
μ_t	eddy viscosity coefficient, p_a/s
i	the sequence number of boreholes
j	the sequence number of time steps
λ	thermal conductivity, W/(m·K)
β	coefficient of thermal expansion, 1/K
c_p	specific heat capacity, J/(kg·k)
T	absolute temperature, K
x_i, x_j	position vector
q	heat flow of per unit volume, W/m^2
$t_{w,1}$	the outdoor air temperature, °C
$t_{w,2}$	indoor air temperature, °C

1. Introduction

With the rapid development of urbanization and the increasing building energy consumption, green building has become the hotspot [1]. The common ways of greening include green elevation of building, green roof, the greening of urban underlying surface, the green partition of the square and so on [2,3]. The greening of building elevation is influenced by the shape of the building largely, the ratio of window to wall and the material of building envelop can limit the rate of greening largely, moreover, the thickness of the building elevation greening is not too thick generally. Therefore, the green roof is used to improve the outdoor thermal environment in practical projects. In the field of greening research, Alexandri and Jones [4] measured the temperature of green wall and analyzed the changing regulation of temperature. The results showed that the surface temperature of the building can be reduced 8.4 °C. Honjo and Talcakura [5] calculated the area influenced by the surrounding thermal environment. The result showed when the distance of green block is 300m, the cooling effect is the best. Akbari concluded the energy consumption of green roof can reduce 30% than no green roof. Liu et al [6] used the PHOENICS to simulate the living environment in a residential area, proving the indoor temperature is reduced about 3 °C when green roof is used. Wang et al [7] explored the temperature distribution under different surface conditions and found that the lawn can reduce the surface temperature greatly. These researching results provide a new reference for the study of green roof. However, there are still few studies in the study of green roof, such as the effect on the outdoor thermal environment. Therefore, this paper simulates the temperature of the exterior surface of the building under different greening conditions, so as to choose the best greening way.

2. Research method for green roof

2.1. The establishment of numerical model

This paper uses the PHPENICS to establish the 3D model and simulates the outdoor thermal environment. The turbulence model selected the improved RNG k- ε model [11]. It eliminates the expressing forms of small-scale movement effectively in the governing equations. The model of RNG k- ε is shown as follows.

Continuity equation:

$$\frac{\partial \rho}{\partial t} + \nabla\left(\rho u_i\right) = 0 \tag{1}$$

Momentum equation: