CONFERENCE PROCEEDINGS

3RD INTERNATIONAL ACADEMIC CONFERENCE ON PLACES AND TECHNOLOGIES

EDITORS
EVA VANIŠTA LAZAREVIĆ
MILENA VUKMIROVIĆ
ALEKSANDRA KRSTIĆ-FURUNDŽIĆ
AND ALEKSANDRA ĐUKIĆ

CONFERENCE PROCEEDINGS

3rd INTERNATIONAL ACADEMIC CONFERENCE ON PLACES AND TECHNOLOGIES

EDITORS
EVA VANIŠTA LAZAREVIĆ
MILENA VUKMIROVIĆ
ALEKSANDRA KRSTIĆ-FURUNDŽIĆ
AND ALEKSANDRA ĐUKIĆ

PLACES AND TECHNOLOGIES 2016

CONFERENCE PROCEEDINGS OF THE 3RD INTERNATIONAL ACADEMIC CONFERENCE ON PLACES AND TECHNOLOGIES

EDITORS:

Eva VaništaLazarević, Milena Vukmirović, Aleksandra Krstić-Furundžić, Aleksandra Đukić

FOR PUBLISHER: Vladan Đokić

PUBLISHER: University of Belgrade – Faculty of Architecture

DESIGN: Stanislav Mirković

TECHNICAL SUPPORT: Jasna Marićević

PLACE AND YEAR: Belgrade 2016

ISBN: 978-86-7924-161-0

ORGANIZERS

University of Belgrade |
Faculty of Architecture

URBANLAB
PROFESSIONAL ASSOCIATION URBAN LABORATORY

MAIN CONFERENCE SUPPORT

Република Србија
МИНИСТАРСТВО ПРОСВЕТЕ,
НАУКЕ И ТЕХНОЛОШКОГ РАЗВОЈА

ИНЖЕЊЕРСКА
КОМОРА
СРБИЈЕ

tipografikplus

TONDACH
Krov za sva vremena!

CONFERENCE SUPPORT

magna coop - Pančevo
APSOLUTNO IZOLOVANO!
www.magnacoop.com office@magnacoop.com

Arhi.pro

LAFARGE

www.insomnia.rs

Beograd
www.beograd.rs

ПРИВРЕДНА
КОМОРА
СРБИЈЕ
1857

ISOCARP
Knowledge for better Cities

PLACES AND TECHNOLOGIES 2016

KEEPING UP WITH TECHNOLOGIES TO CREATE COGNITIVE CITY BY HIGHLIGHTING ITS SAFETY, SUSTAINABILITY, EFFICIENCY, IMAGEABILITY AND LIVEABILITY

CONFERENCE PROCEEDINGS OF THE 3RD INTERNATIONAL ACADEMIC CONFERENCE ON PLACES AND TECHNOLOGIES

CONFERENCE ORGANISERS

University of Belgrade – Faculty of Architecture and

Professional Association Urban Laboratory

ORGANIZING COMMITTEE

Founding members of the Organizing committee

Dr Eva Vaništa Lazarević
Conference Director, University of Belgrade, Faculty of Architecture, Belgrade, Serbia

Dr Milena Vukmirović
Conference Executive Coordinator, University of Belgrade, Faculty of Architecture and Urban Laboratory, Belgrade, Serbia

Dr Aleksandra Krstić Furundžić
University of Belgrade, Faculty of Architecture, Belgrade, Serbia

Dr Aleksandra Đukić
University of Belgrade, Faculty of Architecture, Belgrade, Serbia

Associate members of the Organising committee

Jelena Samardžić
Faculty of Information Technology Belgrade Metropolitan University, Belgrade, Serbia

TECHNICAL COMMITTEE

Dr Milena Vukmirović
Conference Executive Coordinator, University of Belgrade, Faculty of Architecture and Urban Laboratory, Belgrade, Serbia

Branislav Antonić
University of Belgrade, Faculty of Architecture, Belgrade, Serbia

SCIENTIFIC COMMITTEE

In Alphabetical order

Dr Stefan van der Spek,
Delft University of Technology, Faculty of Architecture and Built Environment, Delft, Netherlands

Dr Svetlana Stanarević,
University of Belgrade, Faculty of Security Studies, Belgrade, Serbia

Dr Milena Stavrić,
Graz University of Technology, Faculty of Architecture, Institute of Architecture and Media, Graz, Austria

