Conference Agenda

15th ROOMVENT Conference

Session

CS1: Case studies 1

Session Chair: **Francesco Asdrubali**

Presentations

Research of Thermo-Active Building System with the Floor-mounted Water Panel （Part 2） Performance Verification of Cooling by Mock-up Experiment

Kinuko Kuwayama, Kazunori Murashita, Kotaro Makino, Katsuaki Hidari, Kazuki Wada

Takenaka Corporaion, Japan;

In the previous report, we reported that floor-mounted water panel for this research and outline of the radiation cooling and heating using building thermal storage system (TABS), the verification of radiation capability with test pieces by carrying out experiments.

In this report, an experiment was conducted by reproducing a part of the radiation cooling and heating using building thermal storage system adopted in this building to confirm the system performance.

To conduct this experiment, we create a mock-up in the laboratory that simulates floor air-conditioning on slabs and OA floors using concrete reproducing slab, floor-mounted water panel, plywood, and thermal insulation material.

The size of concrete reproducing slab is 210mm tall, 1100mm wide, 6100mm long, it is covered with thermal insulation material. Six floor-mounted water panel (1960×400mm) is laid on concrete. And plywood, and thermal insulation material is laid thereon. Chamber covered with thermal insulation material is reappearance of air passage of the floor blow-off air conditioner, it is connected to fan coil through a duct.

We performed that experiment that are intended steady state and unsteady state using above mock-up. And we measured Concrete interior and surface temperature, Vertical temperature distribution under the slab, a quantity of radiation heat transfer, and etc. in each examination to calculate air conditioning performance and heat balance and, to grasp characteristic.

Further, it takes much time for TABS to begin to be effective from the start of operation. On the other hand, it is expected that TABS keep radiation cooling/heating effect when TABS operation stopping. Thus we simulated intermittent operation of radiation air conditioning system as consideration of actual operation, and confirmed thermal behaviors of concrete to flow control changes. The following findings by these experiments were obtained.

1) It was found that all experiment case not largely deviated on capability characteristics diagram in either of heating and cooling. Capability characteristics diagram indicated favorable trends in all experiment case

2) We confirmed that it took concrete surface temperature from 30 hours to 40 hours to reach a target temperature by measuring concrete temperature variation. And, extreme temperature distribution was found on concrete surface at steady state.

3) It occurred response delay of thermal behaviors of concrete to flow control changes by simulating intermittent operation of radiation air conditioning system. The necessity of adjusting the start and stop of water supply for radiation air conditioning system matching business hours in the actual room was suggested.

Experimental study of hot aisle containment and cold aisle containment data center cooling systems for improved air distribution and thermal performance

Jinkyun Cho[1], Woosin Choi[2], Taesub Lim[3]

[1]Hanbat National University, Korea, Republic of (South Korea); [2]SK Telecom Co., Ltd., Korea, Republic of (South Korea); [3]Seoil University, Korea, Republic of (South Korea);

Cooling is a constant concern with data centres. IT equipment must be kept within a certain temperature range 24/7 and this is expensive. With increased awareness of data centre cooling and its energy cost impact, the air containment systems are considered the most prominent techniques for IT cooling air distribution control. In this study, the IT environment, thermal performance of the hot aisle containment and cold aisle containment was analysed in a reference high-density data centre. An experimental investigation, field measurements, on the difference in IT environment between the air containment systems was basically compared. The main potential contribution of this paper is to realistically implement the effectiveness of the existing theoretically simple comparison of the air containment system by the actual operating conditions of the data centre.

EFFECTS OF NIGHT-TIME CROSS-VENTILATION ON THERMAL ENVIRONMENTS OF RESIDENTIAL BUILDINGS

Bomin Ko, Junseok Park

Department of Architectural Engineering, Hanyang University, 222, Wangsimni-ro, Seongdong-gu, Seoul, Republic of Korea, Korea, Republic of (South Korea);

Night-time ventilation in the cooling period provides passive cooling effects in residential buildings with minimal energy consumption. The outdoor air supplied from natural cross-ventilation can remove overheated indoor air and provide not only comfort thermal environments but also acceptable indoor air quality for occupants of residential buildings. In this study, the one-year field long term monitoring was carried out in twelve residential buildings to survey the effects of night-time cross-ventilation on indoor environments. The windows status of the twelve samples were also simultaneously recorded during the monitoring periods. The thermal environment of the sample homes was acceptable level in most when the samples were naturally cross-ventilated. The night-time ventilation, however, was not always efficient to improve the indoor thermal environment in the sample homes, because of the enthalpy of outdoor air. It was found that the night-time ventilation is not suitable in residential buildings when the outdoor air is higher than 26℃.

