COMFORT AT THE EXTREMES:

COVID, CLIMATE CHANGE AND VENTILATION

Royal College of Physician of Edinburgh

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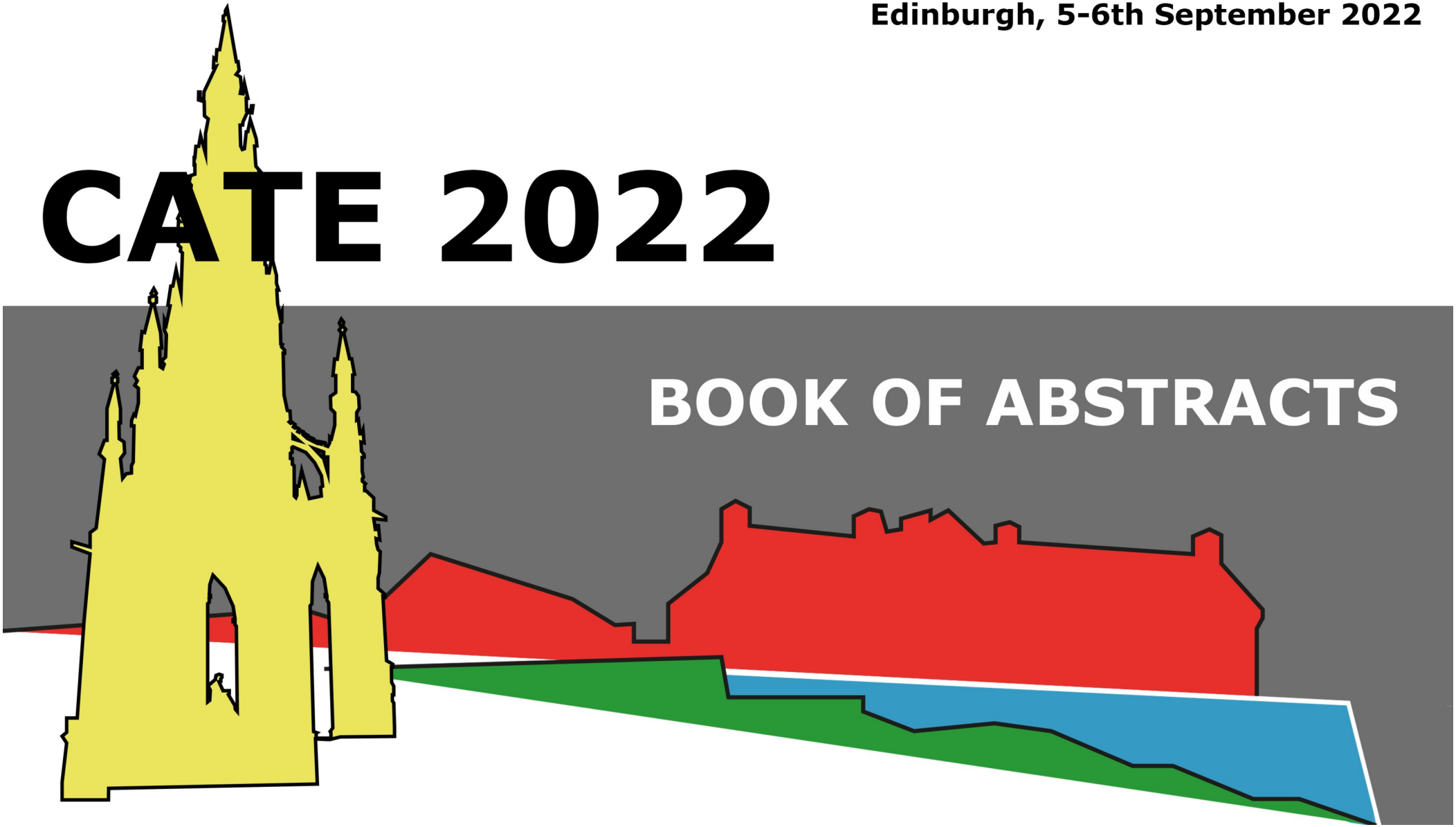

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Humans and Buildings in times of climate change - a perspective on resilience

Hannah Pallubinsky

University of Maastricht

As comfort seekers, we avoid being exposed to temperatures outside of our comfort zone. However, in the light of climate change and the need to drastically reduce our carbon footprint, we need to rethink many of our habits. Enhancing our own human resilience, by training our bodies' thermoregulatory system, presents an opportunity to reduce energy use, while at the same time, improving our health. Allowing for more thermal variation in the indoor environment has the potential to enhance human thermal resilience, while also saving energy and decreasing CO2 emissions.

