Conference Agenda

15th ROOMVENT Conference

Session

VN: Ventilation & NZEB

Session Chair: **Enrico Fabrizio**

Presentations

The most efficient ventilated Dutch nZEB Schools

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Children spent up to 30% of their time in classrooms to pursue their academic goals. Classrooms are the place for students to learn and get educated; the atmosphere is playing an important role in children's learning ability, ability to focus and spend time in a healthy atmosphere. Never the less design a school ventilation system is difficult as the results from evaluation of schools proves.

Understanding the key issues, the everyday practice and their applications is not an easy thing. Never the less almost nowhere is there a bigger lifelong benefit of enhanced engineered environments as in classrooms.

It has been generally established that maintaining good IAQ requires more energy for ventilation and low building insulation could lead to excessive energy loss, so these factors will be examined in order to validate and confirm such correlation This article briefly discusses 22 schools in the Netherlands all in the top ranking of the most energy efficient schools. Various factors have been measured that can give incentive to conclude the indoor air quality (IAQ) in relation to the power consumption of the schools. There are different factors when it comes down to evaluating aspects of a school so this study is focused on IAQ evaluation based on CO_2 concentration and comparing energy consumption of different facilities compared with the IAQ.

Design and operation of an innovative HVAC system for a net-positive energy Solar Decathlon house

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This paper presents the design and operation of a novel heating, ventilation, and air conditioning (HVAC) system for a net-positive energy Solar Decathlon (SD) house as the entry of team University of Wollongong (UOW) for Solar Decathlon Middle East (SDME) 2018 competition. Team UOW got second overall ranking in the SDME competition. The HVAC system mainly consists of an air-to-water heat pump, an Energy Recovery Ventilator (ERV), a dehumidification /humidification heat pump, water-based Thermal Energy Storage (TES) using Phase Change Material (PCM) and radiant panels. The HVAC system was developed to address the challenging climatic condition in the competition site to provide energy-efficient indoor space cooling and acceptable indoor thermal comfort together with the ability of peak load shifting. This next-generation HVAC system had been running during the SDME competition period and successfully maintained indoor thermal comfort conditions which made team UOW won first and second places in the thermal comfort and energy efficiency sub-contests, respectively. In this paper, we introduce this HVAC system and discuss its operation during the SDME competition.

Coupling a horizontal heat exchanger with an all in one machine for heating and cooling a single-family house in a mild climate

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Heat, ventilation and air conditioning (HVAC) systems are considered of great importance in the building sector, as they represent a significant part of the energy demand in buildings. Moreover, they are deeply related to indoor environment quality, which strongly affects occupants' quality of life. This paper presents the analysis on a compact all-in-one and plug-and-play machine providing heating, cooling and mechanical controlled ventilation in a low energy residential building. In particular, the system is composed by a heat pump connected to a heat recovery unit which can pre-heat the fresh air and contribute to the DHW production. In the present work an additional heat exchanger set in the building's basement has been included into the system, in order to pre-heat or pre-cool the outdoor air before entering the heat recovery unit. The compact energy system has been mathematically modelled and its operations have been monitored in a real building recently constructed. The model of the system has indeed been implemented on the basis of a report test on the operating performance of the machine provided by the constructor, and the tuning has been realized according to the real operation tests, properly done for this analysis. The real case study is a low energy building located in Udine (North-East of Italy), inhabited by four people and with total floor area of 240 m^2. The simulated annual energy performance of the all-in-one machine have been obtained and the layouts of the system with and without the ground heat exchangers have been compared. Dynamic simulations have been carried out to examine the indoor thermal comfort for both the configurations, in order to verify the possibility to employ the basement heat exchanger for improving, besides the energy performances, also the indoor environmental quality.

