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Measurement of air pollutants in College of Textile – Design, Technology and Management in Belgrade

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Abstract: Monitoring of indoor air pollutants are important for human health risk assessments, since most of the individuals in developed countries spend the majority of their time in indoor environments. The aim of this study was to investigate indoor and outdoor relationship of different physical and chemical pollutants (O_3, NO_2, HCHO, PM_{10} and $PM_{2.5}$) in the College of Textile – Design, Technology and Management in Belgrade. Sampling campaigns were conducted in different classrooms from 24 to 31 March 2015. PM measurements were carried out with low volume samplers Sven/Leckel LVS3. O_3, NO_2, HCHO measurements were carried out with Radiello passive samplers and physical parameters measurement with Testo equipment. The indoor and outdoor PM_{10} mass concentrations ranged from 22.57 – 43.32 μg/m^3 and 22.58 – 39.56 μg/m^3, respectively. The daily PM_{10} levels not exceeded the guideline value of 50 μg/m^3. The daily $PM_{2.5}$ concentration was exceeded only in one classroom. Others chemical pollutants not exceeded the guideline values. On the basis of received results, cleaning and ventilation strategy program can be recommended.

Keywords: Air pollution, Indoor environments, Particulate matter, Gas pollutants.

1. Introduction

Indoor air pollution is becoming a primary concern regarding human's health worldwide, especially in developing countries. Today, indoor air pollution is a major global public health threat requiring greatly increased efforts in the areas of research and policy-making, since people spend 80-95% of their time indoors. Human exposure to air pollution is dominant by indoor air pollution, which is partly outdoor air pollution that has penetrated indoors and partly pollution from indoor sources [1]. By now, many studies showed the associations between respiratory health and Indoor Air Quality (IAQ) [2]. Hazardous substances can be emitted from buildings, construction materials and indoor equipment or due to human activities indoors. However, each indoor microenvironment has unique characteristics, determined by the local outdoor air, specific building characteristics and indoor activities [3].

The IAQ in educational buildings is expected to be a key role player in the assessment of the effects of the indoor personal exposure to air pollution as students spend at least a third of their time indoors, which is approximately seven or more hours a day [4-7]. IAQ problems in schools may be even more serious than in other categories of buildings, due to higher occupant density and insufficient outside air supply, aggravated by frequent poor construction and/or maintenance of school buildings [8].

Particulate matter (PM) is a complex mixture consisting of varying combinations of dry solid fragments, solid cores with liquid coatings and small droplets of liquid. These tiny particles vary greatly in shape, size and chemical composition, and can be made up of many different materials such as metals, soot, soil and dust. Many epidemiological studies found correlations between exposure to PM and adverse health effects [3]. There is growing evidence of high concentrations of PM in classrooms [9, 10] due to which this pollutant was measured and studied in this paper.

Formaldehyde (HCHO) is an important industrial chemical, a well-known irritant and is classified by International Agency for Research on Cancer (IARC) as carcinogenic to humans (Group 1) [11]. HCHO originates from the decomposition of many volatile organic compounds (VOC), and is also directly emitted by combustion processes such as industrial flares and motor vehicles. HCHO in the non-industrial indoor environment originates, however, only to a limited extent from outdoor air. In addition, it is released directly into indoor air from various types of sources. It is used as an additive to water-based paints and used also in

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Influence of Window U-value on Energy Performance of School Building

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Abstract: Windows have an important influence on energy demand for heating and cooling of buildings. This study presents the measured parameters (window heat flux, indoor and outdoor window surface temperature as well as indoor and outdoor air temperature) required for window U-value calculation. The measurements were carried out in-situ for double glazed window with PVC frame during 7 days. The case study was performed in the College of Textile - Design, Technology and Management - DTM in Belgrade during heating season in 2015. The aim of this paper was to determine the increase in window U-value that occurred during the period of windows utilization (10 years). Calculated window U-value was compared with manufacturer specification in order to determine the windows degradation rate. The results shown that window U-value has increased by 6.2%. Study also considered how the increase in window U-value affects the total energy performance of building. It is shown that annual energy for heating has increased by 1.2%.

Keywords: Energy performance, Heat flux, U-value.