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Indoor environmental quality evaluation of lecture room environments: changes due to infectious disease risk management

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The global COVID pandemic has seen a significant change in ventilation practices, where the need to ventilate buildings has been put centre stage. Longer-term ventilation approaches are likely to incorporate hybrid ventilation strategies to deal with the multi-objective challenge of enhanced comfort resilience in the face of a warming climate but may also need to rely on heat recovery technologies to ensure energy efficient ventilation in wintertime. There are also several buildings which are not likely to undergo energy efficient upgrades for some time and risk management strategies are being implemented in these buildings. Improvements in indoor air quality in existing educational buildings more generally are likely to improve the students learning performance, attendance and could lead to a safer internal environment. Despite this need, a recent review of the literature cites limited examples of evaluations of air quality in university settings. This paper will present an indoor environmental quality evaluation of ten university lecture rooms both before and after changes in ventilation behaviour and systems, that were accelerated due to the COVID-19 pandemic. Preliminary results indicate substantial reductions in indoor carbon dioxide concentrations in all lecture rooms in the post pandemic environment, with mixed changes in indoor temperatures. Mean reductions in carbon dioxide concentrations of between 28% and 53%, and maximum reductions in carbon dioxide concentrations of between 31% and 84% were observed due to behavioural and system changes. These reductions demonstrate the impact these changes have had on these indoor environments and by extension on the infectious disease risk at lecture room level which could lead to an improvement in student learning performance also.

Covid Risk airborne, a tool to test the risk of aerosol transmission of SARS-CoV-2 under different scenarios: a pre-school classroom case study

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The COVID-19 emergency has shown that airborne transmission of SARS-CoV-2 is especially relevant in poorly bad ventilated spaces with high occupancy density, like non-university classrooms, a widespread space typology with very sensitive occupants. Of these, pre-school classrooms stand out, due to the vulnerability of children. Thus, this study has estimated the existing transmission risk of SARS-CoV-2 in a pre-school classroom, due to the especial vulnerability of the children, regarding to different indoor CO2 excess levels. This statistical evaluation has been performed through 68 calculation hypotheses, grouped into 4 cases, according to who is the primary infected occupant (one of the children or the teacher) and depending on whether the teacher wears a mask or not. It can be concluded that, to have acceptable risk conditions for airborne disease transmission (with one infected occupant) in pre-school classrooms, it is necessary to maintain sufficient ventilation conditions to reach a maximum average excess CO 2 level exhaled of 150 ppm, while teachers should wear well-fitting N95 respirators. In this way, infection risk is much higher when the primary infected occupant is the teacher and is wearing no mask or a surgical one —5 or 6 times more.

On Higher Ventilation Rates and Energy Efficiency in Post-COVID-19 Buildings: A New Thermal Comfort Model based on Indoor CO2 Levels and Temperature

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In recent work, a Bayesian model was developed to predict occupants' thermal comfort as a function of thermal indoor environmental conditions and indoor CO 2 concentrations. The model was trained on two large IEQ field datasets of physical and subjective measurements collected from over 900 workstations in 14 buildings across Canada and the US. Posterior results revealed that including measurements of CO 2 credibly increases the prediction accuracy of thermal comfort. In this paper, the new predictive thermal comfort model is integrated into a building energy model that simulates an open-concept mechanically-ventilated office located in Vancouver. Several occupancy profiles are investigated to reflect and compare post-COVID-19 occupancy schedules. This paper proposes a solution for building managers, who are under pressure to increase current ventilation rates during the COVID-19 pandemic, to make changes to the building's control system so that fresh air is increased with minimal energy increase and with no effect on thermal comfort. For instance, simulation results suggest that CO 2 levels can be lowered from 800 to 500 ppm while maintaining the current levels of thermal satisfaction if the heating setpoints are lowered from 24 to 21°C. The heating energy demand will only be increased by 32% compared to an increase of 81% if the indoor air temperature were kept at 24°C.

