A New Technique for Analyzing the Hygrothermal Performance of Building Walls

A. Kerestecioglu, Ph.D. J. Jhinger T. Hamlin

ABSTRACT

This paper presents the mathematical framework used in software that is a result of Canada Mortgage and Housing Corporation (CMHC) sponsored research. The software is designed to study the hygrothermal performance and behavior of building walls and components.

The combined heat and moisture transfer phenomenon is simulated through four fully coupled equations (air pressure, energy, partial water vapor pressure, and liquid pressure equations). Energy and water movement are not only affected by temperature but also by air pressure gradients. In other words, the air velocity calculated from the air pressure equation is used to simulate convective heat and moisture transfer within a structure. Moisture movement affects the thermal equation, and thermal fields affect the liquid and water vapor balance equations. In addition to combined heat and moisture in porous materials, the software also simulates combined heat and moisture transport in air channels.

The governing equations are solved by the finite element method. The material property nonlinearities are simulated in great detail. The boundary conditions are time dependent and nonlinear. Therefore, fluctuations in the ambient and indoor conditions are taken into account. The program is therefore capable of simulating the performance of an arbitrary wall section with its interior and exterior surfaces subjected to varying environmental conditions. The program is capable of simulating the boundary effect of ambient air temperature, relative humidity, air pressure, solar radiation, night-sky radiation, rain, and wind incident on the wall.

The program permits the user to choose a desired wall configuration provided that the material properties of the wall components are available. The software provides an extensive material properties data base. The details of the data base are also discussed.

Finally, we present validation efforts with theoretical and field data

A. Kerestecioglu was formerly with Florida Solar Energy, **H. Jhinger** is with G. K. Yuill & Associates, and **T. Hamlin** is with Canada. Housing and Mortgage Association