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1. INTRODUCTION

Energy saving is becoming a priority since it helps in reducing the greenhouse gas emission, protecting the environment and decreasing the costs. In Serbia, energy consumption is on relatively high level because there has not been pay attention to energy efficiency. Buildings account for one-third of the total energy consumption [1]. The existing building stock in European countries accounts for over 40% of final energy consumption in the European Union (EU) member states, of which residential use represents 63% of total energy consumption in the building sector [2]. Therefore improvements of buildings energy performance and reduction of buildings energy consumption must be achieved. Windows have important impacts on the building energy consumption, indoor environment and energy losses. They occupy a major area of the building envelope (from 10% to 30%) and they are the weakest point as regards to energy losses.

In China, a survey of energy consumption was performed in two major cities and the results show that 60% of the total heat loss occurred through doors and windows [3]. The influence of windows on the building energy demand varies depending on the window features and features off each window components (glass, frame and spacer). To calculate the building energy performance it is necessary to know thermal transmittance (U-values) of windows and building envelope. Many studies treated influence of window orientation, size and glazing type on buildings heating and cooling demand. Inanici and Demirbilek analyzed the building aspect ratios and south window sizes in five cities of Turkey with reference to building thermal performance [4]. They concluded that maximum elongation in east-west axis 1:2 is preferable in hot climates and for cold climates optimum building aspect ratio is 1:1,2. Also found that a building that has conventional (25%) south window sizes is preferable in hot climates and in cold climates larger south window sizes are preferred up to a certain point. Gasparella *et al.* observed the impact of windows size and glazing type, orientation of the main windowed facade and internal gains on winter and summer energy [5]. Among other it was found that the winter peak loads variation with windows percent area is very little and the summer peak loads tend to duplicate or more when the windows surface doubles, except for north orientation. From

Homo sanus in domo pulchra

ASOCIAŢIA INGINERILOR DE INSTALAŢII DIN ROMÂNIA
Filiala Banat Timişoara

UNIVERSITATEA POLITEHNICA TIMIŞOARA
Departamentul de Construcţii Civile şi Instalaţii

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ŞI
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CUVÂNT ÎNAINTE

Motto:
"Amintește-ți mereu ca ai libertatea alegerii."
(Coriolan Babeți)

Fenomenul de încălzire globală a existat dintotdeauna pe Terra, fiind asociat cu fenomene cosmice de maxim solar, manifestându-se cu efecte notabile în imediata apropiere a Pământului și a apei oceanelor. În ultimul secol temperatura medie a aerului înregistrată în atmosferă, în apropierea Pământului, a crescut cu 0,74 ± 0,18°C. Intergovernmental Panel on Climate Change, prin experții săi, afirmă că „cea mai mare parte a creșterii temperaturii medii în a doua jumătate a secolului XX-lea se datorează probabil creșterii concentrației gazelor cu efect de seră de proveniență antropică". Acești specialiști apreciază că fenomenele naturale ca variațiile radiațiilor solare și vulcanismul au avut, până în anii 1950 un mic efect de încălzire, iar după aceea efectul a fost de ușoară răcire. Se apreciază că încălzirea globală are ca și cauză:

1. emisiile de dioxid de carbon de la termocentrale, vehicule;
2. metanul provenit de la ferme agrozootehnice, extracții petroliere, fermentarea depunerilor subacvatice (în special de pe fundul mărilor/oceanelor);
3. defrișările masive (copacii au un rol esențial în echilibrul natural);
4. fertilizarea chimică intensivă a culturilor agricole.

Aceste cauze au și efecte:

1. creșterea nivelului mărilor și oceanelor;
2. creșterea frecvenței și forței uraganelor și furtunilor;
3. acidificarea și desalinizarea oceanului planetar;

Ioan SARBU, Eugen BÎRSAN, Ovidiu ENACHE, UP Timişoara

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INDOOR AIR QUALITY IN EDUCATIONAL BUILDINGS - SERBIAN CASE

Tamara S. BAJC[1], Maja N. TODOROVIĆ[1], Miloš J. BANJAC[1], Žana Ž. STEVANOVIĆ[2], Danka M. KOSTADINOVIĆ[2]