Designing Health Structure in Emergency Contexts. Natural Ventilation as Response to COVID-19 Pandemic.

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The importance of ventilation as response to pandemic emergency is a concept that trace its roots back in the history of human pandemic and it remains valid up to the current covid-19 emergency. Yet, extreme climates, scarcity of resources, and poverty might impinge heavily on the ability of designing a built environment fit for the purpose of guarantee environmental conditions appropriate to respond to pandemic. Often, in contexts of scarcity and hot climates, safety parameters of ventilation in buildings are achieved as ersatz, rather than by design, due to the difficulties of managing economic resources, thermal characteristic, and ventilation requirements. Keep buildings cool and well ventilated seems to be still a challenge.

This work presents a study carried out to design health structures - both permanent and temporary – in response to covid-19, in the Global South. Specifically, the study focused on: 1) the design of a Severe Acute Respiratory Infection (SARI) Treatment Center (hospital for airborne diseases) in the city of Dori in Burkina Faso, and 2) the design and test of High Performance Tents.

Natural ventilation is studied by mean of transient dynamic simulations, using Energy+ software, and the probability of contagion are evaluated applying the Gammaitoni-Nucci model, based on the original Wells and Riley approach. The yearly dynamic simulations are supported by specific 3D airflows analysis by mean of CFD (Computational Fluid Dynamic), with the intent to underline the effects of different internal partitions configu- ration. CFD is also used to evaluate pressure coefficient at the openings. Through this ventilation study and morphological design proposal, this work provides compositional, technological and environmental solutions to overcome limits due to the need of coexistence of ventilation and thermal control, and socio-economic limitations. The significance of this work is the ability to show the importance of the balance between passive ventilation, architectural design and behavioral organization by design. Such approach can play a critical factor to achieve healthy and resilient environment, and offer a feasible solution to the need for health buildings in hot climates and poor contexts.

Post-Occupancy Assessment and the Integrated Design Process: the Architectural Requalification of a Family Health Strategy (FHS) on the João Domingos Netto settlement, in Presidente Prudente/SP, Brazil

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The adequate architecture must consider the project's location and its local climatic characteristics. However, it's common the standardization of some Brazilian's small health spaces, as it shows at the study object - the Family Health Strategy (FHS) on the João Domingos Netto settlement in Presidente Prudente/SP, Brazil. This case is different since the neighbourhood's planning covered two health units in opposite sides. Nevertheless, during the first construction, due to unforeseen events a small part was added to the already existing structure. Thermally uncomfortable, undersized internal spaces, unqualified outdoor spaces and a lack of enough natural ventilation internally are problems applied to the FHS. In the pandemic context, became even more urgent to fix these problems. Thus, this work aims to develop a requalification proposal for the study object, so, post-occupancy assessment methods were used to evaluate whether the design was meeting the users' needs. Having known that, simulations and calculus were made in both current situation and proposal. This approach showed the importance of technology and integrated design process as a tool for decision making; in addition, the proposed design showed sensible reductions on incident radiation, consequently, heat gain, and an important increase on natural ventilation internal flow.