Performance Verification of Combined System of Ceiling Radiation Air-Conditioning and High Performance Windows in Cold Regions inWinter

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近年、日本の関東地方南部に建設されたオフィスビルでは、省エネと快適性を実現するために、天井放射空調システムの採用が増えています。現在、寒冷地でこのシステムの導入が試みられています一方。オフィスビルでは、多くの場合、日光の利用と可視性のために大きな窓が必要です。その結果、外皮の断熱性能が低下する場合があります。特に冬の寒い地域では、周辺地域で熱伝達負荷が増加します。したがって、外皮の断熱性能は室内の熱環境に大きく影響します。

本研究の目的は、冬の寒冷地における天井放射空調と高性能ウィンドウ（AFW）やプッシュプルウィンドウ（PPW）などの組み合わせシステムの有効性を明らかにすることです。まず、冬の寒冷地のオフィス次に、定常CFD解析に基づいて、この天井放射空調システムの熱性能も推定し、CFD解析の有効性を測定結果と比較することにより検証しました。最後に、定常状態CFD分析を使用してケーススタディを実施しました。ケーススタディでは、評価は、冬の寒冷地のオフィスビルに対流式空調を導入する場合と天井放射空調システムを導入する場合を比較することによって実施されました。さらに、この天井放射ケースには高性能ウィンドウが導入されました。この研究から、井放射空調システムと高性能窓の組み合わせシステムの有効性が示されましました。

実験結果と比較することにより、定常CFD解析の予測精度が高いことが検証されました。以下の結果が得られました。

1）天井放射空調システムの導入により、室内ゾーンの温熱環境が改善されることが確認された。ただし、コールドドラフトは周辺ゾーンで抑制されず、不均一な熱環境が確認されました。窓の断熱性能を改善することが提案されました。

2）この複合システムを利用することにより、断熱性能が向上し、冷風が抑制されました。また、高性能窓でブラインドを開くと断熱性能は低下しましたが、断熱効果は十分でした。

3）この複合システムを利用することで、周囲と室内の両方の室温を快適に制御することができました。

Potential of demand-controlled ventilation in different space types in a University hospital building: A case study

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The buildings sector is among the most energy-consuming sectors in EU and worldwide. It has been estimated that up to 30-40 % of the primary energy is consumed by HVAC systems. Especially hospital buildings have high energy demand due to specialized needs and 24/7 usage. Nevertheless, there are means to reduce the HVAC system energy consumption in hospital buildings. One potential method is demand controlled ventilation (DCV) which is generally considered as one of the primary approaches to reduce building energy consumption. E.g. in isolation rooms ventilation is typically running on full speed even when unoccupied, giving great potential for energy savings via demand controlled ventilation.

Different room types, their share of the floor area, used flow rates etc. of a Finnish university hospital building were gone through in this study. The focus was on identifying room types with high area related energy intensity with respect to ventilation. A wireless sensor network was installed into the hospital to monitor indoor conditions, like temperature, CO_2, relative humidity etc., in various room types. Based on the estimated occupancy (assessed by CO_2 measurements), the potential of reducing the ventilation flow rates was assessed and compared between different room types. The room types were ranked by the net flow rate reduction potential. E.g. isolation rooms showed high flow rate reduction potential. This analysis can serve as a general basis for more detailed potential analysis of DCV methods carried out e.g. by building simulation tools. This study is part of a joint research project between Turku University of Applied Sciences and RWTH Aachen University related to DCV methods in healthcare settings.

Coupling energy and numerical analyses for evaluating possible ventilation strategies in a NZEB

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Nowadays, in nearly-zero energy buildings (NZEB), whilst the targets of energy savings and CO_2 emission reductions can be easily achieved by designing efficient envelope and systems, occupant behaviour still represents a challenge, due to its high impact on consumptions. Becoming the role of occupant increasingly important, the evaluation of comfort conditions to be guaranteed inside the buildings are necessary since the project phase. Moreover, according to the revised Energy Performance of Building Directive (EPBD), introduced in 2018, a new focus on indoor environmental quality (IEQ) is fixed, putting in the centre the need for optimizing comfort, health and well-being. In this context, the control of ventilation can greatly affect the IEQ improvement, creating the optimal internal conditions and guaranteeing occupants' comfort and health.

