Conference Agenda

15th ROOMVENT Conference

Session

CS2: Case studies 2

Session Chair: **Vincenzo Corrado**

Presentations

On-site measurement and numerical investigation of the airflow characteristics in National Aquatics Center

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The National Aquatics Center is one of the landmark buildings of the 2008 Beijing Olympic Games and will serve as the venue for the curling competition in the 2022 Beijing Winter Olympics. It is characterized by large space building, ethylene tetrafluoroethylene (ETFE) cushion structure, and various regions with different functions, which are prone to serious problems of air infiltration and regional crosswind. On-site measurement and simulation methods are combined in the present research to investigate the air infiltration of this special building and its interior competition hall in winter. The overall air inflow rate of the building was found to be as high as 261,000 m^3/h, while that of the competition hall was 221,620 m^3/h. The infiltration air flowrate was much higher than the overall needs of the occupants for outdoor air and also lead to uneven distribution of the thermal environmental field and excessive air infiltration load. A multi-zone airflow network was established using CONTAM, whose deviation rate was within 25% verified by the measured data. The model was then used to analyze the influence of transformation methods on air inflow of the whole building and the competition hall. By blocking the east shutter and open door D5 instead of D1, the air inflow rate of the building could be reduced by as high as 33.4% and the ratio for the competition hall is about 16.2%. The present study is believed to be beneficial for the energy-efficient operation of this special building.

Comfort analysis and improvement in large Atrium: the case study of Angelo Hospital in Venice

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This paper shows the study phases for improving thermal comfort, carried out through Computation Fluid Dynamics simulations, in the outpatient waiting area of the Angelo Hospital in Mestre. The hospital, built in 2004 and started operation in 2008, is characterized by a large hall confined by an inclined glass window exposed from East to South-West, without solar shading. The study area is located on a platform located on the 1st floor within the large volume of the atrium exposed to solar radiation. The thermal comfort in the summer season in this area is very bad. To improve the comfort of users with non-structural interventions, the Venetian healthcare company (Ulss 3 Serenissima) has solicited both the Università Iuav di Venezia and the STEAM company in order to collaborate together, propose and implement micro-climate improvement interventions in the area.
Università Iuav di Venezia developed the comfort analysis by using CFD simulations results,in particular Large Eddy Simulation is employed. The LES method captures directly, through a non-stationary 3D simulation, the spatial and temporal turbulent scales of larger dimensions, asking a suitable model, the SubGrid Scale model, the task of taking into account the effects of smaller turbulent scales not resolved by the LES. The solution methodology is suitable for thermal flow simulations, so it is suitable for this case study. The geometry of the area is quite simple so the uniform and structured mesh and the Immersed Boundary Method can manage to solve the problem.
STEAM company, previously designer of the hospital's air conditioning systems, took part in the choice of the configurations to be modelled for the executive project air conditioning system and for the solar shading device to be added to the study area.

The reference configuration, modelled by CFD, consists of the addition of 4 fan coils in the study area, coupled with the installation of a 3 m high metal casing with a slightly rounded shape used for solar shading and lateral confinement for cooling the area. In this phase of analysis only on a portion of the gallery is studied, before applying the final solution to the whole gallery.
Then 3 other solutions to improve comfort are proposed, by increasing the number of fan coils and changing their distribution in space, adding some radiant panels arranged on the walls, and inserting a physical confinement (like doors or air-jet) on the south side and the north side of the study area.

The CFD simulations show which are the potentialities of the initial proposal, the reference configuration, and also highlight some critical issues that could be linked to the position of the fan coils with respect to the metal casing. So, the subsequent intervention proposals, developed in the three proposed configurations, and their comparison allow us to identify the best solution in terms of thermal comfort and to exclude other propositions.

Research of Thermo-Active Building System with the Floor-mounted Water Panel. （Part 1） Development and Examination of the Floor-mounted Water Panel

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The thermal active building system (TABS) is a radiant air conditioning system with excellent comfort and less energy consumption. Recently TABS has begun to be applied in Japan.

In previous TABS, water pipes are embedded in the central concrete core of a building’s construction. However, since the piping is embedded in the slab, there is a problem that it is difficult to maintain and replace the piping.

In this study, we develop a method to cool and heat the slab using a cold / hot water panel laid directly on the upper surface of the slab. The lower surface of the slab is used for radiation heating and cooling on the lower floor. In this air conditioning system, radiant air conditioning and underfloor air distribution (UFAD) system using desiccant air conditioner are coupled. The UFAD system performs ventilation and heat load processing beyond the radiant air conditioning capacity.

The system developed in this study will be installed in an office building scheduled for completion in October 2020. Through this project, capacity verification, operation pattern, energy saving effect prediction and post-operation evaluation will be conducted.