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Abstract:
According to the various researches, the people spend the most of their time indoors which is directly connected to the necessity of adequate indoor air quality. The question of the indoor air quality is of a special importance in educational buildings having in mind the large number of occupants, their health and impact on learning capabilities. The paper deals with the analysis of the indoor air quality in university classroom, using the results of measurements of CO_2 concentration and statistical survey among the occupants' which was performed during the winter semester. The measurements were performed during four weeks, together with the occupants' survey. Measuring parameters were indoor air temperature, relative humidity and CO_2 concentration. The results showed that the higher concentrations of CO_2 measured in classroom caused the symptoms such as stuffiness, sleepiness, reduced concentration, headache and hard breathing. During the fourth week of measurements, when the average CO_2 concentration was about 2050 ppm in classroom, about 65% of students' voted that the indoor air quality in classroom was poor or very poor and felt some of the symptoms such as *stuffiness, sleepiness, reduced concentration and hard breathing, while 15% stated that they had all these symptoms. The analysis of occupants' evaluation regarding the poor indoor air quality impact on their concentration ability showed that subjective feelings of reduced concentration ability were the lowest when the measured CO2 concentration in classroom was also the lowest.*

Key words: *indoor air quality; air temperature, relative humidity and CO2 concentration measurements; statistical survey; ASHRAE standards; learning ability loss*

1. Introduction

According to the various researches [1], [2], [3], the people spend the most of their time indoors which is directly connected to the necessity of adequate indoor air quality (IAQ). The question of the indoor air quality is of a special importance in educational buildings having in mind the large number of occupants, their health and impact on learning abilities. The World Health Organization [3] defines a various health symptoms that are related to occupancy in poor indoor quality environment, such as: mucosal irritation, fatigue, headache, skin irritation, lower respiratory symptoms, nausea, etc. According to Seppanen et al. [4], the ventilation rate and the CO2 concentration are in the direct correlation with health and other occupants' responses. According to their research, the Sick Building Syndrome (SBS) was significantly increased in buildings when CO2 concentration was higher, given as 75% of enhancement of SBS when CO2 concentration was about 1400 ppm, while in mechanically ventilated buildings, these enhancement of SBS was 100%. Indoor environmental quality (IEQ) is mostly described with parameters such as: air temperature, relative humidity and CO2 concentration. Beside this, IEQ is affected by general and local thermal comfort parameters, lighting level, noise level and the concentration of other contaminant particles. The main contributor to the CO2 generation is high occupancy and inappropriate ventilation.

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Investigation of Green Roof Thermal Performance in the Summer Period

Biljana Vučićević[a], Danka Kostadinović[b], Nenad Stepanić[c], Marina Jovanović[d] and Valentina Turanjanin[e]

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Abstract: Green roofs, as roof structures, are one of the green construction segments that represents a modern approach in finding sustainable solutions for large cities. They allow the unused surfaces of buildings` flat roofs to be put into the function of environmental protection, improvement of internal comfort and energy savings. This paper presents values of thermal fluxes and temperatures obtained in the summer period by measurements at conventional bare roof and extensive green roof up to 12 cm thickness in a building in New Belgrade. Based on conducted measurement of thermal fluxes and temperatures, the U-values for the bare and green roofs were calculated and it`s shown that the heat transfer coefficient can be significantly reduced by adding an extensive green roof to the already existing flat bare roof of the building. It is concluded that installing a green roof, on an existing flat roof, can be considered as a very effective measure to improve the old buildings` energy performance due to reduction in the heat transfer coefficient.

Keywords: Green roof, U-value, Energy efficiency.

1. Introduction

Green roofs have received considerable attention in recent years. Increasing global population inevitably leads to an increase in urban population and to significant increase in the number of built facilities. This results in an increase in energy required to establish satisfying comfort in the cities, which leads to deterioration of the microclimatic conditions in the urban environment. In addition to the aesthetic value that green roofs can add to buildings, they have a positive effect on improving the microclimate in cities by reducing noise levels, mitigating heat islands, purifying rainwater and air within the building, and also providing additional living space for people to grow edible plants and habitat for birds and insects.

