Coupling Forced Convection in Air Gaps with Heat and Moisture Transfer Inside Constructions

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Abstract

Introduction: The simulation of coupled heat and moisture transfer in constructions is becoming even more important in the last years. COMSOL Multiphysics represents a powerful tool for this kind of simulations as shown in [1,2,3], although applications in this area are still rare. For the realistic prediction of the heat and moisture distribution in building elements exposed to external climatic condition, solar radiation and rain have to be included in the model. In this paper a two dimensional simulation of an external wall connected to a wooden beam ceiling is presented taking in to account the influence of these climatic phenomena. The effect of the forced convection due to pressure gradients inside an air gap between ceiling and wall is considered. Use of COMSOL Multiphysics: Heat and moisture transfer processes in porous construction materials are described by a system of two partial differential equations derived by imposing the equilibrium balance of mass and energy within an infinitesimal element of volume. The system is solved with COMSOL Multiphysics using the Coefficient Form PDE physics interface. Temperature and relative humidity represent the dependent variables whereas position and time are the independent variables of the problem. The transfer coefficients are material specific and generally function of temperature and relative humidity. Boundary conditions of the third kind are imposed on the external surfaces. Time dependent climatic data including the values of the temperature, of the relative humidity, of the solar radiation and of the rain amount are input in COMSOL by means of the Functions feature. The convective heat and moisture transfer inside the air gap is assumed to be one-dimensional along the gap length. The balance equations describing this phenomenon are implemented using the weak form on the boundaries and coupled with the 2D heat and mass diffusion inside the solids domains. Results: Simulations with different climatic data are carried out in order to investigate the sensitivity of the temperature and moisture distribution inside the construction from the rain and the solar radiation. Simulation results are cross validated with those of another simulation program specific for hygrothermal simulation [4] showing good agreement. Conclusion and Outlook: The results presented in this paper confirm that COMSOL Multiphysics is a useful tool for hygrothermal simulation inside constructions. Comparing to the others considered simulations programs, COMSOL present the benefit of more flexibility allowing solution of 3D Problems and coupling with convection in air gaps. A validation with measured data is necessary and will be carried out within further developments of this work.

Reference

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Figures used in the abstract

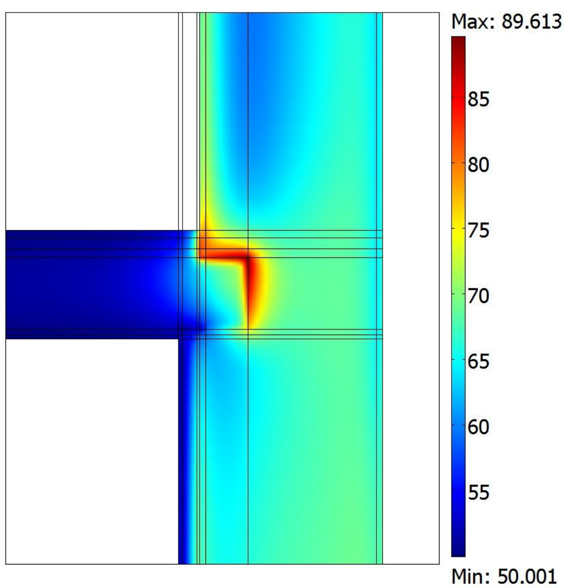

Figure 1: Relative humidity distribution [%] inside the ceiling-wall junction at the end of the simulation (31 December) with convection in the air gap between ceiling and wall.