Field measurement of human thermal comfort in winter across China

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Energy use in building for heating depends on the thermal comfort requirements of the occupants. Personal thermal comfort and clothing behaviours in buildings during winter were studied. The Chinese Thermal Comfort Database contains 41977 sets of data which are from five climatic zones: Severe cold, Cold, Hot Summer and Cold Winter, Hot Summer and Warm Winter and Temperate zones. The database includes indoor and outdoor thermal environmental parameters and thermal responses of the occupants. 14646 sets of data from winter conditions in buildings were screened for analysis. Clothing insulation in Hot Summers and Cold Winter region was classified into seven levels for further studies. Logistic regression was adopted to estimate the change of thermal sensation in the response to indoor operative temperatures. The results indicated that the neutral temperature ranges for occupants in 1.0-clo garments were [17.0 - 24.1 °C] in Severe cold zone, [15.4 - 24.0 °C] in Cold zone and [15.0 - 23.1 °C] in Hot Summer and Cold Winter zone. Adding clothing insulation improves occupants' thermal comfort in winter, but the limitation is maximum clothing insulation of 1.9 clo. The study provides a reference for the creation of comfortable thermal environments with a low energy use.

Thermal indices and comfort in low- and middle-income residences during dry seasons: A case study of Dutse Alhaji and Lugbe in Abuja, Nigeria.

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This research examines thermal indices and comfort in low- and middle-income residences during dry season in Abuja, a hot and humid climate. The study assesses selected residences in Dutse Alhaji and Lugbe within the Federal Capital Territory (FCT) in Abuja. The principal focus of the study is to evaluate thermal indices and comfort in various seasons. To accomplish the research goals, the study considered environmental monitoring of variables, comfort surveys, and mathematical models to compute the thermal indices in different buildings in the study locations. The analysis showed that the thermal indices exceed the applicable thresholds for heat stress and overheating. The mean thermal sensations across the case studies in the dry season showed either "slightly warm" or "warm". In Lugbe, the neutral and preferred temperatures varied from 28.8°C-29.5°C during the dry seasons. While in Dutse Alhaji, the temperatures varied from 28.0°C-30.1° dry season. The temperatures were not within the acceptable bands of ASHRAE-55, CIBSE TM52, and EN16798-1 thermal comfort models. The study suggests residents are vulnerable to heat stress in different periods of the day. The research recommends the integration of passive design interventions that are more affordable, accessible, and user-friendly.

A field investigation on thermal comfort in free-running school buildings during the summer season in the temperate climate of Nepal

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A healthy indoor environment is crucial for students' academic performance and health in schools. Nepal has dynamic environmental conditions according to geography and climate. The school buildings designed in these areas do not use any heating or cooling devices to maintain the thermal environment and, thereby, thermal comfort. As no serious concerns were raised about students' thermal comfort, this study examined the current condition of students' thermal comfort in school buildings in the temperate climatic region of Nepal, aiming to address how sensitive students are to temperature variations inside the school buildings. A survey was conducted on the indoor thermal environment and the associated thermal comfort survey was administered to 246 secondary level students between 12 to 18 years of age, 40% (n = 101) males and 60% (n = 145) females, in seven classrooms in three free-running schools during the summer season in 2019. They voted three times during the regular lecture: in the morning, midday, and afternoon. Under the free-running condition, the indoor globe temperatures were close to the outdoor air temperatures, and the indoor and outdoor water vapor concentrations were correlated with each other. The results showed that approximately 64% of the student's responses were within the central comfort zone of ASHRAE, indicating a preference for a cooler indoor environment. The Griffiths method predicts that the student's mean comfort temperature is 26.9 °C. This study explored the adaptive thermal comfort of students in free-running school buildings in Nepal during the summer.

A Review on Adaptive Thermal Comfort and Energy Saving in Residential Buildings

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The global temperature is expected to rise by 1.5°C or more over the next 20 years. This can cause thermal discomfort, especially in summers and highly-urbanized area. The heating, ventilation, and air-conditioning (HVAC) systems consume about 50% of building energy in order to provide a more comfortable indoor thermal environment. As the building plays a crucial role in creating a safe and comfortable living environment, ensuring a better trade-off between energy consumption and the comfortable indoor environment is important. It is urgent to reduce energy consumption without having to sacrifice occupant's thermal comfort and explore the applicability of thermal comfort standards while determining the impact on energy consumption in residential buildings. This paper aims to clarify the variation of comfort temperature, relationship between comfort temperature with indoor or outdoor temperature and the implication of thermal comfort to energy saving in residential building. As a result, this paper found out that the effects of humidity and air velocity were seldom discussed and the comfort temperature can be estimated from indoor or outdoor temperature. Thus, there is a need for future studies to investigate the effect of humidity and air velocity on residential thermal comfort. A standard approach in designing the future field measurement studies for a different types of built environments, climate, types of building and other factors also need to be considered.

