SHORT TERM SCIENTIFIC MISSION (STSM) – SCIENTIFIC REPORT

The STSM applicant submits this report for approval to the STSM coordinator

Action number: TU 1403 Adaptive Facades Network
STSM title: Analysis and comparison of adaptive and conventional façade types: Increasing application of adaptive facades in Macedonia
STSM start and end date: 22/03/2018 to 15/04/2018
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PURPOSE OF THE STSM

The advent of the adaptive facades and their technological advancement offers possibilities to improve buildings performance and support the drive towards implementing the sustainability goals in buildings. In order to increase the application and utilization of Adaptive façades in moderate continental climates such as Macedonia, it is necessary to understand their possibilities, technical and technological aspects and performance capacities for such a context. In largest part they are not widely used in practice due to economic and technological issues but also due to lack of knowledge for their design and therefore this research focuses in these subjects.

The main STSM's purpose was to explore the possibilities of the adaptive facades, the means of software simulation, to compare different types of facades and to contribute towards increase of the application of adaptive facades in buildings' design. One of the main aims of the research was to create new knowledge, show performance of several types of conventional and adaptive facades, with regard to energy performance, i.e. heating and cooling demands as well as daylight performance. Hence, the STSM research contributes to the goals of the COST TU 1403 Adaptive Facades Network especially to the aims and objective of the WG2 and WG3.

Considering that the assessment of adaptive facades by software simulation of all of the facades` aspects is a complex process, it disables the appropriate utilization of adaptive facades during the design process. Therefore, within this STSM the possibilities for adaptive façade assessment are examined, by using conventional software simulation tools which are most widely used. Additionally, by reviewing the adaptive façade types and software tools, the STSM contributes to higher acceptance of already standardized computer-aided calculation methods; stress the need of developing new generation of software, i.e. standards with accompanying software and/or algorithms. Also the work contributes in identifying gaps in the utilization of adaptive facades in the construction practice and finding opportunities to overcome that state.

This STSM also contributed on enhancing the knowledge on novel concepts and technologies and/or the new combinations of existing technologies for adaptive envelope, and contributed with new findings shared on presentation slides and contributing to the final Training School of the TU1403 Action to be held in

September in Belgrade.

Also, one of the purposes of the STSM was to establish a collaboration with the Host institution, Faculty of Architecture at the University of Belgrade. Also, during the STSM I was involved in studio work with students on their 1st year of master studies in architecture where they were trained to do façade modelling, introductory presentations in energy modelling and conducting an energy performance simulation of facades they designed for an office building in the studio work.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSM

For achieving the objectives of the STSM several types of research work has been conducted. At first an extensive review of the state-of the art literature has been undertaken on adaptive facades, typologies, their characteristic, types of control of the adaptivity and materials used in adaptive facades . A review of software simulation tools has been done in order to choose a most effective tools to conduct testing and analysis of energy performance of façades in a given context. From the findings it was concluded that EnergyPlus tool is most suitable for conducting energy performance analysis and daylight analysis. Therefore, in the first days of the STSM I was dedicated on learning EnergyPlus modelling software in an OpenStudio environment, having provided help from the host institution.

In order to test different types of façades and compare them a case study of an existing office building has been developed as a software model. The existing office building has been taken as a reference model for further comparison. Further, market analysis was made on types of façades, their availability and techno-economic aspects and it was decided to use following materials for façade glazing: double glazing (reference model), double glazing electrochromic and triple glazing with lowE glass panes. The concept of addictiveness of the façade has been implemented in the software models by using electrochromic glass, external screens and switchable glazing. In order to model the office in the simulation software and to have precise regime of occupancy of the space, internal loads and lights use, several interviews with office users have been conducted regarding the work schedule, office space use and working hours.

Further, from the developed models a comparison was made between conventional facades and an appropriate types of an adaptive façade, selected for a given context, in terms of their energy performance as a most common aspect that is being analysed by the architects in the early design phase. This will provide a solid base for future analysis of certain types of facades during the early design phase and which will stimulate their application in the building's design.

Within the STSM a pilot-survey was prepared and distributed among key stakeholders in building design process, such as: architects, investors, construction companies and users, in order to examine their familiarity with adaptive facades concept, to identify the restraints and limitations that disable a broader scope of their implementation in the design process of buildings. The survey forms were collected and allayed during the STSM period and the results gave an important feedback and insight on the possibilities to stimulate a wider application of adaptive facades.