Dr Aleksandra Stupar,
University of Belgrade, Faculty of Architecture, Belgrade, Serbia

Dr Eva Vaništa Lazarević,
University of Belgrade, Faculty of Architecture, Belgrade, Serbia

Dr Milena Vukmirović,
University of Belgrade, Faculty of Architecture and Urban Laboratory, Belgrade, Serbia

Dr Salih Yilmaz,
Izmir KatibCelebi University, Department of Engineering and Architecture, Izmir, Turkey

REGIONAL AND GUEST DEANS COMMITTEE

In Alphabetical order

Dr Bálint Bachmann,
University of Pécs, Pollack Mihály Faculty of Engineering and Information Technology, Pécs, Hungary

Dr Dženana Bijedić,
Vice-dean), University of Sarajevo, Faculty for Architecture, Sarajevo, Bosnia and Herzegovina

MSc Peter Gabrijelčič,
University of Ljubljana, Faculty of Architecture, Ljubljana, Slovenia

MSc Boris Koružnjak,
University of Zagreb, Faculty of Architecture, Zagreb, Croatia

Dr Florian Nepravishta,
(Department department), Polytechnic University of Tirana, Department of Architecture, Tirana, Albania

Dr Svetislav Popović,
University of Montenegro, Faculty of Architecture, Podgorica, Montenegro

Dr Milenko Stanković,
University of Banja Luka, Faculty of Architecture and Civil Engineering, Banja Luka, Republic of Srpska, Bosnia and Herzegovina

REVIEWERS

Dr Evangelina Athanassiou,
Aristotle University of Thessaloniki School of Architecture, Thessaloniki, Greece

Dr Ljiljana Blagojević,
University of Belgrade, Faculty of Architecture, Belgrade, Serbia

Dr Ružica Božović Stamenović,
University of Belgrade, Faculty of Architecture, Belgrade, Serbia and National University of Singapore, Singapore

Dr Olja Čokorilo,
University of Belgrade, Faculty of Transport and Traffic Engineering, Belgrade, Serbia

Dr Grygor Doytchinov,
Institute for Urban Design, Technical University of Graz, Austria

Dr Nataša Danilović Hristić,
Urban Planning Institute of Belgrade, Belgrade, Serbia

Dr Aleksandra Đukić,
University of Belgrade, Faculty of Architecture, Belgrade, Serbia

Dr Alenka Fikfak,
University of Ljubljana, Faculty of Architecture, Ljubljana, Slovenia

Dr Darija Gajić,
University of Banja Luka, Faculty of Architecture and Civil Engineering, Banja Luka, Republic of Srpska, Bosnia and Herzegovina

Dr Bob Giddings,
Northumbria University, Faculty of Engineering and Environment, Newcastle, United Kingdom

Dr Jelena Ivanović Šekularac,
University of Belgrade, Faculty of Architecture, Belgrade, Serbia

Dr Vlatko Korobar,
St. Cyril and Methodius University, Faculty of Architecture, Skopje, FYR Macedonia

Dr Saja Kosanović,
University of Priština, Faculty of Technical Sciences, Department of Architecture, KosovskaMitrovica, Serbia

Dr Aleksandra Krstić-Furundžić,
University of Belgrade, Faculty of Architecture, Belgrade, Serbia

Dr Višnja Kukoč,
University of Split, Faculty of Civil Engineering, Architecture and Geodesy, Split, Croatia

Dr Lucia Martincigh,
University of Roma Tre, Faculty of Architecture, Rome, Italy

Dr Juan Luis Rivas Navarro,
University of Granada, Department of Urban and Regional Planning, Granada, Spain