Study on winter comfort temperature based on daily survey in mixed-mode office buildings in Aichi prefecture of Japan

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9 Kansai University, Japan
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People spend most of their life-time indoors where they expect the comfortable environment. Comfort temperature is important to investigate because the chosen office indoor temperatures affect the energy used in the building, and people in thermally comfortable environment are generally more productive. The effects of temperature on comfort are broadly recognized for thermal comfort. Japanese office buildings are well equipped with the air-conditioning systems to improve thermal comfort of the occupant. Various field studies conducted in different parts of Japan has given the comfort temperatures in Japanese offices. The main objectives of this research are to analyse the comfort temperature in Japanese offices in winter, and to investigate the relationship between the comfort temperature and the indoor air temperature.

This study measures the environmental conditions of the office buildings, the occupants' characteristics, objective data of thermal environment and the subjective questionnaires of the thermal comfort. The field data is collected in five office buildings located in Aichi prefecture. We collected 3364 votes for the winter season. Griffiths' method is used to calculate the comfort temperature.

The result suggests that the occupants were found to be highly satisfied with the thermal environment in their offices. Even though the Japanese government recommends the indoor temperature of 20 °C for heating, the comfort temperature was found to be 5 °C higher in mixed mode. The comfort temperature is related to the indoor air temperature. This indicates that the occupants are well adapted towards the given thermal environment of these mixed mode Japanese office buildings.

Climate Change Adaptation Strategies - downtown Amman.

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In line with the climate challenges Amman is facing, innovative solutions should be implemented to uphold various effects and increase the city's adaptive capacity. This study aims to identify the role of Green Infrastructure in climate adaptation, Quraish street in Amman is chosen as a case study to represent a dense urban environment that has a high share of impermeable reflective surfaces and lacks proper vegetation. The research employed a dynamic simulation strategy using computational simulations to quantify the effects of different green infrastructure scenarios on heat mitigation, air pollutants reduction, and stormwater management. The scenario-based approach was used enabling community and expert participation along with site assessment and analysis in the design phase. Results indicate that using planters with dense trees has notable effects on heat mitigation but negligible effects on pollutants concentrations. In contrast, sparse tree canopies showed negligible effects on heat mitigation and also negligible effects on pollutants concentrations. The use of stormwater planters for runoff management showed minimal effects on runoff reductions. In contrast, the green envelope scenario showed notable effects on stormwater runoff reductions and negligible effects on heat mitigations and pollutants concentrations.

The effect of prevailing climate, outdoor pollution levels and ventilation rates on indoor air quality in social housing in Almaty, Kazakhstan

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Increased ventilation rates were one way of reducing Covid risks. However, there are some negative health effects associated with increased air flow rates if the external air is polluted. There have been very few studies of residential indoor air quality (IAQ) in Kazakhstan. For this research existing low-income, mid-rise and naturally ventilated social housing in the city of Almaty were modelled to simulate indoor contaminant levels for different ventilation rates and climatic conditions. CONTAM v3.4 was used to model indoor concentrations of gaseous nitrogen dioxide (NO2) and particulate matter (PM2.5) – chosen for their negative impacts on cardio-respiratory health. Outdoor levels of NO2 and PM2.5 were provided by an air quality monitoring station a few kilometres from the housing. NO2 and PM2.5 levels were estimated to investigate how combinations of weather and ventilation rate might influence IAQ. Combinations of particular wind speeds and directions, coupled to window opening patterns, could lead to indoor levels of NO2 and PM2.5 that were higher than are recommended in health standards. Further work will carry out field monitoring of indoor pollutants to calibrate the accuracy of the CONTAM model and provide data on existing IAQ levels in Kazakhstan's social housing stock.