Green roofs, as part of the building's thermal envelope, also affect the thermal performance of the building and the building energy consumption for heating and cooling. In paper [1] they used simulation program to determine the effects of tree different types of rooftop garden on the annual energy consumption in five-story commercial building in Singapore. The results showed that the insulation of the rooftop garden can give saving of 0.6-14.5% in the annual energy consumption. The results also showed that the increase of soil thickness would further reduce the building energy consumption and that the moisture content of soil can affect the outcome quite substantially. In paper [2] they investigated the potential for building retrofit in the UK. Authors find that as over half of the existing UK building stock was built before any roof insulation was required, it is older buildings that will benefit most from green roofs. They reviewed the case for retrofitting existing buildings and it is found there is strong potential for green roof retrofit in the UK. In paper [3] simulation was conducted for a single-family house with conventional and green roofs in a temperate French climate. Their results showed that in the summer, the fluctuation amplitude of the roof slab temperature was found to be reduced by 30°C due to the green roof. The heat flux through the roof was also evaluated and it was found that the roof passive cooling effect in the summer was three times more efficient with the green roof and annual energy demand was reduced by 6%. They suggest that green roofs are thermally beneficial for hot, temperate and cold European climates. Study performed by [4] investigated the thermal characteristics of an extensive green roof under air-conditioned and non-air-conditioned states by using experimental data obtained on successive sunny summer days. They found that bottom of the soil layer functioned as a „cooling source“ that

The Impact of School Building Green Roof on Outdoor Air Pollution

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Abstract: In recent years air pollution has become a major concern in urban areas. The outdoor air pollutant near school buildings is important because can influence student health and performance. Over last two decades it is recognized that green roofs can have a positive influence on air quality. This paper presents a comparison of air pollutant concentrations above green roof and conventional roof of school building. During last year, lightweight extensive green roof was installed in one part of school roof. The outdoor concentrations of PM_1, $PM_{2.5}$, PM_{10}, CO, CO_2, O_3, NO_2 and TVOC were measured for two months, during summer season. The results show that green roof has highest impact on PM_1, $PM_{2.5}$ and PM_{10} concentration.

Keywords: Air pollution, Air quality, Green roof, PM.

1. Introduction

Over the last few decades air pollution problem has become world prime concern. Every year, more than 4.2 million premature mortality is a result of exposure to outdoor air pollution, while 91 % of the world's population lives in places where air quality exceeds World Health Organization (WHO) guideline limits [1]. It is estimated that the number of premature mortality caused by outdoor air pollution could double by 2050 [2]. Air pollution is mainly caused by vehicle emission and production of energy for commercial and residential use. According to the WHO, particulate matters, ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides, and lead are common outdoor air pollutants with a strong effect on human health and ecosystem. Many of these gasses directly or indirectly contribute to global warming and climate change. Exposure to air pollutants can increase a child's risk of developing asthma, can also impact a child's heart, brain and nervous system development, even before birth [3]. It is well known that outdoor air pollutants can travel long distances. Health and Environment Alliance (HEAL's) monitoring of indoor and outdoor air pollutants around 50 primary schools in six capitals of the European Union (Berlin, London, Paris, Madrid, Sofia and Warsaw) indicate that polluted air traveled from outside into the classrooms and caused poor air quality [4]. Therefore, schools and other educational facilities are vulnerable to poor air quality, which can affect student performance and health.

The positive influence of green roofs on the environment has been widely recognized. Last two decades, green roofs become popular because they can increase building energy efficiency, reduce urban heat island and storm water runoff, sequester carbon, *etc*. Carbon dioxide, needed for photosynthesis and other air pollutions enter the plant leaf through stomata. Green roof reduces solar heat gains through shading, insulation and evapotranspiration thus lower required cooling energy and emission from power plants [5]. Also, green roof trough transpiration lower albedo of urban surfaces and the ambient air temperature, which reduces ozone formation. Yang et al. [6] quantify the impact of green roofs on air pollution in Chicago. In one year, 19.8 ha of green roof removed 1675 kg of air pollution, whit O_3 accounting for 52%, NO_2 (27%), PM_{10} (14%), and SO_2 (7%). In Singapore, after installation of a green roof with crushed stones and gravel, mass concentration of $PM_{2.5}$ and PM_{10} had increased by 16% and 42% respectively. Sulfur dioxide was reduced by 37% and nitrous acid by 21% [7]. Standards and regulations are necessary, for controlling air pollution in cities. The pollutions concentration measurements can be compared with the national and international recommended values. The air pollutions guideline levels according to WHO [8] and Serbia air quality requirements [9] are presented in Table 1.

