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Evaluation the hygrothermal effects of integration the vegetation into the building envelope

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ABSTRACT

The carried scientific research regarding evaluation the hygrothermal effects of integration the vegetation into the building envelope was influenced with the differences in necessity to use air-conditioning in the houses, which are not surrounded with vegetation in horizontal structure and which have such vegetation during the summer time. The experimental testing is based on the precise measurements of the relative humidity and temperature, which were carried close to the building plaster in the place without influence of vegetation and between the wall and vegetation. Vegetation on the house, which was used for experimental purposes, is made up of the vine species with a thickness of 40 cm in the place where measurement was carried. Although the investigation takes longer, the paper aims to one month to show the summer time. The mathematical modelling of the obtained data was realized using the numerical as well as the statistical methods The paper aims especially on modelling the differences in relative humidity and temperature of the air and between the wall and vegetation. The dependence of temperature differences was expressed as a piecewise function using the method of Least squares of multiple regression as statistical method. Also the proportional energy to that which might be saved daily instead of its use for air-conditioning in the house was determined. The measurements as well as the used methods: showed sufficient accuracy.

1. Introduction

The problem of vegetation in housing estates is mostly discussed especially in tropical countries, where the cost for the use of the electricity for air conditioning is extremely high. The vegetation type is considered a natural device to optimize energy usage to manage the thermal comfort with the proper cooling elements especially for the corridor inside in the building that is situated in the tropic area [1]. The problem of increasing temperature appears also in rapidly growing agglomerations where new houses are built to the detriment of vegetation [2]. To optimize the impact of housing estates in environmental conditions requires a considerable effort. So called urban street "canyons" affect the absorption of solar radiation, evaporation rates, increase of surface temperature, storage of heat, the turbulence and wind climates of cities. All these effects can drastically alter the environment. From this point of view the vertical gardens in the form of vegetation growing in vertical structure on the facade of the houses might set a compromise between the growing need to create new living quarters while preventing the retreat of vegetation. Research focused on the effects of building density that is expressed as a percentage of built area on potential temperature including so-called canyon effect depending on building height. Mean radiant temperature was determined and expressed in relation with the building density. In most cases it was proved that higher building density causes higher temperatures. On the other hand, taller buildings with vertical vegetation cause higher cooling effects [3]. Designing the proper vertical garden is considered also an environmental art [4].

Vertical gardens as well as the green roofs are used to promote conditions to strengthen conditions for developing the sustainability in urban areas. Vegetation also might be the way to prevent the phenomenon of the urban heat islands [5]. Necessity to mitigate effects of so-called urban heat islands is important not only for the reason that air conditioning loads has a great impact to

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energy consumption but also for the global impact to the environment condition. One of the possible remedy is recommendation of light colored surfaces and designing the vegetation also in family domestic dwellings. This way surrounding helps to keep the entire neighborhood cool. Define the status of the area; the concept of "Albedo" is used. Albedo as surface's reflectivity is measured as the amount of light per unit area in lux [6]. As Albedo varies with a location's latitude the roof assumes the most critical role. Notions such as Albedo, evapotranspiration, and anthropogenic heat are put also into a relation to a surface of buildings [7].

Research that is based on comparison the thermal properties in town parks and the rest of the urban area leading to managing the effective incorporation of vegetation into the urban area [8] tries to mitigate the consequences of climate change. Of course the quality of vegetation as well as its influence on the surrounding is directly influenced with choosing the proper species of the plants [9]. For instance the role of sand fence and plants such Sea oats and Bitter panicum is highlights as coastal barriers against a storm [10]. Proper species of plants in union with optimal building geometry of arrangement the vegetation influence nocturnal cooling rates and spatial distribution of air temperature also in a high-latitude city [11]. Exploring various geometric configurations of urban green wooded sites led to development an empirical model for predicting the cooling effect [12]. Testing of growing the suitable cultivators in the experimental laboratory [13] showed methodology for making the proper decision for suitable species of plants to be grown in high-latitude cities as well as on the facades of high buildings.

Building a garden lying in overpopulation urban area can be introduced not only in the form of vertical but also as a roof garden. In this case the vegetation might have also impact on functions or stability of building therefore the important role plays collaboration of experts in the design as well as implementation the proper technologies, which might prevent the negative impacts on stability of the buildings [14]. From this perspective, the vertical garden seems like a safer solution. Application of so-called living walls, as walls covered by plants which are not growing from the ground, is considered appropriate in both tropical as well as temperate locations. Research studies [15] that were based on questionnaire led to setting the following aims: educate young people to raise environmental awareness, empower the local communities to manage providers of innovative design solutions, strengthen usage of eco-friendly materials and promoting synergy of various professions towards development of sustainable future. So designing the strategies that promote ecological behavior as well as emotional affinity towards nature [16] plays important role not only in every profession but also in education process of population.

Vegetation might have also an important role as a barrier adjacent to traffic sources [17]. Well-structured experimental data might describe processes related not only to air pollution but also to the vegetation influence on the air quality. Also information from meteorological and agricultural studies enables to model the effects of landscaping on solar gain, humidity, temperature and wind speed in urban climates [18]. Also for the reason of water consumption in the cities, it is important to model the relationships between moisture and potential vegetation [19]. A new technology for mapping using light detection and ranging (lidar) systems [20] helps to recognize bare-earth points, areas with buildings and vegetations.

The experimental measurements were performed not only in tropical counties but also in Göteborg, Sweden (57°N) where the scientists [21] used the solar and long wave environmental irradiance geometry (SOLWEIG) model to simulate 3-dimensional mean radiant temperature and radiation fluxes in complex urban settings. In the countries, which are situated in more northern areas the investigation of building properties are usually connected with the insulation material on the building envelope. Construction the

Fig. 1. View of the wall of the house, where vine species are formed in vertical structure on its facade.

model of impacts the various strategies with vegetation application on indoor comfort in the building as well as optimization the summer energy consumption with respect to comparison of insulated and non-insulated buildings [22]. The simulation expresses the boundary indoor conditions such as constant air change rate and constant indoor heat gain. As every application the insulating material is connected with possible risk process in the space between the wall and insulation it is important to investigate the hygropthermal properties on the building envelope as a complex process [23].

Growing vine species to be built in vertical structure on building facades as living vine-based architecture [24] was investigated with respect to the increasing thickness of vegetation per year. In our research we decided to test the hygrothermal properties of the vine species, which are applied on the facade of the house, with respect to their influence on the surroundings.

2. Methodology

To investigate the impact of vine species, which are applied in vertical structure on the facade of the house as a building envelope, on their ambient surrounding, two sensors were mounted to measure the air temperature as well as the relative humidity. One sensor is placed on such part of the house wall that is without the vegetation in the sensor ambient surrounding. Another sensor is placed between the wall and vegetation. The house where the experimental testing was practiced is situated 49°N, 286 m above sea level. The house positioning influences that energy demand for cooling system in the form of air-conditioning is currently occurs only during the summer time. The vegetation is applied on the south part of the house.

Fig. 1 shows part of the wall of the house that is overgrown with vegetation, which consists of vine species. The arrow on the figure indicates a sensor for measuring humidity and temperature