The impact of local variations in climate on optimum design techniques and discomfort in dwellings of rural villages of SW China

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This paper reports research to aid in the optimisation of redevelopment processes for rural villages in SW China. The stimulus for the paper came from observations of variable outcomes and from missed opportunities to incorporate better climate sensitive design. Issues arise from lack of awareness amongst some stakeholders. SW China, and particularly Yunnan Province, is taken as the focus because of the number of ethnic minorities present which affects how new skills and knowledge might be taken up in rural areas. A number of villages have been visited to collate data and observations. Villages that were identified in government programmes for potential redevelopment were chosen for study. Meteonorm Software was used to augment climate data for the sites and the Climate Consultant software used to identify most promising options for changes to design. Analysis was carried out for contemporary climate and for future climate with RCP 8.5 scenario. Outcomes suggest that new design solutions can be introduced into the palette of choices available to local stakeholder. Although climate can occasionally be extreme the design options can offer choices to avoid much discomfort, even following potential climate change. An important conclusion is the need for further support to the process to raise awareness and optimise outcomes amongst local stakeholders.

Influence of modern transitions in rural settlements on the thermal expectation of inhabitants

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Rapid urbanization has led to the replacement of local traditional materials in rural dwellings with industry-manufactured materials like cement and steel. This transition in the building envelope directly influences the indoor thermal environment of the dwellings. While traditional dwellings relied predominantly on passive design for regulating the indoor thermal environment, modern dwellings are integrated with electro-mechanical appliances for the same. Rural inhabitants accustomed to wider temperature changes and attaining comfort through behavioral adaptation, now have access to active adaptative strategies. Long-term dependencies on these adaptive strategies could influence the thermal resilience of the inhabitants. This study attempts to explore the changes in the thermal expectation of rural inhabitants subjected to modern transitions. A field study was conducted in a rural settlement in cold climate zone of India. Thermal sensation surveys of inhabitants living in traditional and modern dwellings were performed. The higher reliance of traditional and modern inhabitants on passive and adaptive strategies respectively, was evident from the survey. Comfort temperatures of the traditional occupant group was lower than the modern occupant group. In conclusion, the study found a significant distinction between the thermal expectation of the two groups in both their thermal sensation and adaptive behavior.

A brief overview of assessment frameworks and instruments related to well-being and productivity in relation to indoor environmental quality research

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This paper presents an overview of frameworks, instruments and tools used for subjective and objective assessment of well-being and productivity (or work performance). These instruments have been drawn and collated from a wide range of studies, including those that focus on factors unrelated to indoor environmental quality (IEQ). However, we perform a qualitative review of these instruments from the lens of IEQ domain, and with the objective that they may be used to observe, document, analyse and understand the relatively less-explored facets of IEQ research.

Health-related heat and cold adaptive capacity: projections under the UK Shared Socioeconomic Pathways

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High and low ambient temperatures can have adverse health effects on human beings. Previous health impact assessments projecting future health burdens under climate change scenarios usually focus solely on the change in climate, leaving the contribution of potential societal adaptive capacity on future health burdens an under researched area. This study contributes to this topic by projecting adaptive capacities to heat and cold in the UK under the five Shared Socio-Economic Pathways (SSP). The mechanisms of key factors affecting adaptive capacities are reviewed, including economic status, inequality, social cohesion, health care, behavioural changes, urban management and population, greenspace and energy efficiency. Heat and cold adaptive capacity indices are constructed using proxy variables and data from the UK-SSP project semi-quantitative projections. The results show a strong increase in adaptive capacities under SSP1, stable or slightly increased adaptive capacities under SSP2 and 5, and strong maladaptation under SSP3 and 4. Adaptive capacity to heat is generally lower than for cold, driven by the negative effect of increasing urbanisation on heat adaptation due to an increased urban heat-island effect, and the positive effect of improved energy efficiency measures on cold adaptation.