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GREEN LIVING ROOFS AS A PART OF GREEN INFRASTRUCTURE

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ABSTRACT

The deficiency of green spaces in urban areas is the consequence of rapid urbanization. Replacing nature with built, impervious surfaces leads to numerous environmental problems. Greening the building envelope by integrating living, organic systems into modern structures we could regain losses. In dense urban areas, roofs make up a large percentage of the impervious surfaces. Converting conventional roofs into green roofs, also designing new ones to be green, we could influence the percentage of green infrastructure in the cities, protect biodiversity and create a better quality of microclimate in urban settings. The aim of this review paper is to address the questions bearing in mind the role of green living roofs as a part of both nature and the built environment. We will present and analyze examples of green roof initiatives and policies from different countries based on environmental benefits that green roofs can achieve, such as increment of building thermal efficiency, dust and air pollution reduction, storm-water runoff reduction, interior noise levels reduction, urban heat island effect mitigation, and increment of the biodiversity. Implementation of green living roofs in Serbia will be considered as well as technical standards, guidelines and policy support concerning these systems.

Keywords: *green roof; environmental benefits; policy; green infrastructure;*

1. INTRODUCTION

Altering the surface cover of an area causes a change in the environment. The deficiency of green spaces in urban areas is the consequence of rapid urbanization. Nowadays, more than 50% of the human population is residing in cities and it will rise up to 70% in 2030, consequently, by the year 2030 average global air temperature rise of 2 °C is predicted. Pavement and buildings, as predominant surface covers in urban areas, absorb solar radiation and transmit heat back into the atmosphere. Impervious surfaces contribute to the urban heat island effect and urban stormwater runoff, as they prevent rainwater from filtering down through subsoil. Roofs make up a large percentage of the impervious surfaces in cities. In urban areas, roof area fraction may vary from 20% to 25% for less or more dense cities [1].

At the location where green space is limited green roofs make use of the natural processes and functions of vegetation to minimize the effects of impervious surfaces. Adapting the existing building envelope by integrating living, organic systems with inorganic and lifeless structures is an effective and sustainable solution for improving the environmental balance of cities. Converting conventional roofs into green roofs we could influence the percentage of green infrastructure in the cities, protect biodiversity, and create a better quality of

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Development of Smart Capacitive Sensor for Continuous Real Time Soil Water Content Monitoring

D. Kostadinović +, D. Dimitrijević Jovanović ++, N. Stepanić +, and E. Petrović +++

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***Abstract* - The measurement of water content is very important in agricultural production, environmental science, and several industries. There is a need for a precise, non-destructive, and inexpensive sensor for in-situ water content measurement which would have wide application possibilities. The challenge is that most commercial sensors are too expensive and the installation is labour intensive. This paper presents the design and development of a smart capacitive sensor for real-time soil water content and temperature monitoring. This capacitive sensor indirectly measures the soil water content by measuring the change in soil relative permittivity. The output of the sensor is the frequency response of the soil's capacitance and the soil temperature. Two types of sensor probe were design, first for use in extensive green roofs and the second one for use in agriculture. The developed sensor is low cost, easy to install, simple to handle, and can be used for measuring water content in different porous materials.**

***Key words*: Capacitive sensor, water content, soil, green roof**

I. INTRODUCTION

Accurate measurement of water content is important in agricultural science, environmental science, hydrological, climate research, and industrial plants such as pharmaceutical, food, etc. Soil water content is fundamental to private companies and government agencies concerned with environmental monitoring, flood control, reservoir management, soil erosion, and water quality. Non-invasive soil water content determination is an important component in precision agriculture and irrigation scheduling [1, 2]. In irrigation management, it is crucial to monitor soil water content for optimal plant growth, health, and efficient use of water resources [3]. Excessive irrigation increases the cost of production and also causes excessive fertilizer loss to runoff. An insufficient amount of water limits plants transpiration and photosynthesis and reduces yield and crop quality.