Also, during the STSM I was involved in architectural design studio in the 1st year of Master, led by the host of this STSM, prof. Aleksandra Krstic-Furundzic at the Faculty of Architecture in Belgrade. The purpose of my involvement, as agreed with the host, was to train the master students on performing energy analysis in EnergyPlus and implement those skills and knowledge in their studio work. Their task for this semester was to design a sustainable office building of up to 7000m2 and to design a façade having in mind energy performance and daylight needs. After several contact hours with the students they have modelled several design solutions of facades, some of which static and some adaptive, with movable shadings. The design solutions were applied to an office module of 16/6/3m in order to provide a basis for their comparison.

By the end of the STSM I was preparing PowerPoint slides for the training school in Belgrade in September 2018 and started writing a research paper with dissemination of the findings to be published in a journal/conference paper.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

The STSM research provided several significant findings on the modelling and simulation aspects, the performance of the adaptive facades as well as their applicability in the context of Macedonia. At first it was concluded that the most suitable simulation software is EnergyPlus having the broadest possibilities for simulating extrinsic control types of adaptive facades, and use materials such as: electrochromic, thermochromic (with certain limitations), PCMs, switchable glazing etc. Also it gives possibilities to simulate movable shadings such as: interior or exterior screens, shadings and similar.

In the research 18 models of an office space were made, both with a static and an adaptive façade properties. The models had variable glazing size on the south side wall, such as: 46%, 66% and 100% window-to-wall ration. The software simulation provided significant insight onto their performance, after which several conclusions were made.

The triple glazing with lowE and louvers had lowest energy demand compared with the other models, followed by the model with triple glazing lowE and exterior movable screen. The double glazed electrochromic glazing had slightly more energy consumption annually. Considering the lower price for the triple glazing altogether with the louvers/exterior screen it can be concluded they are a more economical design solution in terms of return of the investment compared with the double glazed electrochromic glass. The triple glazing system without movable shading had highest cooling demand due to the low emission foil that tends to keep the internal generated heat gains from the lighting, equipment, people as well as solar gains inside the office, not letting the heat to dissipate to the outside. However the double and triple glazing with lowE foil have significantly lower energy demand for heating the space when compared with the baseline model with double glazing. By analysing the cooling it could be concluded that in models with glazing with lowE foil, by increasing the window-to-wall ratio (WWR), the cooling demand significantly rises. As for the electricity for interior lighting there is a slight decrease when increasing the WWR ratio. Also, for all of the models a daylight analysis was made, except for the model with switchable glazing due to software limitations, which shows that the utilization of movable shading, not only decreases the cooling energy demand and electricity for interior lights it also regulates to a certain extent the illuminance of the office space.

From the conducted survey among stakeholders such as: architects, investors, users and construction companies, several findings could be pointed out. The architects, investors and construction companies are more familiarized with the concept of adaptive facades, opposite the users. Therefore, in order to stimulate increased implementation of adaptive facades in the design of buildings it is necessary to inform and educate the users on the benefits of adaptive facades in terms of energy savings, improved comfort etc. Further, the most common types of adaptive elements that have been used are external movable screens, followed by internal screens and movable louvers. Switchable glazing has not been used in Macedonia due to its high price. From the survey key design factors have been determined that influence the implementation of adaptive façades in buildings. Among the surveyed stakeholders there is high compliance for the design aspects with high importance, such as: costs, maintenance, durability, interior comfort and energy savings.

FUTURE COLLABORATIONS (if applicable)

The STSM provided me the necessary infrastructure for conducting the proposed research, i.e. the access to previous studies and enabled knowledge transfer, which is of importance for my growth as researcher and for the outcome of this STSM. I was provided with the tools and know-how for achieving the aims of the STSM such as: development of simulation models and comparison of energy performance of an adaptive and traditional façade. I was introduced with the EnergyPlus simulation software in the OpenStudio platform, and gained relevant skills that are necessary to model, analyse and compare conventional and adaptive facades.

Also, one of the purposes of the STSM was to establish a collaboration with the Host institution, Faculty of Architecture at the University of Belgrade. During the STSM I was involved in studio work with students on their 1st year of master studies in architecture where they were trained to do façade modelling, introductory presentations in energy modelling and conducting an energy performance simulation of facades they designed for an office building in the studio work. Following the fruitful collaboration with prof. d-r Aleksandra Krstic-Furundzic, a similar collaboration could be established in the future.

Additionally, the STSM is of benefit for the STSM researcher and the Host institution as it enabled establishing network for future collaboration in terms of joint application for future research projects.