Adopting Passivhaus Principles in Residential Buildings in the Extremely Hot and Dry Climate of Saudi Arabia

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Energy consumption per capita in Saudi Arabia is three times higher than the global average. The residential sector accounts for about 50% of the total national energy consumption. In 2016, Saudi Arabia established a new socio-political plan, Vision 2030, to diversify the economy and mitigate energy usage, particularly in residential buildings. This research assesses energy-efficient measures to help reduce energy consumption in Saudi residential buildings. The city of Makkah, with an extremely hot climate year round, is selected for the analysis. This research considers the feasibility of meeting a rigorous energy efficiency standards, Passivhaus, in Saudi Arabia. The emphasis was on improving the building envelope and using high-performance windows in an existing two-storey residential villa. This house type and occupancy level represent the most typical type in Makkah. The dynamic thermal simulation software DesignBuilder was used to compare the energy performance of the villa built to meet the Saudi Building Code (SBC) and built to meet Passivhaus standard requirements under the current and 2050 climate scenarios. Results indicate that meeting the Passivhaus standard for the building envelope can significantly reduce the cooling demand by 57%, and that the Passivhaus model was more effective than the SBC model in facing the challenges of future climate change.

Correlation model to evaluate two European climates' impacts on thermal comfort and indoor air quality in houses

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This study presents the development of a climate correlation model encompassing the impacts of diverse climatic parameters for the indoor conditions prediction concerning thermal comfort and indoor air quality (IAQ). We investigated the relationship between outdoor and indoor conditions in free-standing small houses, and compared the results of two contrasting European climates - Nordic and Mediterranean. The impacts of ventilation modes on the IAQ - infiltration and natural ventilation through window openings – were compared using a black-box model generated in the CONTAM and EnergyPlus simulation engines. The effects of ventilation and heating schedules, model size, and orientation for prevailing wind were tested considering factors that could statistically change correlation equations. The correlations between dry bulb temperature, operative temperature, temperature differences between indoor and outdoor, and airflow were analysed to identify significant patterns or trends between variables without controlling or manipulating any of them. The results were evaluated using adaptive thermal comfort equations and equations to estimate space-specific indoor CO2 concentrations. The study informed the importance of user-driven decision-making processes for predicting the indoor conditions from outdoor climatic parameters which could encourage behavioural change for building operation to improve building thermal comfort and IAQ through natural ventilation strategies.

Urban heating, lack of green and lack of space: the contribution of urban vegetation to the improvement of environmental quality in open urban spaces in the city of São Paulo, Brazil

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The suppression of urban vegetation and the increase in built density and impervious surfaces are one of the main factors for the aggravation of local climate change effects. This lack of green decreases the environmental quality of open urban spaces and undermines their role in sociability, walkability, and inhabitants' health. This becomes more evident after the emergence of the COVID-19 pandemic, since the availability of adequate open urban spaces is essential to reduce the risk of contamination. In the city of São Paulo, the local Climate Action Plan (PlanClima SP) points out some strategies and actions that should be implemented to increase urban spaces' quality, many related to nature-based solutions. However, there is a lack of public spaces available for vegetation implementation, especially in the city centre. Thus, this work aims to develop urban redesign patterns that enable the insertion of vegetation in the Santa Ifigênia, a densely built-up area located in the centre of São Paulo, and contribute to the implementation of the PlanClima SP, regarding green adaptation measures and nature-based solutions. The results showed that it is possible to redesign the urban spaces to increase the urban vegetation, to improve the environmental quality and resilience of densely built areas and land surface temperature reductions up to 18 K were registered.

Investigation: The Urban Heat Island phenomenon in the Holy City of Makkah, Saudi Arabia, and its impacts on energy consumption