Various methods have been developed for laboratory and in site measuring of soil water content. The oldest method for water content measurement is the gravimetric method also referred to as the thermo-gravimetric method. This method consists of comparing the sample weight before and after it is oven-dried to a constant weight. It is assumed that calculated weight loss is completely due to water evaporation. This method can be inaccurate when the oven drying process evaporates volatile substances and organic matter. The gravimetric method is economical and highly accurate, but invasive, time and labor-intensive, and convenient only for laboratory applications. The indirect methods determined the soil water content based on the other thermal properties like specific heat capacity, thermal conductivity, and dielectric properties. The tensiometric method provides a direct measure of soil moisture tension (unbounded water available to the plants) and it is used in irrigation scheduling. The main disadvantage of the tensiometer is that the lower water limit for the good growth of most plants is beyond the tensiometer range. Nuclear Magnetic Resonance, Neutron Scattering, and Gamma Attenuation are nuclear-based methods. These methods are accurate and non-destructive, however, the high cost, the requirement of a licensed operator, and radiation hazard limit the applicability on the site.

The capacitive sensor, resistive sensor, frequency domain reflectometry (FDR), and time domain reflectometry (TDR), are the most commonly used sensors based on an electromagnetic technique. A disadvantage of these methods is that they require calibration for each soil, due to different physical, chemical, and biological characteristics [4]. The FDR estimates soil water content by measuring changes in the frequency of a signal as a result of soil dielectric properties [5]. The main advantage of FDR and TDR is that they are nondestructive, but compare with TDR, FDR can provide less precise results due to sensitivity to soil characteristics. The TDR is one of the most effective methods for moisture measurement in porous materials. The TDR determines the dielectric constant using an electromagnetic pulse, which is emitted into the soil through a probe, buried in the soil. From the reflected signal, the propagation velocity can be calculated. TDR is a rapid and non-destructive method, however, the high price of TDR soil moisture meters limits the applications. Another disadvantage of TDR is soil temperature and salinity sensitivity. Ground Penetrating Radar (GPR) is based on the same principle as TDR, but the measurements can be taken without direct contact between the sensor and the soil. GPR is an accurate and non-invasive method for measuring soil water content at an intermediate scale.

The most commonly used devices are capacitive sensors. These sensors indirectly measure the soil water content by measuring the change in soil dielectric permittivity. Capacitive sensors do not require direct exposure of the metal electrodes, which can reduce the corrosion of the electrodes, compared with resistive sensors. Capacitive sensor

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UTICAJ ZELENOG KROVA NA KVALITET GRADSKOG VAZDUHA

THE IMPACT OF GREEN-ROOF ON URBAN AIR QUALITY

Žana STEVANOVIĆ*, Danka KOSTADINOVIĆ, Marina JOVANOVIĆ, Vukman BAKIĆ, Nenad STEPANIĆ

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Značaj kvaliteta vazduha direktno utiče na kvalitet života ljudi i vegetacije u urbanoj sredini, a primena zelenih krovova urbanih područja poslednjih godina postaje sve važnija u borbi protiv efekta staklene bašte. Da bi se definisali odgovarajući kapaciteti uticaja na mehanizam zelenog krova i pružila metodološka objašnjenja za postavljanje zelenog krova, potrebno je pridržavati se širokog okvira propisa o kvalitetu vazduha Republike Srbije koji su integrisali evropsku Direktivu 2008-50-EC. Poboljšanje metodologije održivog postavljanja zelenog krova zasnovano je na analizi intenziteta vektora disipacije koncentracije zagađivača u kritičnoj zoni emisije zagađujućih materija i u zoni postavljanja zelenog krova. Kriterijumi za izbor podataka zasnovani su na stacionarnim uslovima emisije koncentracije eksperimentalno izmerenih emisija CO, CO_2, NO_2 gasova. Pridržavajući se standardne matrice zagađenja, eksperimentalno poređenje podataka zasnovano je na analizi intenziteta dva vektora disipacije koncentracije zagađivača. Analiza prvog vektora zagađenja odnosi se na kontrolnu tačku SEPA Novi Beograd - Mostar, koja je postavljena kao kontrolna tačka u merenju zagađujućih materija. Analiza drugog intenziteta disipacionog vektora koncentracije zagađivača je merno mesto postavljeno iznad zelenog krova na školskoj zgradi u najgušće naseljenom urbanom području. U odnosu na vrstu zagađujućih materija prema Direktivi 2008-50-EC, Annex I A, definisan je vremenski kriterijum za period kontinuiranog uzorkovanja emisija CO, CO_2, NO_2, i kvalitet podataka uzetih u analizi. U analizama su uočene razlike u emisijama dva vektora u formi ΔCO, ΔCO_2, ΔNO_2, koje su direktne posledica delovanja zelenog krova kao pasivnog filtera za ovu vrstu izvora zagađenja. Dobijeni rezultati mogu se integrisati u strategiju šire primene zelenog krova, a kao jedna od dodatnih mera u cilju smanjenja i kontrole emisija gasova staklene bašte bilo bi i definisanje zelenog pasoša u okviru dokumentacije energetskog pasoša objekta.

