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Transient Analysis of Air-Conditioning Load and Room Conditions Considering Simultaneous Heat and Moisture Transport of Multi-Layered Constructions

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Moisture transport in a building has a major role in condensation problems. It also has much importance in the formation of room air humidity and air-conditioning load. The focal point of this paper is to evaluate room air humidity and air-conditioning load considering moisture transport by desorption and absorption of multi-layered constructions. For this purpose, a computer code has been developed. A brief description of the calculation method and the mathematical background is given. Validation of the procedure is carried out by comparing measured and simulated humidity and temperatures. Simulated examples are shown with the results that the sorption effect keeps air humidity of a storehouse stable and increases air-conditioning loads of an ordinary office room by about 5%.

NOMENCLATURE

- x room air humidity [kg/kg(dry air)]
- θ room air temperature [°C]
- w moisture flow of a wall [kg/h m^2]
- q heat flow of a wall [W/m^2]
  (X, Θ, W and Q are s-domain variables corresponding to x, θ, w and q)
- $\mathbf{G}$ transfer function (impedance) matrix of a layer of a composite construction
- $\mathbf{H}$ sub-matrix of matrix $\mathbf{G}$
- $\mathbf{K}$ admittance sub-matrix
- K element of sub-matrix $\mathbf{K}$
- Λ Laplace transform of a triangle input
- $\mathbf{P}$ potential vector $(X\ Q)^T$
- $\mathbf{F}$ flux vector $(W\ Q)^T$
- L number of construction components facing outside
- I number of construction components facing inside
- s complex variable $(=\gamma+\mathbf{i}f)$
- M moisture supplied to room air [kg/h]
- H heat supplied to room air [W]
- m room air weight [kg(dry air)]
- A area of a construction [m^2]
- Δ time increment [h]

Subscripts

- r room
- o outside
- g generation in a room
- ac by air-conditioning
- v ventilation air

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INTRODUCTION

CONDENSATION is one of the most important problems related to moisture transport in a building. From an indoor air quality point of view, however, evaluation of moisture transport to and from room air is a more important problem. The main objective of this research is to predict room air humidity and air-conditioning loads on a transient basis considering moisture transport by absorption and desorption through building components to produce a high quality environment.

Many building materials, especially wood and fiberboard, have the effect of stabilizing room air humidity by their moisture sorption. This effect has been used to protect precious objects from dampness under humid Japanese summer conditions. For example, the highest quality Japanese chests for storing Japanese kimonos are made of paulownia wood, and walls of traditional storehouses are made of clay without finishing on the inside surfaces.

In buildings for living, the same effect is also favorable for establishing a healthy indoor air climate by avoiding high humidity during damp weather. On the contrary, intermittently operated air-conditioning systems may have to handle excess loads compared to those without sorption effect. Qualitatively, it is well understood that the larger the area of materials with high moisture