TABLE OF CONTENTS

ARCHITECTURAL TECHNOLOGIES I – ENERGY ISSUES

ARCHITECTURAL TECHNOLOGIES II - INNOVATIVE METHODS, SOFTWARE AND TOOLS

BUILDING STRUCTURES AND MATERIALS

CLIMATE CHANGE I – ENERGY ISSUES

BUILDING CLIMATE CHANGE II – STRATEGIES, PROTECTION AND FLOODS

SUSTAINABLE COMMUNITIES AND PARTICIPATION I – PLANNIG ISSUES

SUSTAINABLE COMMUNITIES AND PARTICIPATION II – CONCEPTS, METHODS AND COMMUNITY

IMAGE, IDENTITY AND QUALITY OF PLACE I – PLANNING ISSUES

IMAGE, IDENTITY AND QUALITY OF PLACE II – PUBLIC SPACES

IMAGE, IDENTITY AND QUALITY OF PLACE III – CONCEPT, METHODS, EDUCATION

RESILIENCE OF PLACES

ADAPTIVE REUSE

INNOVATIVE METHODS AND APPLICATIONS FOR SMART(ER) CITIES

URBAN MOBILITY, TRANSPORT AND TRAFFIC SOLUTIONS

DIGITALTOOLS-BASED PERFORMANCE EVALUATION OF THE ADAPTIVE BUILDING ENVELOP IN THE EARLY PHASE OF DESIGN

Komnen M. Žižić[1]

PhD student at the Faculty of Architecture, University of Belgrade; Assistant at State University of Novi Pazar, Vuka Karadzica bb, 36300 Novi Pazar, Serbia, e-mail: komnen.zizic@gmail.com

Aleksandra Krstić-Furundžić, PhD

Full professor, Faculty of Architecture, University of Belgrade, Bulevar kralja Aleksandra 73/II, 11000 Belgrade, Serbia, e-mail: akrstic@arh.bg.ac.rs

ABSTRACT

Amelioration of indoor comfort for the building occupants, reduction in energy consumption and carbon dioxide emissions can be achieved with application an adaptive building envelope in new and old buildings.

Nowadays, there is a lack of methods for predicting and evaluating the performance of the adaptive building envelop at component and whole building scale. Also there is a need for guidance on how to model the adaptive envelope system and how to simulate one in a suitable way.

The aim of the paper is to review the existing literature and projects on methods, techniques and strategies for the adaptive envelope performance assessment in the early phase of the design (in scope Computer-Aided Architectural Design - CAAD).

Authors are currently carrying out a classification, critical and comparative analysis of the existing simulation and modelling approaches for the adaptive façade with focus on the design of exterior shading systems. After the aforementioned analysis they have implemented workflow proposed on a case study.

The case study is discussed to show how the method proposed and based on digital tools can be applied. Numerical simulation is conducted to predict and to evaluate performance and possible energy reduction application the adaptive exterior shading system. In this case geometry and material characteristics of shade systems are investigated in relation to daylight and light performance of indoor space.

Keywords: adaptive envelope, digital tools, early phase of design, performance assessment, shading systems.

INTRODUCTION

Climate changes and growing sensitivity toward energy consumption have inspired designers with new challenges regarding the design of the environment. In the construction industry the

[1] Corresponding author

energy consumption is the highest and innovative solutions, new and different design approaches need to conserve energy. The building envelope is one of the most important parts of building that contributes to energy efficiency of building and thus low environmental impact. Design of the building envelope influences on the consumption of energy and indoor comfort quality. In this sense, adaptive envelopes can provide extreme benefits.

The building envelope performance directly influences cooling and lighting energy consumption. According to ASHRAE Fundamentals Handbook (2009) one of the most important ways to reduce overheating of interior spaces and reduce energy required for cooling is to block direct solar radiation before it reaches the glass. Olgyay states that "the most sensitive single element of the structure is the window area. Its positioning for winter and solar control during summer produces the largest effect on heat flow balance" (Olgyay, 1963). Also quality of the fenestration, frame and glass, may influence the reduction of solar heat gains. When designing adaptive building envelopes, one of the main challenges is designing the outer layer of the envelope – shades, which in extreme cases should prevent overheating the interior space, and at the same time enable sufficient penetration of daylight inside the object.

Modern scientific and technical achievements offered new possibilities for designing shading devices. The role of the adaptive envelop is to control energy flows between the interior and exterior of the building, and thus with adaptive envelope it is possible to managed the energy consumption for cooling, heating, lighting and ventilation of indoor space. For the façade, design is believed to be the crucial in achieving zero energy buildings or an overall reduction in energy consumption. Also, it is necessary that the architectural, structural and building physics requirements are integrated in the design of the adaptive facade system. Shades can be designed as movable objects that move according to the Sun. Other possibility is designing shades that are immovable and whose shape and position are optimized based on the geometry of the Sun on the annual level. Both approaches offer new dynamism of forms and shapes.

