SIMULATION OF COMBINED HEAT MOISTURE AND CONTAMINANT TRANSPORT IN BUILDING SCIENCE PROBLEMS

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INTRODUCTION

This paper describes a general purpose software, Florida Software for Enervironment Calculations (FSEC 1.2), that is capable of solving various transport equations used in building science (e.g., combined heat and moisture transfer, fluid flow, contaminant equations, etc.). The governing equations are solved by finite element methods.

The major capabilities of the software are as follows:

- Solves up to 250 coupled linear or nonlinear, spatially-distributed, steady-state or transient partial differential equations.
- One-, two- or three-dimensional simulations.
- Mesh generation with bandwidth minimization.
- Ability to select from a library of equations or to define additional equations.
- Ability to modify time steps, boundary conditions, numerical solution schemes, material properties, and other variables on a run-time basis.
- Utilities that include: detailed, inter-element thermal radiation, psychometrics, matrix and vector manipulation algorithms.
- Provisions for interfacing user defined routines and programs.
- A building simulator.

The equation library of the software includes the following equations:

- Energy equation.
- Various moisture transport equations.
- Fluid flow equations.
- Turbulence equations (k-ϵ model).
- Contaminant diffusion equations.
- Elasticity equations.

The software offers several combined heat and moisture transfer simulation modes.

- Distributed heat and moisture transfer models for both solid and air domains.
- Distributed heat and moisture models for solid and lumped heat and moisture models for air domains.
- Distributed heat transfer models for solid, lumped moisture transfer models for solid and lumped heat and moisture models for air domains.

The following simulations are performed to demonstrate the simulation capabilities of the program.

Effect of moisture adsorption and desorption on indoor conditions and associated loads: A residential building is simulated with different combined heat and moisture models. In one case distributed heat and moisture equations and in the other case distributed heat and lumped moisture equations are used to simulate the building solids. The results show the effect of moisture adsorption and desorption of building solids on indoor conditions, associated loads and mechanical unit run time.

Effect of mechanical unit performance on indoor conditions: The performance of the mechanical unit with different efficiencies is simulated. In the simulations, the sensible heat fraction of the mechanical unit is varied and its effect on indoor conditions and mechanical unit run time are studied.

Formaldehyde emission rate of a particle board: 1 inch thick particle board is exposed to cyclic air temperature and vapor concentration variation.

Distributed heat and moisture transfer equations are used to predicted the temperature and moisture (vapor and liquid) concentrations within the particle board. An empirical equation is used to calculate the formaldehyde emission rate.

Contaminant distribution in a house: The effect of various wind directions on the distribution of contaminants in a ventilated building is simulated. The contaminant source is located at the fireplace. In the simulations the flow equations with contaminant equation are solved.

FSEC 1.2 has been successfully used to simulate a variety of building science problems. The software offers extensive capabilities, but input file preparation is tedious. The current version is intended for users with an extensive numerical analysis background.