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論文題目	Numerical Study on Indoor Climate Using Single-Phase and Multiphase Models （単相および多相場モデルによる室内気候の数値解析的研究）		

（論文内容の要旨）

In this study, numerical investigations were carried out for indoor climate, consisting of velocity, temperature and humidity, using single-phase and multiphase models. In order to confirm the accuracy of the computational methods, the numerical results were compared with wide range of experimental results. Following the verification, it was shown that the numerical method enables us to find optimum heating method under same heat supply conditions in a full-scale multi-story house.

In Chapter 1, on the basis of the literature survey for indoor climate investigations, the background and objectives of the present study were made clear. The available experimental results were also surveyed in the preceding studies, while the current situations about numerical studies were discussed. Finally, in consideration of optimizing indoor climate for houses located in cold districts, it was determined that the focus of the numerical study is place on the following two types of common heating methods: panel heaters and floor heaters.

In Chapter 2, two types of numerical model were introduced: a single-phase (or separate-phase) model and a multiphase model. The single-phase model is similar to the usual computational methods, in which boundary meshes are set up between the indoor air and surrounding walls. Since the boundary conditions for temperatures or heat fluxes on the walls must be specified, this model is usually difficult to apply to actual houses having complicated-shaped wall boundaries. By adding the equation of humidity to the governing equations for a non-isothermal incompressible fluid, the single model was applied to the various benchmark problems with relatively simple geometry. On the other hand, the multiphase model deals with the gas-solid multiphase field as one-fluid model in multiphase flows. The fluid computations are conducted in rectangle-structured cells, while the solid materials are represented by tetrahedron elements, to which different thermal conductivities can be assigned. In contrast to the single-phase model, the multiphase one is applicable to the complicated problems, such as indoor climate in a full-scale multi-story house.

In Chapter 3, the single-phase model was applied to various experimental results to confirm its accuracy. After the comparisons with three-dimensional isothermal cavity flows and non-isothermal natural convection flows, the single-phase model was applied to non-isothermal flow with an obstacle plate in the computational region. Finally, this model was applied to the forced flow with a humidifier on the bottom of the three-dimensional box. All predicted results were quantitatively compared with the existing experimental data and it was concluded that the single-phase model can be used to predict non-isothermal flow with humidity within the three-dimensional domain which has relatively simple geometry. After this, using the single-phase model, the time required to increase the temperature in the room using different heating elements was investigated; this included changing the locations of the heating elements. It was shown that the floor heaters consumed less time to increase the temperature of the room.

In Chapter 4, using another computational method, the multiphase model, the indoor temperature and velocity distributions were numerically predicted for an actual scale three-story house, in which the measured data had been obtained by preceding study. In order to apply the computational method to the actual house, the solid materials, such as walls, windows and roofs, are represented by finer tetrahedron elements, while multiphase field is calculated on structural collocated grid system. For the solid materials consisting of the house, the corresponding thermal conductivities are assigned on the basis of the experimental conditions. With the above experimental conditions, two cases of computations were conducted: 1) computations with the same condition as experiments and 2) numerical experiments to find optimum heating method. In the first computations, the heat panels were set up at the same location as the experiments. In the computations, the temperature distributions and the flow patterns of air within the multi-story house were obtained taking account of thermal interactions among indoor air, solid materials and outside air. With the comparisons with experimental data measured in multiple positions in the house, it was shown that the multiphase model allows us to reasonably predict the indoor climate of the house. In addition, the numerical experiments were conducted for the same multi-story house with the different heating methods: floor heaters and attached panel heaters. From the comparisons with temperature distribution and other thermal characteristic values, it was suggested that the floor heating method is more efficient than panel heaters. Conclusively, it was shown that the multiphase model is useful to find optimum heating method in actual houses.

In Chapter 5, the investigated results from Chapter 2 to Chapter 4 are summarized and the conclusion of this study is briefly described.