The study offers some important insights on relation between the performance evaluation, the early phase of design, and the adaptive building envelope. But the paper does not engage with practical constraints. The overall structure of the paper takes the form of three sections. The first one begins by laying out the importance of the early phase of design. The second section considers the adaptive building envelope and the third section discusses the performance evaluation based on digital tools including presentation of the case studies. Throughout this paper, the term digital tools will refer to small or big programs, plug-ins, add-ons or scripts which are based on computational logic and on algorithmic procedures.

THE EARLY PHASE OF DESIGN

It is often practice in designing process to consider the building physics and check the energy performance of project when the designing process is nearly the end and project solution is already defined. In many cases, completed project does not fulfill the requirements of building physics and then it is necessary to create many modifications or corrections of the project or in many cases start all over again. The alternative is to consider the building physics and to assess the energy performance from the very beginning of the designing process and so searching for successful solution. But mostly, tools and calculating methodologies are designed to be used on developed solutions. Working procedures, in relation to early designing stage and using of digital tools, are undefined and in phase of developing. Petersen Steffen et al. (2010) in the article *Method and simulation program informed decisions in the early stages of building design* state that today is needed to develop practical design technique to reach high energy performance building, especially in early phase of design, because advice design tools are not well developed and limited to evaluate energy performance of building by designer. Some reasons are: the need to find, develop, check and then compare the many possible solutions in a short time period, but to do so requires accurate and valid information so that architects can make the right decisions.

Lack of working procedure for designing dynamic shading system, especially when choosing and using digital tools is noted.

THE ADAPTIVE BUILDING ENVELOPE

During the past half century a number of research papers, books and projects have been published suggesting different ideas about the building ability to adopt changeable circumstances. In the book *Soft Architecture Machines,* Negroponte Nicolaus (1975) states that buildings need to adapt to environmental conditions and human demands and needs. Some authors have mainly been interested in the adaptive architecture concerning the interactivity regarding to environment's and users' changes, like John Frazer (Frazer, 1995), Mike Weinstock (Hensel et al., 2013), Cedric Price (Mathews, 2006) and Gordon Pask (Pickering, 2010). Michaela Turrin et al. (2011) in *Parametric modeling and optimization for adaptive architecture* have noted: "… adaptive architecture is based on the interdependence between the varying needs/demands and the capacity of a building to satisfy them in a changing environment". Jan Knippers and Speck Thomas (2012) in the article "*Design and construction principles in nature and architecture*" use the term *convertible structure* to define an adaptive building envelope that is able to change its geometry. This paper presents the adaptive behavior as process in which the building envelope transforms from one form to another one and has ability to self-adjust to changeable user's needs and demands and to changeable situations in environment.

Designing the shading systems

To date, several studies have examined the association between workflow approaches and the design of louvers. In the book *Sun, Wind & Light: Architectural Design Strategies,* Mark DeKay et al. (2014) provide us with the strategies for design external shading devices. Olgyay Victor (1963) presents approach to analytical design of shading systems in the book *Design with climate: bioclimatic approach to architectural regionalism*. Mazria Edward in book *The Passive Solar Energy Book* (1979) further developed aforementioned Olgyay's graphic method for shading systems design. From then until now, the approach of Mazria and Olgyay to design and devise louvers has been improved and advanced.

In Methods and approaches in designing shading systems ware the same for a long period but in the past two decades the breakthrough has been made in this area. In this period many authors developed different methods based on computation technologies. Among the many methods for designing louvers, a method called Eco thermal method, Eco Degree Day method or Shaderade method should be noted. Sargent et al. (2011) presented the use of this method in designing shading system and noted that it enabled achievement of the best results and the greatest energy savings. This method is incorporated in DIVA, and used in case study analysis.

THE PERFORMANCE EVALUATION

The designers/architects need the knowledge about techniques and strategies for the use of digital tools to assess specific performances of adaptive envelope in the early phase of design. In this case the strategies means a set of decisions regarding the way in which architects/designers can perform the process of designing adaptive building envelopes on the basis of digital tools. This particularly applies to the collection of relevant information and processing and inclusion of this information in the conceptual design in accordance with the requirements of the design. Proposed design workflow is divided in a several steps: defining working criteria; making parametrical models; simulation and analyzing; measuring and assessing performance; preparing data for manufacturing and fabrication; also process optimization can be considered; physical simulation and testing prototypes.