The status of airtightness performance of dilapidated dwelling s in Korea

SUIN LEE[1,2], Jae-Sik Kang[2], Gyeong-Seok Choi[1,2]

[1]Smart City &Construction Engineering, University of science & technology; [2]Department of Living and Built Environment Research, Korea Institute of civil engineering and building technology;

Building energy consumption accounts for 29% of the total energy consumption in the world, and many research studies for reducing building energy consumption have actively carried out. The thermal performance of envelops of buildings (walls and windows), which directly affects the energy consumption of the building, has been improved, and the importance of energy consumption due to infiltration of air has come to the fore worldwide. Therefore, the purpose of this study is to quantitatively measure and analyze the airtightness performance of dilapidated dwellings in Republic of Korea. We collected data of the airtightness performance of 60 dilapidated dwellings and evaluated them based on the current state and the standard of the airtightness performance in other countries. As a result, the airtightness performance (ACH_{50}) of dilapidated dwellings was 20.81 h^{-1} on average, which is the second lowest value among the nine countries (Belgium, Canada, Estonia, Finland, Greece, England, Norway, and United States) selected for comparison. In addition, based on the ASHRAE Standard 119, a rating criteria of the airtightness performance of dwellings, it was classified as 'H' and ranked as 7 out of 10. Based on the results of this study, we intend to use the data as a basic data for further research for developing the airtightness performance improvement method to improve the building energy efficiency.

Study on ceiling mounted displacement ventilation for classrooms

Takuya Kawamura[1], Jun Koyama[1], Tatsuo Nobe[1], Makiko Kasahara[2], Nobuhiro Miura[2], Yusuke Doi[3]

[1]Kogakuin University, Japan; [2]Shimizu Corp.; [3]Mitsubishi Jisho Sekkei inc.;

In Japan, HVAC system of the mixing is often adopted as the air conditioning system for classrooms; however, air quality in the breathing area tends to be low because it mixes indoor air.

The purpose of this study is to develop an air conditioning system that improves the air quality in the breathing area of classrooms. In this paper, the outline of the developed air conditioning system and the results of performance evaluation are described.

As the air conditioning system, the authors adopted the displacement ventilation, which has been widely used mainly in Western countries and has been increasing in recent years in Japan. In the conventional displacement ventilation (wall mounted type), the outlet is installed at the lower part of the room; however, considering the movement of the occupants and the reduction of the effective area, the authors planned to install it at the corner of the upper part of the room (ceiling mounted type).

From the results of ventilation efficiency by the tracer gas, the air change effectiveness in the breathing area is 1.3 for the ceiling mounted type, while it is 1.4 for the wall mounted type. The two cases were approximately the same value, and the improvement of air quality can be expected by ceiling mounted type. In the indoor environment evaluation by the subject experiment, the formation of an air layer due to the difference in air temperature, which is a feature of the displacement ventilation, was observed in the room.

In the future, by reexamining the specifications of the outlet and enhancing the feasibility of the ceiling mounted type, in addition to classrooms, the authors are looking into the prospects for displacement ventilation system with ceiling blowing to the offices.

A case study of the indoor air quality in schools belonging to an area of the Sicilian Island interested by the presence of petrochemical refineries

Fabio Cibella[2], Laura Cirrincione[1], Paolo Colombo[2], Gaspare Drago[2], Alessandra Longo[2], Valeria Longo[2], Giorgia Peri[1], Silvia Ruggieri[2], Gianluca Scaccianoce[1,2]

[1]Department of Engineering, University of Palermo, Italy; [2]National Research Council of Italy – Institute for Biomedical Research and Innovation – Palermo, Italy;

