Heat, Air, and Moisture (HAM) Modeling of Historic Windows

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Abstract

Regarding the thermal resistance of the external envelop of buildings, windows are the weakest places. This is especially true for historic windows with original single pane glazing in historic buildings. To reduce the energy consumption and to improve thermal comfort of historic buildings, replacing these windows by modern double glazed windows would be a logical choice. The authentic character of these buildings, however, would be affected too much. Therefore, special effort has to be given to this kind of windows. There are a number of ways to improve the thermal performance of these windows. One approach is to add a single glazing pane from the inside or outside to the existing single pane glazing, making use of a (ventilated) cavity. Apart from that, special glazing has been developed, e.g. vacuum glazing, to replace the single glazing pane, with a vacuum glazing with comparable thickness. To predict the thermal performance of these windows, a multi-physical simulation approach is necessary. The paper will deal with the modeling approach of these types of glazing. The typical total thermal transmittance of these windows will be calculated, making use of the three-dimensional thermal bridge coupling effects on the thermal performance of the glazing panes. COMSOL will be used to solve the multi-physical coupling of the differential equations for Heat, Air and Moisture (HAM). The results of the three-dimensional simulations are compared with relatively simple 1-dimensional calculations by hand and measurements in a so-called hot-box measurement laboratory device and also with in-situ measurements. Generally, good results are obtained by numerical simulation, compared to measurement results. For a number of glazing types, 1-dimensional calculations by hand give a good impression of the thermal performance of rather complex glazing configurations. Surface temperatures of the glazing panes, risks on condensation and energy losses can be estimated with a reasonable accuracy. If the boundary conditions are more complex and if ventilation of air in the cavity is introduced, calculations by hand are not sufficient or possible anymore and more complex computer simulations are necessary.

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Figures used in the abstract

Figure 1: Indoor ventilation: temperatures.

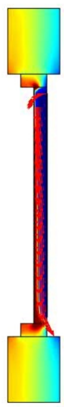

Figure 2: Indoor ventilation: relative humidity.

Figure 3: Outdoor ventilation: temperatures.

Figure 4: Outdoor ventilation: relative humidity.