Digital-tools

In the past several years, many digital tools were developed and many researches ware conducted. In this paper, the digital tools that architects use to design, check and test the exterior shading system of the building envelope are presented. End-user development (EUD) is based on visual programing tools such as RhinoScript for Rhino, MEL for Maya, DesignScript for Revit etc. With these tools the end user automates and customizes sub tasks during design process. A visual interface of this tools help architects/designers to end-user development (EUD) without high level programming knowledge. The main aim of this script is to give opportunities for repetition and automation during design process. Tools include knowledge of building physics which is the basis for designing that should contribute to preservation of the environment and user's wellbeing. Grasshopper (visual programming plug-in for RhinoCeroes) within RhinoCeros platform is used in design process to parametrically make geometry of shading system, envelope and building. These tools aid the architect/designer to use the least necessary geometry to cover the opening on the building envelope during a certain period of the day. In other words, using these tools designers can determine the geometry of the shades in relation to geometry of the movement of the Sun for a specific location.

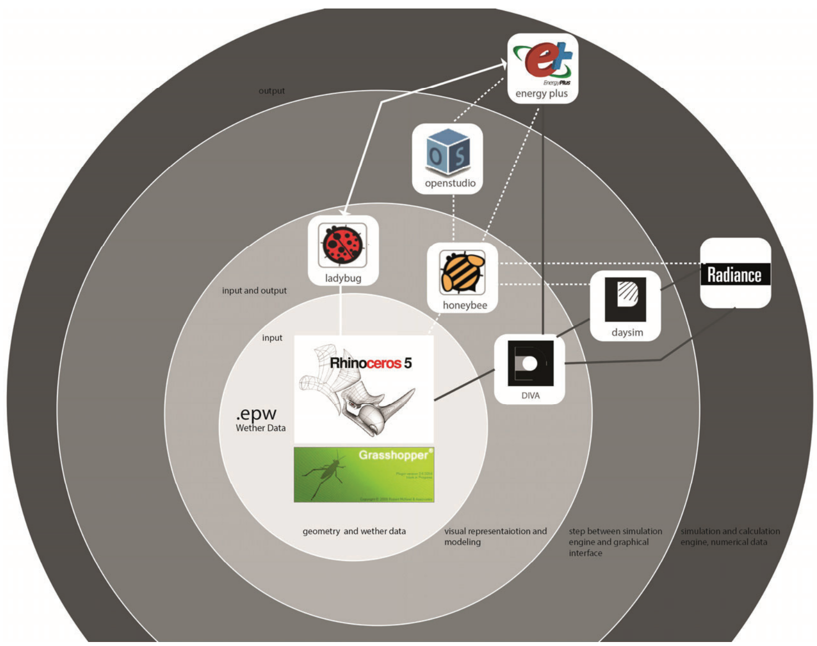

Figure 1: Diagram of relation between digital tools within Rhinoceros platform that are used in design process of an adaptive envelope.

In the past few years, digital tools for Rhinoceros platform have been developed to simulate energy flows in an architectural design at different levels – from component level to urban contexts. This tools (Honybee, Ladybug, DIVA, geco, Archisim) link the working environment Rhino with EnergyPlus when calculating thermal properties, and Daysim, as part of Radiance, when calculating daylight in interior spaces analysis (Figure 2). For example, the tool DIVA is used for performance design. Using this tool it is possible to check the lighting and thermal properties of the model, within Rhinoceros platform.

The case study office building in New Belgrade, Serbia

The following section will discuss in detail above mentioned workflow for the early phase of design (Figure 2). Here is presented basic information about the design of the exterior shading system for the office building located in New Belgrade, Serbia. Here is offered the method for assessing daylight performance in the effort to reduce energy consumption and to achieve visual comfort. Firstly, weather data for Belgrade city are considered. Then a typical office story has been selected to be the model for testing. The parametrically made model of the office unit and the shading systems is created. Subsequently is made input for simulation to test design solutions of shading systems.