Indoor and outdoor air pollution have a significant impact and represent a relevant risk factor for human health. An increasing awareness towards this problem, due to the fact that people tend to spend most of their time in confined environments (especially in Developed Countries), combined with the growing demand for a general improvement in the quality of life, has brought the scientific community to more accurately pay attention on this subject. In fact, in relation to their effects on human health, outdoor and indoor pollution have been so far mostly considered separately. In particular, contaminants present inside enclosed environments are mainly attributed to emissions from internal sources, such as equipment and consumer products related to the occupants' behaviour. On the other hand, concerning the outdoors, fossil fuel burning by power stations, chemical industry and motor vehicle emissions represent some major pollutant sources. To contribute on this important matter, this paper presents a study referring to the "RESPIRA" Project, developed in the context of the Cross-Border Cooperation Programme "Italy-Malta 2007-2013", aimed at analysing the indoor and outdoor air quality and respiratory health in schools, belonging to the Mediterranean islands of Malta and Sicily. Particularly, twelve schools involved in the study were located in Sicily, in the towns of Gela, Butera, Niscemi and Mazzarino, in the southern part of the island. The main aim of the case study was the singling out of relationships between outdoor pollutants concentrations, revealed by means of public urban monitoring stations, and indoor pollutants concentrations, measured on field in the considered enclosed environments: these measurements were relative to the substances that are known to be amongst the main risk factors for the human health (NO_x, SO_2, O_3, CO, VOCs). In particular, an on-field monitoring campaign was aimed at assessing the state-of-art of the environmental conditions of these schools, characterized by the presence of a significant petrochemical industry, currently being phased out. The performed analysis made it possible to highlight the main criticalities regarding the recorded concentration levels of the monitored pollutants and to draw some interesting considerations about the link between indoor and outdoor air conditions, with particular reference to a specific category of confined environments (i.e. schools) occupied by a vulnerable group of occupants like children. The specific objectives of the study were the definition of emission sources (frequency of use of specific consumer products), the measurement of indoor pollutant concentrations (in this way assessing the health effects of exposure to indoor air pollutants from consumer products in vulnerable groups, like students), by taking into account also socio-economic factors. More in general, thanks to the presence of health and medical researchers among the scientist's group, the purpose of the study was the identification of the relationship between indoor exposure to pollutants and health effects, through the analysis of main risk factors, in this way providing a contribution to the assessment of guidelines meant at the prevention of health effects in subjects living in environments at risk for the presence of indoor pollutants.

ANALYSIS ON THE FACTORS INFLUENCING THE NATURAL VENTILATION EFFECT OF THE ATRIUM IN EXPO BUILDING

Chenyu Li[1], Mengxiao Xie[2], Jian Wang[1]

[1]Architecture Design & Research Institute of Tongji University（Group）Co., Ltd., Shanghai, China; [2]Tongji University, Shanghai, China;

The atrium is the shared space of the building.It can introduce external natural environment to the internal and improve the internal micro climate of the building. Air conditioning system was replaced or partly replace by the natural ventilation, which was widely applied to the large expo buildings. Research on architectural design factors how to affect the atrium wind pressure natural ventilation, to optimize the design of the building and achieve a more healthy,comfortable and energy saving effect, has been the relevant scholars.

Firstly, model parameters can be derived from 16 actual expo buildings with atrium. Make the following assumptions and settings to the basic building: The expo building is located in Shanghai, facing to north. There are no other buildings or landscape nearby. The basement area of the building is 3556.2m^2 with a height of 17.7m. The atrium is the core type and the vertical high court. Based on the orthogonal experiment method,study the effect of four main factors of architectural design (the atrium plane shape, the atrium size, the opening size and height of the envelope) on natural ventilation. Design 25 set of conditions (four factors, five levels) through the CFD numerical simulation method. The evaluation standard is the ratio of wind speed and air age to the standard. The best combination of the two indexes is put forward. The optimal value ranges of four architectural design factors are summarized.

The order of degree of influence on the natural ventilation effect of atrium is the opening size of the enveloped, the atrium plane shape, the atrium size and the opening height of the envelope. The research range of edge number of atrium is 3~∞, the optimal values is 6 in the range. The research range of proportion of the floor space of atrium is 5~25%, the optimal values is 20% in the range. The research range of proportion of the opening area of the enclosure structure is 5~25%, the optimal values is 20% in the range. The research range of height of the window ledge is 0~4.0m, the optimal values is 3m in the range. When more than 50% of comprehensive score as standard, the optimal range of values are 4~∞ about the edge number of atrium, 15~25% about the proportion of the floor space of atrium and the opening area of the enclosure structure, 3m about the height of the window ledge. The research results have certain reference value for the use of related design personnel.

A simulation study to assess the impact of natural ventilation on the hygrothermal behaviour of a historic library using EnergyPlus

Nuno Garcia Saraiva, Adélio Rodrigues Gaspar, José Joaquim Costa

ADAI, LAETA, Department of Mechanical Engineering, University of Coimbra, Coimbra, Portugal;

Taking a historic library of the University of Coimbra as a study case, this work is focused on assessing the impact and conservation risks of using the main door of its noblest room. From a previous monitoring campaign, it was possible to correlate important fluctuations of the indoor environment conditions with the natural ventilation induced by opening the main door. Consequently, a comprehensive study is required to assess the impact of such ventilation events on the hygrothermal conditions and to study mitigating solutions.

