Conference Agenda

15th ROOMVENT Conference

Session

AD2: Air distribution & ventilation efficiency 2

Session Chair: **Ran Gao**

Presentations

A field measurement on energy loss through door open while air conditioner running in a commercial store

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While air conditioner running, leaving doors open causes the energy loss because of infiltration that caused by indoor and outdoor temperature difference. There are several methods to reduce infiltration such as air-curtain, but there are few exact measured or calculated data. The purpose of this study is to evaluate the energy through the door open while air conditioner running and to propose the energy-saving method. To achieve this goal, using full-scale measurement in a commercial store during cooling period to measure the infiltration rate, thermal environment and energy consumption with the door opened, the door closed and four method to reduce infiltration: air-curtain (vertical and horizontal), mist and cloth curtain. The measured results show that the infiltration rate at door opened state was increased by about 134.6 times compared to the door closed state. When the cooling temperature is set to 26 ºC, the room temperature in the opening door cooling was measured to be about 5~9 ºC higher than the closing door cooling. The energy consumption at the door opened state was increased about 199.1 % compared to the door closed state. In the four methods to reduce infiltration, the infiltration rate and energy consumption was most reduced at cloth curtain fitted compared to the door opened state. The room temperature at the cloth curtain fitted was measured to be about 5 ºC lower than the door opened state. Infiltration rate increased due to wind infiltration in addition temperature difference infiltration.

Importance of occupants' distribution on CO2 exposure in ventilated rooms

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CO2 is used as a marker for exposure to indoor pollution. CO2 concentration measured in the air exhausted from the room or near the walls is used to estimate the CO2 exposure as well as to control supplied ventilation rate. However, research reveals that the CO2 concentration in the inhaled air can be more than 30% higher than the concentration measured in the air exhausted from the room.

Previous research has identified that part of the own exhaled air is re-inhaled. This leads to increase of CO2 concentration in the inhaled air above the CO2 concentration in the surrounding room air. In rooms with total volume ventilation most of the inhaled air is from the convective boundary layer existing around human body. The convective flow entrains part of the own exhaled air with high CO2 concentration and thus contributes to the elevated CO2 exposure. The importance of the convective layer for the entrainment of air exhaled by the surrounding occupants, before it is mixed with the room air, on the CO2 exposure was studied. Experiments were performed with three persons and a breathing thermal manikin (BTM) in a room equipped with chilled ceiling, air supply from ceiling slot diffuser and heated window to simulate solar load. The CO2 concentration in the air exhaled by the manikin was increased to the level of an average person. The supplied outdoor flow rate, calculated based in the CO2 mass-balanced method to maintain 1000 ppm at the exhaust, was 29 L/s. The temperature of the supplied air was 18 C. The chilled ceiling temperature were controlled to maintain the room temperature at 26°C. CO2 concentration in the air inhaled by the BTM was 16% higher than at the exhaust. This was mainly due to re-inhalation of own exhaled air. The location of the neighbouring "occupants" had no impact on the inhaled CO2 concentration. The ventilation flow rate calculated by the mass balanced method and CO2 concentration measured in the exhaust air may not be accurate to assess occupants' CO2 exposure.

Simulation-based performance assessment of different ventilation design and control strategies in apartments

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Based on multizone modelling in Contam, the performance of several ventilation systems (MEV and MVHR systems) with respect to IAQ and energy efficiency was analysed in apartments of multi-family dwellings. Besides, the distribution of the air flow rates supplied to and extracted from the individual apartments via ventilation components (passive vents, mechanical supply and/or exhaust fans) and in/exfiltration from outdoors and inner common spaces (shafts, stairwell) was studied. The level and direction of air transfers between rooms were also considered. The impact of different demand controlled ventilation (CO2, RH, VOC) and design strategies were simulated and compared with results obtained with standard constant flow strategies.

EFFECT OF RETURN AIR IN HVAC SYSTEMS ON POLLUTANTS CONCENTRATION FORMATION IN ROOMS

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Indoor environment and indoor air quality in a room with a heating, ventilating and air-conditioning (HVAC) system are affected by supplied air-condition such as airflow velocity or pollutant concentration from the HVAC system. The supply air is generally controlled by mixing fresh air from the outdoor environment and return air from rooms in the HAVC system. The proportion of the return air included in the supply air in the HVAC system is generally adjusted at a rate determined under the assumed indoor conditions when the HVAC system was designed. The percentage of return air that is included in the supply of the HVAC system is typically adjusted at a rate determined by the indoor conditions assumed when designing the HVAC system. However, the return air ratio will be adjusted if the use of the room changes. The purpose of this study is to investigate the effect of supply air return

from the HVAC system on indoor air quality in three rooms with different exhaust opening locations. We discuss the structure of the formation mechanism in local pollutant concentration distributions using various indices on the ventilation efficiency of a local domain in 3 rooms with different layout of the exhaust outlet location. As a result, when the percentage of the return air at the supply inlet becomes large, the influence of the change of the mixing ratio of fresh air and return air on the formation of the local concentration field is confirmed to be significantly large. The visitation frequency of pollutants on a target local domain increases exponentially, and then the averaged concentration of the pollutants of the local domain also increases exponentially.

