SHORT TERM SCIENTIFIC MISSION (STSM) – SCIENTIFIC REPORT

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

Action number: TU 1403 (Adaptive Façade Network)

STSM title: Improving of experimental methods for performance evaluation of Double Skin Facades

STSM start and end date: 17/09/2017 to 24/09/2017

Grantee name: Matthias Friedrich

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| **PURPOSE OF THE STSM:** |
| **Background**  According to the energy efficiency requirements for buildings, naturally ventilated double facades can provide a considerable reduction of energy needed for building operation. However, poorly planned double facades may lead to significant increase of energy use as user discomfort.  Aalborg University (host) and HafenCity University (visitor) are using different methods for optimization and prediction of the thermal behavior of double facades. These methods are described below.  The proposed STSM is focused on experimental procedures to determine the air exchange rate in double skin facades and in the related rooms. These will be, based on the research emphasizes of the host and the visitor, different methods for tracergas measurements as well as direct determination of a velocity profile by using hot sphere anemometers.  **Aims and objectives**  The scientific objectives of the STSM visit are the comparison and discussion of different methods to determine the air exchange rate.   * The HafenCity University uses SF6 tracergas for determination of the air exchange rate in occupied rooms. The advantages of SF6 are the non-existence in the air mixture, it is not breathed out by humans and it is fully non-toxic. These benefits make SF6 a good tracergas for occupied rooms. As SF6 is a strong greenhouse-gas, it should be used in low dosages. * Aalborg University uses CO2 tracergas for determination of the air exchange rate in cavities of a double skin façade. In comparison with SF6 it is a weak greenhouse-gas and therefore it can be used in higher dosages. However, CO2 can´t be used for measurements in occupied rooms. * Aalborg University used 46 hot-sphere anemometers in a double façade cavity for recording of an air velocity profile. With an exactly measured profile, the air flow rate can be calculated. Due to the huge number of sensors installed in the cavity, the airflow might be influenced by the obstacles. |

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| **DESCRIPTION OF WORK CARRIED OUT DURING THE STSM:** |
| It was intended to split this STSM in two parts: Firstly, a comprehensive study about the state of the art in air flow measurements focused on applications in double skin facades is done. The different tracer gas methods applied at HCU and AAU were discussed. ‘The Cube', an outdoor test facility located at the main campus of Aalborg University, was visited.  Building on that, a measurement plan for the comparison of experimental methods of measurements of the airflow in naturally ventilated double skin facades was developed. In front of the Civil Engineering department laboratory a second skin of glass towards the outside shall be installed. This double skin façade is exposed to unobstructed wind conditions and facing south. This new facility shall be used to investigate and compare different methods for measuring the naturally induced air mass flow.  Due to delays in erecting the double skin façade and because of limitations in the STSM time frame, the second part had to be cancelled. It is planned to continue the project with own financing. |

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| **DESCRIPTION OF THE MAIN RESULTS OBTAINED:** |
| Knowledge of naturally induced airflow rate in a double-skin façade (DSF) cavity is crucial for its performance evaluation and design optimization. The prospects of exploring this field are, however, limited due to the lack of experimental methods for the measurement of naturally induced airflow. Hitchin and Wilson [1] explained three methods to investigate the natural ventilation in buildings: tracer gas measurements, determining velocity profiles and applying the equation of continuity as well as the use of models with measured pressure differences across the opening. The air change rate of naturally induced air flow is significantly different in occupied spaces and façade cavities. Moreover, the cavity depth strongly influences the air change rate in double facades. Therefore, the transferability to double-skin façades of existing methods for determining air flow rates in the building sector is tested within this research. Furthermore, number of existing experimental methods for estimation of airflow rate in the built environment is limited to following: Tracer gas measurements, velocity profile method, applying the orifice equation, ultrasound measurement of velocity and Particle Image Velocimetry (PIV) applications.  DSF wide cavities exposed to the wind are characterized by possibly highly transient and turbulent flow regimes. Due to these fluctuations, the air velocity may vary between 0 and 5 m/s [2, 3]. Equipment for velocity measurement has to be able to perform for these velocity magnitudes. Moreover, ambient temperatures, glazing temperatures as well as the measurement equipment installed in the cavity are significantly affected by solar radiation [3]. These facts make above methods difficult to apply for double-skin façades.  Until now, the experimental methods developed specifically for natural ventilation in buildings were applied for measurements on double-skin facades. Low accuracy combined with high uncertainty and complexity of these methods is acknowledged within the field of building ventilation. Nevertheless, it is important to examine whether these methods are applicable for use in DSFs. It has to be investigated, what uncertainties can be expected within the application and what accuracy can be reached. Ultimately, a guideline to improved measurement accuracy of naturally incused airflow in double-skin façades is crucial to be developed.  [1] E. R. Hitchin und C. B. Wilson, „A Review of Experimental Techniques for the Investigation of Natural Ventilation in Buildings,“ Building Science Vol. 2, pp. 59-82, 1967.  [2] O. Kalyanova, R. L. Jensen und P. Heiselberg, „Measurement of air flow rate in a naturally ventilaed double skin facade,“ Aalborg Univerity: Department of Civil Engineering, Aalborg.  [3] R. L. Jensen, O. Kalyanova und C. E. Hyldgaard, „On the use of hot-sphere anemometers in a highly transient flow in a double-skin facade,“ in Proceedings of Roomvent 2007: Helsinki 13-15 June 2007 FINVAC ry, Aalborg. |

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| **FUTURE COLLABORATIONS (if applicable)** |
| In addition to the aforesaid introduction to the topic of natural ventilation, an unofficial document is written and is still being complemented with different measurement techniques for determining air mass flow in naturally ventilated double skin façade cavities. It is intended to continue writing this document and to make a full paper to be sent to COST Action TU1403 "Adaptive Facades Network"- Final conference.  Due to delays in erecting the double skin façade and because of limitations in the STSM time frame, the second part of the STSM had to be cancelled. It is planned to continue the project with own financing. |