The present work is based on the simulation of the hygrothermal behaviour of this heritage building using EnergyPlus and its airflow network (AFN) model that accounts for the effects of natural ventilation. The thermal model of the building is validated by comparing the results with the data available from continuous monitoring campaigns. Several operating configurations with alternative entrances for visitors are simulated.

The analysis of the simulation data allows (i) to estimate the heat balance between adjacent spaces of the building; and (ii) to assess the impact of the indoor conditions relatively to the conservation requirements. This assessment is based on the short period fluctuations (SPF) of the indoor air temperature and humidity and on the concept of a performance index (PI), which represents the percentage of measured/predicted data that lie within a range defined by thresholds recommended in the most used guidelines for conservation, namely ASHRAE (2015) and UNI 10829 (1999).

The results suggest that the door should remain closed as much as possible. Finally, the need to improve the hygrothermal conditions leaves an open field for further research regarding climate control systems.

Hygrothermal and energy retrofit planning of masonry façade in historic building

Hyun Mi Cho, Young Uk Kim, Seunghwan Wi, Seong Jin Chang, Beom Yeol Yun, Sumin Kim

Yonsei University, Korea, Republic of (South Korea);

In the past few decades, population growth coupled with rapid economic growth around the world has led to significant increases in building energy consumption. Building materials and building energy technologies must be optimized to reduce greenhouse gas emissions and building energy consumption. Energy retrofits of historic building have the potential to reduce building energy consumption, decrease carbon emissions, and maintain comfort for the occupants. Therefore, this study analyzes the retrofit effect by applying retrofit package to improve hygrothermal and energy performance in historic buildings with masonry façade. Infrared thermography was used to evaluate building envelopes and analyze weaknesses to construct a building retrofit packages that combines passive, active, and renewable technologies. The building retrofit packages were able to reduce the risk of mold growth in the interior wall and reduce energy consumption by up to 60%. Results of the energy retrofit analysis indicate that improvements in the window performance and airtightness reduce the heating energy consumption. In particular, the improvement in airtightness drastically reduced heating energy consumption in winter. However, even if the U-value of the window improves, it does not mean that the energy savings will continue to increase. As a result, when the passive technology and the active technology are applied together, it showed optimal energy savings. Building performance retrofits will be the subject of further studies, enabling the continued use and conservation of historic buildings.

Operational Challenges of Modern Variable Air Volume Ventilation Systems: A Case Study

Simo Kilpeläinen, Wertti Bask, Sami Lestinen, Risto Kosonen

Department of Mechanical Engineering, School of Engineering, Aalto University, Finland;

This paper reports the findings and conclusions of a field study conducted on the operation of variable air volume (VAV) ventilation systems installed in eight public buildings in Southern Finland. We performed the study in winter 2018-19 and the studied buildings were all without any reported problems with HVAC systems operation and/or indoor air quality.

We chose one representative space from each building as the location for the field measurements. All buildings had a pressure-dependent VAV system where the air-handling unit keeps the static pressure in the ducts constant regardless of damper positions. The dampers were simple ON/OFF-type in three sites and proportionally controlled in the other five.

We conducted the measurements in two stages. In the first stage, we made a field visit and measured the airflows in all designed operation conditions of the chosen space. For the second stage, we left temperature/humidity loggers to monitor the thermal conditions during normal operation of the space.

The measurement results indicate that out of the eight studied spaces, only one VAV system was performing according to design specifications. While this sounds alarming, the flaws in functionality were mostly minor and none of the sites experienced indoor air quality and/or thermal condition –related problems during the time of measurement. Nonetheless, this result shows that in most of the selected representative cases the potential benefits of VAV were partially lost due to malfunctioning systems.

The most common reason behind the malfunctions were improperly set/balanced supply and exhaust airflows. Differences between measured and design airflows were greater than 10% in all but one of the studied spaces. Another common fault were incorrect temperature/CO_2 set points for boosted airflows, which caused the systems to run too much in normal or boosted mode depending on the case. Other findings included reverse polarity in dampers (closing instead of opening when boost was needed) and design airflows beyond the measuring range of the airflow sensors.

Our findings based on the studied set of buildings indicate that while no dramatic malfunctions were observed, there are many problems related to the operation of VAV systems. In some cases, the systems were poorly designed whereas in others they were commissioned incorrectly and not properly tested during the final inspection and/or maintenance to spot the faults. VAV systems are by nature more delicate and complicated than conventional constant air volume (CAV) systems. Hence, it is imperative that all parties involved (designers, commissioners, inspectors, maintenance personnel) are properly trained to understand how the system should work and how to ensure it does so. In addition, it is very important to monitor the performance of the system regularly, as the faults do not necessarily affect conditions sensed by the users of the spaces.