The pollutants were generated uniformly in a local domain (lower zone than y = 5.6 line through the center of recirculating flow in Case Cr) for *VF* and *L-PFR* analyses, and it was generated in each CV for *NEV* analysis.

Numerical Simulation of Jet Interaction in a Test Ventilated Classroom: Flow Structure Sensitivity to Supply Diffuser Operation Mode

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The objective of the study is to analyze the air distribution in a test ventilated classroom equipped with a ventilation system composed of four four-way ceiling diffusers. Unsteady Reynolds-Averaged Navies-Stokes (URANS) simulation was performed using the ANSYS Fluent software. The focus of the discussion is on the effect of supply diffuser operation mode on the flow structure and thermal comfort. The parametric study covered four cases with varied louver angle, supplied flow rate and the supply diffuser area. For a particular set of parameters, the computational results are validated with the full-scale measurement data obtained in the classroom under isothermal summer conditions with omnidirectional thermo-anemometric sensors. Assessment of thermal comfort in the occupied zone is presented and discussed.

EXPERIMENT STUDY ON AIR DISTRIBUTION PERFORMANCE IN A RAISED FLOOR DATA CENTER

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This paper aims to study the airflow characteristics in a raised floor data center (RFDC) by comparative analyses of three cases conducted in field measurements. Multiple factors, the airflow rates both for the perforated tiles and CRAH units, the air temperature for the racks and CRAH units, the load density of IT equipment, the CRAH unit location as well as its return air temperature control (Independent Control and Average Control), were all concerned. Two airflow performance indexes, Supply Heat Index (SHI) and Return Temperature Index (RTI), were introduced to evaluate the air distribution performance. Results show the rack inlet temperatures were within the recommended range from ASHRAE, but hot air recirculation was observed in the measurement area caused by insufficient air supply and the rack vacancy, leading to an average vertical temperature difference of 5.8℃ in the cold aisle. The average value of SHI and RTI in the higher density area in Independent Control (IC) improved 0.12 and 34.7%, respectively, when shutting down the far-away CRAH units. However, values above improving little in Average Control (AC), which generated a remarkable reduction of airflow rates and power consumption.

Comparison of natural and mechanical ventilation in bedrooms – Importance of CO2 sensor positioning

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People spend over 20 years of their life in bedrooms, and it is observed that adequate bedroom ventilation and outdoor air supply improves sleep quality and next-day performance. Most of the published literature focused on the ventilation rate in the entire bedrooms rather than in the breathing zone of the sleeping persons. For the purpose of avoiding higher exposure to carbon dioxide (CO2) at nighttime, it is crucial to focus on the actual ventilation rate through CO2 measurements in the breathing zone during sleep. The main objective of this study was to examine the spatial distribution of the CO2 concentration (c-n) close to the breathing zone of a sleeping person in bedrooms with natural ventilation (NV) and bedrooms with mechanical ventilation (MV). In this study, a bedroom equipped with trickle ventilation on the window and a bedroom equipped with mechanical ventilation are adopted for representative conditions. The field measurements were performed in the residential buildings during the heating season in a cold climate. CO2 sensors were placed vertically and horizontally at 0.5 m distance from the sleeping person’s head and near the door. The ventilation rate was estimated based on the measured CO2 decay in the morning after the person left the bedroom. The results showed that when the trickle vent on the window was kept open and the bedroom door closed, there was a continuous CO2 build-up throughout the night, and it reached up to 3200 ppm. By contrast, in the bedroom with mechanical air supply, the CO2 build-up raised to 1500 ppm within 1 hour and then reached steady state at around 1000 ppm. It was observed that there was only a slight difference in the CO2 levels measured at different points around the head.

Analytical expression of dynamic local cooling load (LCL) of the non-uniform environment

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To satisfy the local requirements is energy-efficient for indoor thermal environment. The method to calculate local cooling load (LCL) of non-uniform environment under steady state with accessibility of heat source (AHS) has been proposed. However, there is no method to calculate dynamic LCL because the convective heat gain from building envelope is coupled with indoor temperature. In order to get the calculation method of dynamic LCL, , equivalent convective heat transfer coefficient between inner surface of external surface and local zone is proposed to simplify the convective heat transfer from envelope in this paper. The calculation method of dynamic LCL is then established based on the superposition of the dynamic heat transfer from building envelope as well as the indoor heat gain. The LCLs of different target zones are investigated and compared through case studies. The main conclusions are as following: 1) The equivalent heat transfer coefficient could be used to explicitly determine transient convective heat transfer; 2) The convective heat is influenced by both the thermal property of building envelope and airflow patterns; and 3) the LCL oriented to different target zones varies owing to the difference between the amount of convective heat gain as well as AHS. This study will help the design and operation of non-uniform indoor thermal environment.