Study on Airflow and Heat Flux in Underfloor Air-conditioning Systems

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Introduction

Air-conditioning systems that use underfloor space as air supply chamber in air-conditioning, heating and ventilation are called underfloor air-conditioning systems.

In this work, we used OpenFOAM in order to grasp airflow in the chamber and thermal conduction in building frame.

Experimental Room

One of the room in the actual apartment houses was converted into the experimental room. The air-conditioning unit was set on the south side of the room. The circulation fan under the air conditioner supplies air to the chamber. The air blows from two floor outlets near the window to the room.

Simulation Flow

Simulation was divided into two stages: airflow simulation in the chamber and thermal conduction simulation in building frame. At the first stage, the properties of airflow in the chamber were revealed. Wind velocities gained at this stage were used as boundary condition of the building frame surface at the second stage.

Stage 1: Airflow simulation (Steady state)

Wind velocity

Inlet 0.61 m/s
Outlet 2.72 m/s

Results

Simulated wind velocity was compared with measured wind velocity at 10 measurement points, SL+75mm. The results of simulation generally corresponded with measurement value.

Stage 2: Thermal Conduction Simulation

Radiant heat transfer rate between the building frame and double floor was regarded as negligible. Convective heat transfer rate from the air in the chamber was substituted for boundary of the building frame surface. The floor surface was divided into 10 surfaces. Wind velocity calculated by airflow simulation was averaged within each surface. These averaged wind velocity ($\nu$) and air temperature at each measuring point ($Ta$) were substituted to boundary. Convective heat transfer coefficients were calculated by Jurges' formula.

Heat balance equation

$$\text{Q}_{\text{conv}} + \text{Q} = \Delta \text{E}_{\text{cond}}$$

Jurges' formula

$$\alpha = 3.9y + 3.1(y < 2)$$

Results

Experimental reproduction: heat flux in building frame and surface temperature

Near the floor outlet, CFD results relatively corresponded with measurement values.

At the front of air-conditioner, CFD results did not precisely correspond.

Apart from the outlet, CFD result corresponded with measurement values well.