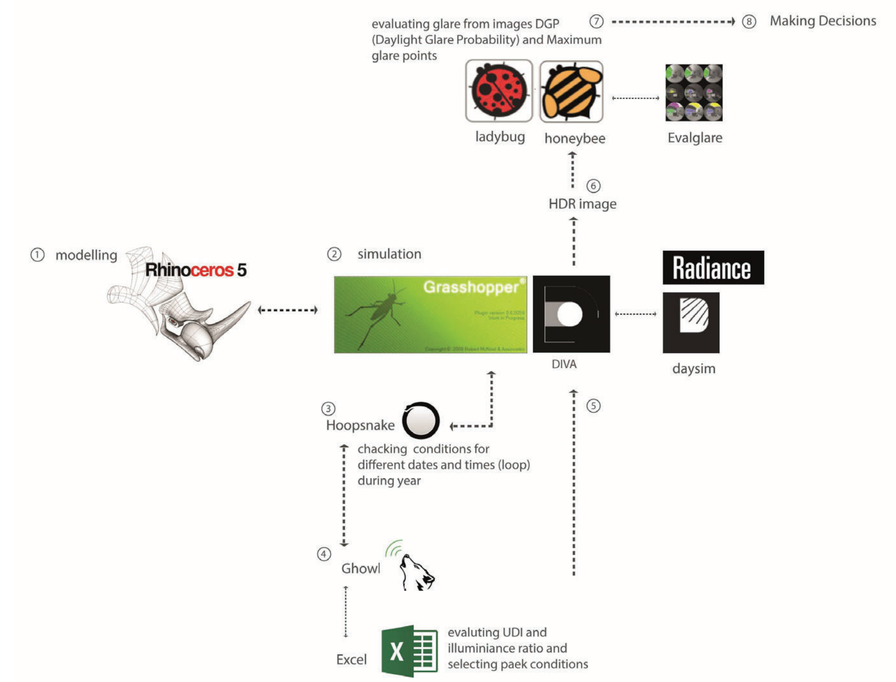

Figure 2: Diagram workflow of the performance evaluation for the visual comfort (1 Input parameters, 2 calculation/simulation, 3 assessment and evaluation, 4 making decisions, 5 implementation/redesigning).

The office building is located in New Belgrade at latitude 44° 48'N and longitude 20° 27'E. The orientation of the typical office unit is the south. The building has the facade without the exterior shading system; the glass transparency and the interior blinds are used to control thermal and daylight performance in the building. This case study based on the parametric geometry, is used to investigate the geometrical characteristics of exterior shading systems and their influence on thermal and cooling loads, and on the daylight performance in the interior office space.

The Figure 3 shows parametric modeling that was used to define geometry of typical story and exterior shades. Several steps were conducted: division of office building on stories and choosing of a typical one. At the beginning, the selected story was separated from the entire building, and then measuring and testing were performed using simulations. Dimensions, such as story height, front width, and walls, openings and floors ratio, were parametrically entered so that they could be changed by changing the values of these parameters. Then the defined geometry was divided into components, for example: floor, celling, walls, roof, doors and windows, so that the specified geometry could be recognized as a totality in digital tools EnergyPlus and Radiance.

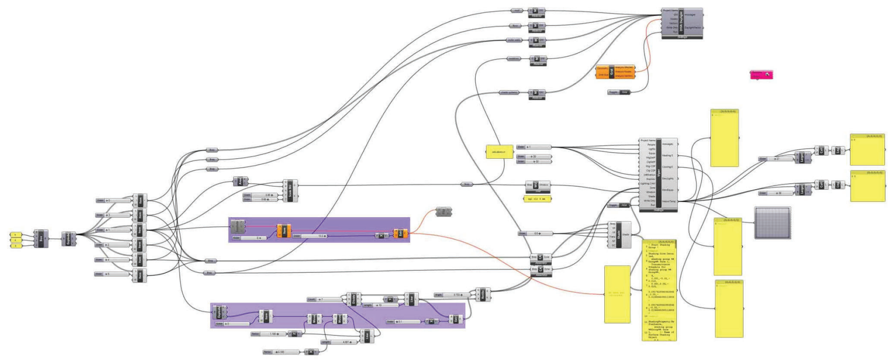

Figure 3: Parametrically defined model: geometry of typical office unit with exterior shades (EUD-Grasshopper)

Simulation and verification of daylight performance is done using the next metrics: annual heating, annual cooling, artificial lighting, DA_{500lux} and UDI $_{00\text{ - }0000lux}$. Standards for daylighting were considered according to *IESNA Lighting Handbook* (Quality of the Visual Environment) and the used value of minimum luminance for working space in office building was 500lx. This value is expressed as a percentage and represents the time during the year when workspace is being used and minimum illuminance requirements are met, using only day/natural light. At beginning of the simulation process, the input values are entered for the location in Belgrade. Then, a characteristic material was added to each layer which contains geometry. This is necessary in order for Radiance to be able to identify which components have which reflection, absorption or transparency, so that the simulation of lights arrangement could be performed. Then positions of nods - sensors were defined, setting the plane and points, on which the illuminance was measured.