In this report, the outline of this system using a floor-mounted water panel is introduced, and the result of the radiation capacity verification using a test piece is shown.

The experiments were conducted to verify whether the lower surface of the slab can be cooled and heated to the target temperature with a floor-mounted water panel. The target temperature was set to 22 degrees C for cooling and 27 degrees C for heating with reference to other projects using TABS with embedded water piping. The temperature of the lower surface of the test piece slab reached set temperature in about 7 hours.

The radiation capacity measurement test was performed in a way based on ARCH 2017 CHTRSVer.1. This test standard established by the Association of Radiant Cooling and Heating Systems of Japan defines measurement conditions and measurement methods for determining the cooling and heating capabilities of ceiling radiant panels using water as a medium. This standard refers to the European Standard (EN).

The room cooling capacity per installed panel area was 30-35W / ㎡, and the room heating capacity was 50-60W / ㎡. The ratio of the amount of heat transfer between the lower and upper panel sides was 77%: 23% when cooled and 84%: 16% when heated respectively.

From the test results, it was confirmed that the floor-mounted water panel has sufficient slab cooling and heating performance to build TABS.

Case study of possible thermal comfort risks when centrally controlled demand response is introduced in a district heated public building

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Demand response consist of a group of methods where end-user's energy usage is modified to decrease CO_2 emissions of energy production and to provide cost savings for energy producers and building owners. While demand response of electricity has widely been studied and also used in many countries, research on demand response of district heating has just begun some years ago. But, it is obvious already at this point, that demand response will play a significant role in smart district heating systems in future. However, thermal comfort should not be sacrificed when demand response is introduced in district heating. Heating power of space heating in a district heated building could be controlled at centralized or decentralized levels by using e.g. dynamic district heat price. Decentralized demand response control refers to adjustments of mass flow of water radiators on room or zone level by e.g. electronic IoT thermostats, while centralized control refers to adjustments on system level e.g. inlet water temperature control of radiator network. The goal of this study was to examine how much deviations could be incurred in the inlet water temperature and how that affected user's perception on indoor temperature. Different centralized demand response control algorithms and settings were tested in a campus building of Aalto University in Finland by controlling inlet water temperature of radiator network and collecting indoor temperature data of all the rooms by a building automation system. Feedback on acceptance of indoor temperature was also collected by internet based survey and feedback buttons during the study. To ensure that all the 115 occupied rooms kept within the required temperature range, the control depended, in addition to dynamic hourly district heat price, also on the mean air temperature of the coldest and warmest rooms. When mean air temperature of the coldest rooms fell below 20 ℃, or mean air temperature in the warmest rooms rose over 24.5 ℃, a normal control curve for inlet water temperature was used. Results show that a range of variation of indoor temperatures is high between the rooms, but the temperatures during the periods without demand response control did not drastically deviate from the test periods when the demand response control was implemented. It is also evident that room air temperature of individual rooms is not possible to control accurately by using centralized demand response control. It seems, it could be possible to change inlet water temperature of radiator network quite a lot (about +10/-20 °C) from the normal without users notice it. However because of relatively low level of responded persons, more research is required to confirm this conclusion.

Analysis of the Potential of Smart Ventilation Controls: Application to a University Classroom in Bolzano

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Proper room ventilation is crucial in order to ensure adequate Indoor Air Quality IAQ in environments with high people densities, such as school classrooms. In many cases, natural ventilation solution are insufficient to achieve prescribe IAQ conditions and mechanical ventilation systems have to be adopted. This, however, implies additional energy costs which may be reduced by means of advanced control solutions, such as occupancy based HVAC system schedules, CO_2 concentration controls, etc. Furthermore, mechanical ventilation is sometimes insufficient to keep low CO_2 concentrations in environments with high people densities and natural ventilation through short opening of windows is required anyway, with impacts on people's comfort (e.g., local discomfort due to draughts) and building energy efficiency (e.g., thermal losses and sudden decrease of room temperature).

In this research, we used a classroom belonging to the Living Labs of the Free University of Bozen-Bolzano as a case study and performed long-term measurement campaigns. The room is conditioned primarily through the main air conditioning system serving the thermal and the fresh air needs for whole floor. As a secondary system, two radiators are present. Air temperature and humidity and CO_2 concentration were recorded for two winter seasons, on a 10-minute timestep. Analyzing humidity and CO_2 data, typical behaviors regarding windows openings were determined.

After that, an EnergyPlus model of the classroom was developed, calibrated against the measurement data during the first winter season and validated against the second one. The calibrated simulation model was then exploited to investigate different control scenarios related to the supplied flow rates of fresh air, such as occupancy-based and CO_2 controls, aimed at reducing the number of windows opening. Energy performances were compared in the different cases, as well as IAQ and thermal comfort conditions and the impact of environmental conditions on occupants' performance loss.