However, the simulation of the phenomenon of ventilation in the built environment is not an easy task in the traditional energy simulation software that are commonly used during building design phase. Indeed, the multi-zonal model, typically used in this group of software, is not always enough, since it usually assumes that the air is well mixed in the different zones. For this reason, such models are not able to predict the local thermal comfort distribution in the occupancy zone. To face this challenge, computational fluid dynamics (CFD) is often implemented, being able to decompose the building zones into a large amount of control volumes, providing a detailed description of the airflows and, thus, allowing a more in-depth analysis of temperature and air distribution. Conversely, CFD software is not able to provide insights in terms of energy consumption and occupant behaviour.

The paper aims to investigate the integration of energy CFD simulations into a single computational framework, in order to evaluate how different ventilation strategies (i.e. natural, mechanical, hybrid), coupled with efficient heating and cooling systems, can provide diverse conditions of local thermal comfort and air quality, as well as different energy performances. Focusing on the case of a residential NZEB in Piedmont Region, the so-called CORTAU House, the study is performed by means of DesignBuilder, a software able to integrate 3D modelling, hourly-based energy simulations, and an internal CFD module in a single environment. Different scenarios are performed, simulating typical winter and summer conditions, and typical indicators for thermal comfort and air quality are assessed.

Results show that, although natural ventilation seems to be an effective strategy thanks to the moving of fresh air into the building, the indoor air distribution is not homogeneous. Furthermore, in winter season, local discomfort conditions can be generated in the proximities of open windows; on the contrary, during summer, the introduction of air at lower temperatures may be useful for passive cooling strategies. The mechanical ventilation strategy appears to be the best solution, guaranteeing the satisfaction of thermal neutrality conditions. Indeed, the use of this latter strategy, even if more expensive in terms of installation costs and characterized by higher energy consumption, can assure an adequate indoor air distribution and air change and satisfy thermal comfort and indoor air quality conditions.

Energy efficient heating and cooling ventilation system with integrated PCM heat storage units

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Due to increased user requirements, changed building types as well as due to the advancing climate change, there has been a significant increase in the cooling energy demand for buildings in recent years. In order to ensure this increase in an energy-saving way and at the same time to further reduce the demand for heating energy and the consumption of fossil fuels, it is necessary that buildings are considered as one system with their surroundings and the available environmental energy.

However, as this energy is, due to daily cyclical and seasonal fluctuations, not available in constant amounts and at a constant temperature level, the storage of these available environmental energies is playing an essential role to achieve a highly efficient system. The storage temperature has a significant influence on the efficiency of the systems.

This article will show how this can be performed with a ventilation system with integrated latent heat storages, coupled with conventional technologies to form a complete building system. Latent heat storages are already sporadically used in the building sector, but they are often not efficient due to the small surface for heat transfer or to the small quantity of storage material that can be applied. In addition, the existing technologies are often not well controllable and not integrated into an intelligent complete building concept. For this reason, this new approach is now being pursued to eliminate these deficits. The focus is therefore on the key component of the planned complete building system, the novel latent heat storage units, which are loaded and unloaded via a ventilation system with integrated heat exchanger and water circuit. These latent storage units have been developed by Innogration GmbH, who are also a partner in this project. The heat extraction and dissipation for the heating and cooling of the building occurs via the ambient air. As phase change material (PCM), paraffins, salt hydrates or fats can be used, which melting and crystallization temperatures can be variably adjusted within a certain temperature range and which can be inserted without encapsulation. In the framework of the overall system, two different storage types will be developed. Smaller decentralised storage units, which ensure daily cooling of the building in the summer, and larger central storage units, which contribute to seasonal heating during the winter months. In this paper first results of laboratory experiments for loading and unloading of the novel decentralised storage units using different types of PCM will be shown. The storage temperature is at a level similar to the ambient temperature.