Ključne reči: *zeleni krov; kvalitet ambijentalnog vazduha; zagađenje vazduha; urbana područja; Direktiva i politika EU*

The importance of air quality directly affects the quality of life of people and vegetation in the urban environment, and the application of green-roofs of urban areas in recent years has become increasingly important to the fight against the greenhouse effect. In order to define adequate capacities of the impact on the green-roof mechanism and provide methodological explanations for the installation of the green-roof, it is necessary to adhere to the broad framework of air quality regulations of the Republic of Serbia that integrated the European Directive 2008-50-EC. The improvement in methodology of sustainable green-roof installation is based on the analysis of the intensity of the pollutant concentration dissipation vector in the critical zone of pollutant emission and in the green-roof installation zone of interest. The data selection criteria are based on stationary emission conditions for the concentration of experimentally measured emissions of CO, CO_2, NO_2 gases. Adhering to the standard pollution matrix, the experimental comparison of the data is based on the analysis of the intensity of the two vectors of dissipation of the pollutant concentration. The analysis of the first vector of pollution refers to the SEPA control point New Belgrade - Mostar, which was set as a control point in measuring pollutants. The analysis of the second intensity of the dissipation vector of the pollutant concentration is a measuring point placed above the green-roof on the school building in the most density populated urban area. In relation to the type of pollutants according to the directive 2008-50-EC, Annex I A, where the criterion for the condition of time stationery is defined for the

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Integration of Building Information Modeling (BIM) and Building Energy Modeling (BEM): School Building Case Study

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Abstract: Building Information Modeling (BIM) allows us to reduce the time spent on designing, include preferable information in the project, and design structures quite meticulously. Building Energy Modeling (BEM) can play a significant role in the design process and optimization of buildings, helping architects and engineers understand the energy performance of a specific building and its environmental impact. However, challenges in translating data and interoperability have caused barriers to utilizing the information from BIM to BEM. Building Information Modelling (BIM) and Building Energy Modeling (BEM) tools are progressively used for the assessment of the energy efficiency of buildings. This research paper investigated the information exchange accuracy from BIM (Autodesk Revit) to BEM tool (DesignBuilder) and determined the accuracy of DesignBuilder in estimating the heating energy consumption of the school building. An accurate 3D model of a school building was first developed in Autodesk Revit and then extracted to DesignBuilder through the gbXML format. The validation of the dynamic model is done by comparing the simulation program results and actual energy consumption. The geometric and spatial data for the case study building were translated successfully from Revit to DesignBuilder and with a high degree of accuracy. The acceptable percentage difference between simulated and actual heating energy consumption was obtained.

Keywords: Building Information Modeling (BIM), Building Energy Modeling (BEM), DesignBuilder, Revit, energy consumption.

1. Introduction

In the past decades, Building Energy Simulation (BES) programs have been used increasingly as a tool to design energy-efficient buildings. However, their widespread adoption in the AEC (Architecture, Engineering, and Construction) industry depends on their perceived reliability and the accuracy of their outputs. Another recent development in this area has been the integration of Building Information Modeling (BIM) software with building energy simulation tools. A BIM is a data-rich, object-oriented, intelligent, and parametric digital representation of the facility, from which views and data appropriate to various users' needs can be extracted and analyzed to generate information that can be used to make decisions and to improve the process of delivering the facility [1]. In more practical terms, a BIM can be defined as a digital database of a particular building that contains information about its objects. This may include its geometry (generally defined through parametric rules), performance, planning, construction, and operation. The use of BIM in public buildings has much to offer, creating facilities data, asset register, maintenance and service data, as well as service procurement data; although it can be expensive to set up, the time taken for the data entry and the implementation of the model is paid off in the subsequent stages of management.