CONCLUSIONS

This paper is presenting traditional and contemporary methods of designing shading systems. This paper explains the workflow that could help designers/engineers to make effective and informed decisions in the early phase of the shading system design. This is presented as a simplified method for a predicting visual and thermal performance of interior space considering a design of a shading system for office building in the early phase of design. Shading system is defined parametrically and then optimized to reduce energy for lighting and to achieve visual comfort of users. We believe our work could be a starting point for future investigation. One area of future work will be to represent: relationships between models and tools explicitly, in the detailed phase of design. This work should benefit greatly by using data on Building Information Modelling (BIM) and Building Energy Modelling (BEM).

ACKNOWLEDGEMENTS

This work has resulted from research within the scientific project: “Spatial, Environmental, Energy and Social Aspects of Developing Settlements and Climate Change – Mutual Impacts” (TP36035), financed within the program Technological Development by the Ministry of Education and Science of the Republic of Serbia, and COST Action TU1403 “Adaptive Facades Network”. The authors would like to gratefully acknowledge COST Action TU1403 “Adaptive Facades Network” for providing excellent research networking.

REFERENCES

American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE). 2009. "Fenestration." In *ASHRAE Handbook Fundamentals,* by ASHRAE, 15.1-15.21. Atlanta: ASHRAE.

Dekay, Mark and Brown G. Z. 2014. *Sun, Wind & Light: Architectural Design Strategies.* 3rd edition. New York: John Wiley and Sons.

Frazer, John. 1995. *An Evolutionary Architecture*. London: Architectural Association.

Grijalva, Karla. 2012. "Associative Design for Building Envelopes' Sun Control and Shading Devices". MSc, Arizona: Arzona State University.

Hensel, Ulrich Michael, Achim Menges and Michael Weinstock. 2013. *Emergent Technologies and Design: Towards a Biological Paradigm for Architecture.* London: Taylor & Francis.

Illuminating Engineering Society of North America, (IESNA). 2000. Quality of the Visual Environment. In *IESNA Lighting Handbook*, edited by Mark Stanley Rea. 9 edition. New York: Illuminating Engineering.

Knippers, Jan and Thomas Speck. 2012. "Design and Construction Principles in Nature and Architecture." *Bioinspiration & Biomimetics* 7 (1): 015002.

Mathews, Stanley. 2006. "The Fun Palace as Virtual Architecture: Cedric Price and the Practices of Indeterminacy. " *Journal of Architectural Education* 59 (3): 39–48.

Mazria, Edward. 1979. *The Passive Solar Energy Book*. Emmaus: Rodale Press.

Negroponte, Nicholas. 1975. *Soft Architecture Machines*. Cambridge, Massachusetts and London: The MIT Press.

Olgyay, Victor. 1963. *Design with climate: bioclimatic approach to architectural regionalism*. London: Oxford University Press.

Petersen Steffen and Svend Svendsen.2010. "Method and simulation program informed decisions in the early stages of building design." *Energy and Buildings* 42: 1113-1119.

Pickering, Andrew. 2010. "Gordon Pask: From Chemical Computers to Adaptive Architecture." In *The Cybernetic Brain: Sketches of Another Future*, 309–78. Chicago: University of Chicago Press.

Rutten, David. 2015. *Grasshopper: Generative Modeling for Rhino*. Version 0.9.0020 [Computer Software]. Robert McNeel and Associates. Retrieved from www.grasshopper3d.com

Sargent, A. John, Jeffrey Niemasz and Christoph F. Reinhart. 2011. Shaderade: Combining Rhinoceros And Energyplus For The Design Of Static Exterior Shading Devices. *Building Simulation.* Sydney

Turrin, Michela, Peter VonBuelow, Axel Kilian and Rudi Stouffs. 2011. "Parametric Modeling and Optimization for Adaptive Architecture." TU Delft Architecture: Building Technology.