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An Experimental Evaluation of the Thermal Performance of Felt Type Vegetated Façade System

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1 Introduction

Fourth Assessment Report of Intergovernmental Panel on Climate Change indicates that average temperature on earth has increased by 0.75 °C from the beginning of the 20th century until today. Additionally, it is predicted that average air temperature on earth will increase by 1.8-4°C at the end of 21th century. Urbanization causes reduction of huge amount of green areas and replaces them with surfaces with low albedo value. These changes cause a significant rise of urban temperature known as heat island effect. Greenhouse effect plays also an important role in the increase of ambient air temperatures. In order to decrease greenhouse gases emissions, it is essential to use renewable energy sources instead of fossil fuels and/or reduce energy consumptions. Energy consumption caused by building sector can be reduced by several sustainable design strategies. One of them is covering walls with vegetation, that is called as vegetated facade systems (VFS). Literature review reveals that vegetated facades minimize heat gain through building facade, decrease surface temperature and increase energy efficiency. Studies in Köppen subgroup “Csa” (mild with no dry and hot summer climate) indicate that VFS reduce the maximum exterior surface temperature of reference building surface up to 25°C in cooling period. Although there are studies which evaluate thermal performance of VFS, there is not any experimental study in literature which evaluates thermal performance of felt type (type which used felt material as growing media) VFS applied on an insulated existing building wall which is located in Csa climate. Hence, an experimental study was conducted to measure thermal performance of felt type VFS in Kocaeli. Aim of the present paper is to evaluate thermal performance of felt type VFS in Csa climate conditions during cooling period in summer and fall seasons.

An existing office building located on Gebze Technical University Campus was chosen as experimental building, two facade surfaces of the building were determined to be used as vegetated and reference facades. Both facades are oriented to the south and exposed to solar radiation for the majority of the day. Existing wall system of the building is composed of the following components from inside to outside: 19 cm brick wall with 2 cm thickness interior plaster and 5 cm thickness expanded polystrene heat insulation material and 3 cm thickness exterior plaster. The vegetated facade is composed of two main components: existing wall system and vegetated system. Vegetated system consists of following components from inside to outside: galvanized steel frame mounted on the wall, PVC panel of 1 cm thickness fixed on this frame, first and second layers of geotextile felt attached on it and vegetation layer embedded the felt pockets. Also, an instrumental setup was installed at the reference and vegetated facade systems to measure solar reflectance, surface temperatures and parameters regarding climatic data. Local meteorological data (air temperature and humidity, wind direction and velocity) was measured by a weather station installed on the roof parapet of existing building. Three pyranometers were used to measure solar radiation incident reaching to and reflected from both façades. Infrared non-contact thermometers were used to measure surface temperatures of exterior wall of reference facade, exterior wall of vegetated facade, back and front side of the PVC panel, second layer of felt. Contact thermometers were used to measure surface temperatures of interior walls of both facades. Also, indoor air temperature of the rooms behind both facades were measured. Monitoring periods included months representing summer and fall seasons of the year 2017. Because of the reason that user behaviours were found to be different in office rooms during weekdays behind vegetated and reference rooms, representative weekend days were selected for the both periods when high solar radiation was observed. Exterior and interior surface and indoor air temperatures of both facades were compared with each other. Indoor air temperatures were evaluated according to comfort temperature range identified in ISO 7730 and ASHRAE 55 Standards.

Test results indicate that in day time with high amount of solar radiation, felt type VFS decreased exterior surface temperatures of an insulated existing wall by maximum of 24°C and 30.5°C for representative days of summer and fall periods, respectively. Also, during the night time, exterior surface temperatures of vegetated wall is higher than exterior surface temperatures of reference walls for both periods. Interior surface temperatures of reference facade were also higher than interior surface temperatures of vegetated facade along the day time. However, differences between interior surface temperatures of reference and vegetated facades are negligible. Differences between maximum interior surface temperatures of reference and vegetated facades were 1.3°C and 1.8°C for representative days in summer and fall periods, respectively. Also, there was no significant difference between indoor air temperatures behind vegetated and reference walls. This is due to the fact that existing building exterior wall assembly includes 5 cm thickness expanded thermal insulation material which enhance thermal performance of brick wall. In addition, indoor air temperatures behind both facades were evaluated according to ISO 7730:2005 Standard and ASHRAE Standard 55-2010. For representative summer day, indoor air temperatures behind both facades were not in the range of 23-26°C which is recommended as a comfort range for cooling period in both standards. Nevertheless, indoor air temperatures behind VFS were in the comfort range in day time for representative days in fall period, while indoor air temperatures behind reference facade were not in the comfort range in that day. These results show that most remarkable results occured in fall period. In conclusion, it can be claimed that VFS has a positive contribution on thermal performance of building wall during cooling period. Also, if the existing exterior wall was designed without any thermal insulation, it is obvious that the VFS would present greater passive cooling effect. In addition, solar reflectance of reference facade was 3-8 times higher than solar reflectance of VFS. Lower solar reflectance values of VFS indicate that these systems have positive impact on reducing urban heat island effect.

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