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Thermal analysis of above-grade wall assembly with low emissivity materials and furred airspace

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ABSTRACT

A 3D numerical model was developed to investigate the effect of foil emissivity on the effective thermal resistance of an above-grade wall assembly with foil bonded to wood fibreboard in a furred assembly having airspace next to the foil. This model solved simultaneously the energy equation in the various material layers, the surface-to-surface radiation equation in the furred airspace assembly, Navier–Stokes equation for the airspace, and Darcy and the Brinkman equations for the porous material layers. In this work, the furring was installed horizontally. In the first phase, the present model was benchmarked against the experimental data generated by a commercial laboratory for an above-grade wall assembly. The wall consists of a conventional wood frame structure sheathed with fibreboard and covered on the interior side with a low emissivity material bonded to wood fibreboard that is adjacent to a furred airspace assembly. The results showed that the predicted *R*-value was in good agreement with the measured one. After gaining confidence in the present model, it was used to predict the effective thermal resistance of the same above-mentioned wall but having Oriented Strand Board (OSB) sheathing in lieu of wood fibreboard sheathing. In the second phase, the model was used to quantify the contribution on the wall *R*-value by having a low foil emissivity. The results showed that a low foil emissivity of 0.04 can increase the *R*-value of this wall to as much as ~9%. This is on-going research. The present model is being used to investigate the transient thermal response of foundation wall systems with furring installed horizontally and vertically, and subjected to different Canadian climate conditions.

1. Introduction

A 2D and 3D hygrothermal model called “hygIRC-C” that uses COMSOL Multiphysics [1] was developed at the National Research Council of Canada’s Institute for Research in Construction (NRC-IRC). This model simultaneously solves the highly nonlinear 2D and 3D Heat, Air and Moisture (HAM) transport equations. These equations were discretized using the Finite Element Method (FEM). This model was benchmarked against the hygIRC-2D model that was previously developed at NRC-IRC, and test results in a number of projects.

In the case of accounting for heat, air and moisture transport, the 2D version of the present model was used to predict the drying rate of a number of full-scale wall assemblies subjected to different exterior and interior boundary conditions [2]. The results showed that the present model and the hygIRC-2D model [3,4] as well as the experimental measurements were in good agreement in terms of the shapes of the drying and drying rate curves. Additionally, the predicted average moisture content of the different wall assemblies over the test periods was in good agreement, all being within ±5% of those measured [2].

In the case of accounting for heat and air transport (no moisture transport), the 3D version of the present model was used to conduct numerical simulations for different full-scale wall assemblies with and without penetration to represent a window in order to predict the effective thermal resistance (*R*-value) with and without air leakage [5]. These walls incorporated different types of insulation, specifically, spray polyurethane foams and glass fibre batts. The predicted *R*-values for these walls were in good agreement (within ±5%) with the measured *R*-values in NRC-IRC’s Guarded Hot Box (GHB) [6,7].

More recently, the present model was used to assess the dynamic heat transmission characteristics through two Insulating Concrete Form (ICF) wall specimens installed in the NRC-IRC’s Field Exposure of Walls Facility (FEWF) [8]. In the early stage of this project, 3D

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