While BIM technology is expected to facilitate the evaluation process with predefined and enriched building information, energy simulation can be applied as a tool to evaluate the energy performance of a building in operation. Building Energy Modeling (BEM) is a method of creating buildings' energy models to quantify buildings' energy performance and evaluate the environmental impacts, thus helping architects and engineers

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IMPACTS OF COURTYARD ENVELOPE DESIGN AS AN IMPORTANT ARCHITECTURAL PARAMETER FOR ENERGY SAVINGS

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ABSTRACT

When designing facilities with lower energy consumption, the most crucial parameter is the correct choice of location. The terrain configuration has a distinct influence on the organization of the urban plan and the building design. It largely determines the microclimate, especially the temperature level, direction, and wind speed. The subject of this paper is the analysis of courtyard configuration as a dominant parameter in architectural design and energy savings. The courtyard is an open area that is tied to a specific building. It is usually surrounded by walls, other buildings, or a fence. The courtyard's dimensions significantly affect the project's development and the location's microclimatic characteristics. The courtyard's proportions and configuration directly affect the building's shape, so it is essential to consider the advantages and disadvantages of different influential parameters adequately. The influence of solar radiation on heat gains is evident, while it also increases the energy demand of buildings with different shapes and proportions of yards. Through an overview of various architectural aspects, the paper provides guidelines that can be useful to designers and spatial planners to form and select adequate courtyards for the buildings.

Keywords: courtyard configuration, architectural design, energy savings, urban planning;

1. INTRODUCTION

Increased urbanization in larger cities has influenced the design of buildings with an increased need for mechanical ventilation. Along with ensuring higher air quality and thermal comfort for the tenants, there was an increasing energy consumption. Global warming and climate change consequently lead to significantly higher energy consumption to provide thermal comfort in buildings, directly affecting the environment.

As a result, there has been a general movement toward finding effective design strategies to reduce buildings' energy demands and encourage further awareness of energy-conscious design. Designing a passive solar

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Spatial uniformity of thermal conditions in public buildings

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Abstract

The objective of this study was to investigate the spatial uniformity of the thermal environment in public-purpose buildings. The study involved the school cluster of 7 thermal identities of the Fanger thermal scale. The spatial uniformity of the thermal comfort of the younger population in public places has been studied. For the study of seven identities, the experiments in literature only focused on the adult population. In this study, the objective was to identify the type of seven identities that young people experience in their environment. Through experiments, the researchers were able to measure the degree of understanding among the young population. Case studies are mainly focused on the young population to identify the kinds of seven thermal identities on the Fangers thermal scale. They are also conducted to study how these groups experience thermal environments. The first modification refers to the procedure for carrying out the questioner survey from the methodology annex of EN 7730.Specifically, the modification refers to the number of times that a questioner survey should be conducted. The concept of subjective thermal comfort is related to the development of young people's behavior. This study shows that their subjective feelings about temperature comfort are related to their bodies' natural balance. The goal of the experiment was to study spatial uniformity of thermal conditions in public buildings.

Keywords: thermal comfort, younger population, thermal behavior, temperature, clothing insulation, thermal balance, whole body

NOMENCLATURE

c - Scaling factor.

C_{res} - latent heat exchange by respiration, W/m^2.

E_c - heated exchange due to evaporation on the skin, W/m^2.

E_{res}- exchange sensitive heat by breathing, W/m^2.

f - Frequency

H - Sensory heat losses, W/m^2.

k - Weibull shape factor.

M - Heated production due to human body metabolism, W/m^2.

u_a – air velocity (m/s)

u_{ra} - relative air velocity (m/s)

u_W - wind speed (m/s)

PMV_{exp} - Predictive Mean Vote indicator experimental W/m^2

PMV_{vote} – Predictive Mean Vote indicator analytical W/m^2