All-air system for heating and cooling in residential buildings: a simulation-based analysis

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Energy saving and CO2 emissions are a pivotal environmental priority of the last decades. The buildings sector is responsible for about 40% of total energy consumption. Some of the open options to decrease this value are improving the quality of building envelope and using energy-efficient heating and cooling technologies, also based on renewable energies. On the other hand, HVAC systems should provide high indoor air quality for the users as well as the control of heat and latent gains. In this work, an all-air system for both heating and cooling of residential dwellings is investigated. The all-air system was modelled through the software TRNSYS, simulating the building and the plant at the same time. To consider the effect of the weather, annual simulations were carried out in three different locations: Helsinki, Milan and Rome. Moreover, the all-air system was compared with a radiant floor system in the same conditions. The results outline as the proposed all-air system is an interesting solution when the building envelope is optimized to control the heat losses and the solar gains.

DESIGN AND TESTING OF A FLEXIBLE TEST BED FOR THERMAL AND FLUID MECHANIC INVESTIGATIONS OF DOUBLE SKIN FAÇADES

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The paper presents the concept, design, and preliminary tests of a novel experimental testbed designed to investigate the performance of double skin façade (DSF) systems. The testbed is a flexible mock-up, equipped with a combination of different actuators that allows, in combination with a climate simulator, the experimental assessment of different configurations of DSF,

The test bed is equipped with more than ninety sensors to enable the measurement of thermal and fluid mechanical phenomena in the DSF. A comprehensive description of the design of the data acquisition system is presented in this paper, along with the software for real-time data acquisition and visualization, developed in LabVIEW. The first results from preliminary measurements of the thermal transmittance (U-value) and solar factor (g-value) of some configurations of DSF are also reported to highlight the first take-home lessons from the use of this test rig.

Comparison of Cooling Power and Thermal Response Characteristics of TABS depending on Installation Position of Piping

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建物のフレーム（主にコンクリートスラブ）を輻射および蓄熱部品として利用するサーモアクティブビルディングシステム（TABS）は、1990年代後半からヨーロッパで頻繁に導入されてきました。近年、日本ではオフィスビルにTABSを導入するケースが増えています。TABSは、建物の熱容量を使用して、高い省エネ、熱的快適性、およびピークシフト性能を備えています。また、スラブは天井なしで直接冷暖房されるため、吊り天井を設置せず、各階の高さを低くすることができるというメリットもあります。一方、配管の設置位置については、ヨーロッパではスラブ中央に埋められた配管が広く使用されていますが、日本ではスラブの上下に設置することで、地震の場合の漏水リスク。しかしながら、配管の設置位置により、輻射電力や熱応答特性が変化する可能性があります。本研究では、CFD解析によるケーススタディを実施し、一般的なオフィスビルのスラブの上部、中央、下部に配管を設置した場合のTABSの予備性能を比較しました。冷却能力については、給水温度、配管ピッチ、水流量のケーススタディを実施し、ステップ応答法を用いて熱応答特性を比較しました。また、MATLAB / Simulinkを使用して3種類のTABSの最適制御方法について基礎研究を行い、従来の制御をTABSに適用すると、エネルギー消費量が増加したり、室内の熱的快適性が低下したりします。以下の結果が得られました。1）配管を低くするほど冷却能力が高くなります（図1）。これは、スラブ底部に配管を設置することで、配管から室内空間への熱抵抗が低下したためと考えられます。2）配管底部に設置した場合、配管付近の相対湿度が95%以上（給水温度16℃）で結露の危険性が高いため、運転段

階で除湿などの対策が必要でした。3）配管の設置位置によって熱応答特性に大きな違いがあり、配管を低く設置することで遅延時間が短くなり、応答性が向上しました（図2）。