ARCHITECTURE AND CONSTRUCTION

RESEARCH OF COOLING EFFECT OF VEGETATION LAYER OF GREEN STRUCTURES IN CONSTRUCTION

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Abstract. *Energy efficiency of construction can be improved by green structures combined with living plants. Cooling effect can decrease the refrigeration load on air conditioning or cooling systems. Nevertheless, there is no academic definition of it. We propose defining this effect as temperature drop by transpiration cooling because of evapotranspiration. The results of researches in wind tunnel provide the recommendation about boosting the air flow in refrigeration period, throttling it at spring and autumn if the grass is mowed or boosting the flow if the grass is not mowed but taking in mind problems with some opened corners.*

Keywords: *energy efficiency, green construction, green structures, cooling effect, evapotranspiration.*

One of the most important problems in construction is energy efficiency. The first opinion in design of energy efficient buildings is proper design of walling. The unique solution is green constructions combined with living plants. It can solve many tasks including the energy efficiency (because of cooling effect by evapotranspiration, reflection of solar energy and converting it to biomass in refrigerating period, additional heat insulation and rain-water utilisation), saving and augmenting the biodiversity (additional green areas with genuine and foreign plants, keeping migration ways of biota in areas with compact building), improving the living conditions (additional recreation zones, absorption of pollutants and noise, killing of hazardous microbiota by phytoncids) etc.

Cooling effect of plants brings the important contribution in energy efficiency in buildings with such constructions. But it is not well-studied. There is no straight definition of the effect. The most of researches compare air temperature in the vegetation layer and above non-greened parts. But the temperature deviation on different finishing of roofs at the same conditions and sunny weather can be four times greater than the cooling effect (up to 7 K) in [3-6].

We propose the straight definition of the cooling effect as the temperature drop due to evapotranspiration. It is dependent only on factors in and around the greened surface. Therefore the following researches are based on this definition. The effect is the temperature drop in the vegetation layer respect to the ambient air temperature. Wind influence has been simulated in wind tunnel of Heat Gas Supply and Ventilation Department of Kyiv National University of Construction and Architecture (Fig. 1).

There are two series of experimental researches. The first series has been performed on natural grass with high averaged high 40 mm and 123 mm. Because of the non-uniform growth the effect has some deviation in different points, but the average one can be found from the curve on the Fig. 2 and may be used for walling design.

The second series uses the same grass after its growth up to average high 399 mm. The bended grass forms the layer with thickness of 258 mm. The results are on the Fig. 2.

The cooling effect at grass high 40 and 123 mm and at near to zero air velocity is 0.56...0.94 K. Flow velocity 5.5 m/s cause significant rise of the effect up to 3.09…3.29 K. Increasing of the flow velocity to 8.88 m/s causes some additional rise of the cooling effect – up to 3.14…3.83 K. When the grass is grow without mowing the cooling effect is 1.32…1.33 K except one corner point – (0.88 K). Nevertheless, the air velocity causes no increase or degradation of the cooling effect up to zero, except one corner with the same effect as in the previous series.


a


b


c


d


e

Fig. 1. Experiments of cooling effect in wind tunnel:
a – the wind tunnel with the model; b – the grass with high 40 mm;
c – the grass with high 123 mm; d – the same, top view; e – the grass with high 399 mm

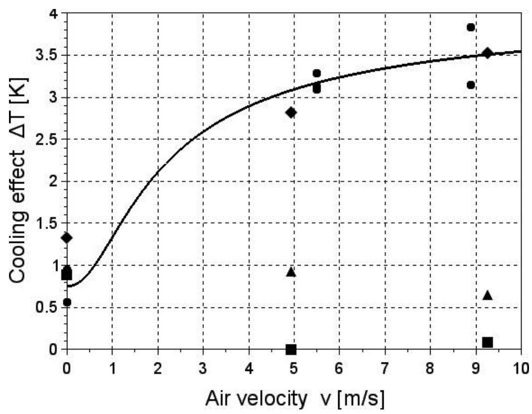

Fig. 2. Cooling effect vs air velocity: ● – grass high 40 and 123 mm, different points; ▲ – grass high 399 mm, around the center of the model; ■ – grass high 399 mm, a corner at the windward side; ♦ – grass high 399 mm, a corner at the opposite side

It is very easy to describe the results using the images on fig. 1, b-e. The small grass is blown. Therefore, the air flow can move through the vegetation layer, take away the evaporated moisture and intensify evapotranspiration. The non-mowed grass inclines under its own weight and cause very high resistance of the vegetation layer for the air flow. Thus, the air will flow around the layer causing unventilated area above its top. Air velocity inside the grass is near to zero. The vapor accumulates inside and above the vegetation layer causing decay of evapotranspiration.

The air flow can pass some corners using the short way across them without going deeply into the layer. Such corners locally act as mowed grass. These local areas cannot significantly save energy for cooling of premises below them because of the small area and randomness of their nascence.

The results show the necessity of flow control around the green structures for maximum energy efficiency. For mowed grass the flow may be boosted as much as possible for the current weather conditions and plants grow possibility only at the refrigeration period. At spring and autumn the flow may be throttled. The more efficient solution for autumn is avoiding mowing and keeping the air flow. Now we design the solutions for flow control on green roofs. We have applied for a patent for an invention.

Conclusions. Cooling effect of vegetation layer on green constructions is dependent on grass mowing and wind flow. The wind flow significantly raises the cooling effect of the short or mowed grass and decreases the cooling effect of non-mowed grass except some random corners.

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