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The rapid growth of the urban population is impacting and creating challenges for the surrounding environment. The most significant effect of urbanization is rising the temperature in the urban areas that is well known as Urban Heat Island (UHI) effect phenomenon. The UHI causes a serious thermal environmental problem including increasing temperature. This research implemented an on-field measurement to investigate the UHI effect in Makkah city. The aim of this project to study the UHI effect upon energy consumption based on dry-bulb air temperature and relative humidity measurements in the city. I-button data loggers were used to monitor dry-bulb air temperatures at 36 selected locations to measure the air temperature and the effect of the UHI extension pattern all over the city during year 2019 – 2020. The Arafah site, 18 km from the city center, was selected as the reference station for this research during the experimental period. According to the observation, the monthly day time UHI averages as high as 2.9 C and the monthly night-time UHI average as high as 2.53 C. Moreover, three main factors were studied (i.e., Sky View Factor, Distance from City centre and Albedo). Thus, an algorithms-based approach was carried out to generate equations for each month, day and hour. The generated algorithms link parameters such as Sky View Factor, Distance from City centre and Albedo to predict the UHI intensity for any site in the city comparing to the reference site. In addition, a Design-Builder model was used to calculate the buildings' energy consumption. By modifying and applying generated equations to the weather file. the Design-Builder software results revealed the extent of UHI's contribution to increase in energy consumption.

The effect of environmental settings on walking comfort of older and younger adults in very hot weathers

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Walking effectively reduces age-related risks of chronic diseases and promotes active ageing among older adults. However, thermal discomfort experienced in hot weathers affects the willingness to walk. Thermal comfort in walking is a relatively less explored field, but it is essential to provide further understanding on outdoor comfort. This study investigated the interrelationship between microclimate conditions, environmental settings, and comfort sensation in walking. Older-adult and younger-adult participants were recruited to conduct a walking experiment in urban green spaces and densely built-up areas. On-site measurements were conducted to record microclimate variables in different environmental settings. Thermal sensation votes were obtained. The physiological equivalent temperature (PET) was estimated with microclimate variables, clothing index, and metabolic rates calculated with individual walking speed. The results indicate that after reaching thermal discomfort walking in unshaded areas, tree shade can effectively restore comfort in very hot weather. Building shade would change the thermal sensation from "hot" to "slightly warm", but not to the neutral level. Compared to younger adults, older adults tend to have a larger difference in thermal sensation when they walk in built-up areas and green space, and also a more noticeable difference in neutral PETs obtained in these two environmental settings. Based on this study, neutral PETs for older adults in walking were 31.6°C in green spaces and 33°C in built-up areas. Neutral PETs for younger adults in walking were 32°C and 32.6°C in green spaces and built-up areas, respectively.

Gender effects on thermal perception: A controlled experiment

Ricardo Forgiarini Rupp, Natalia Giraldo Vasquez and Jørn Toftum

International Centre for Indoor Environment and Energy, Department of Environmental and Resource Engineering, Technical University of Denmark

Gender is one of the main factors explored in earlier thermal comfort studies. The main objective of this work is to analyse potential gender effects on thermal perception under equivalent thermal conditions. The method is based on controlled experiments involving human subjects who were exposed to different thermal conditions in a climate chamber. During the experiments, participants were asked to answer questionnaires including background questions (e.g. physical characteristics) and thermal perception questions (thermal sensation, preference, comfort and acceptability). The criteria for the subject's participation took into account age, gender, body composition, health condition and thermal history. In total, 24 subjects participated in the experiments (50% females). Results showed that, in fact, gender had no significant effect on thermal perception under equivalent thermal conditions.

Analysis of a questionnaire for visual comfort assessments: Effects of question formats

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International Centre for Indoor Environment and Energy, Department of Environmental and Resource Engineering, Technical University of Denmark

This study tests two sets of questionnaires to collect subjective lighting assessments. The questionnaires, one using semantic differentials and the other using Likert-type statements, were presented to 48 participants to compare the differences due to the question format. Experiments were performed in a climate chamber simulating an open-plan office. In a randomized order, participants were exposed to three temperatures (20 °C, 25 °C, and 30 °C) while the artificial lighting was constant (550 lux, 3200 K). Light perception, visual comfort, and acceptability were assessed through 13 items using 7-point scales. Overall, the statement format had higher internal consistency than the semantic differential format. Questions about visual comfort seemed to be reliable under both questionnaire formats, while further development of questions about perception is needed to increase their internal consistency. Although most of the answers were not different due to the questionnaire format (naverage= 61.5%), 38.5% of the answers were different, and the changes were small or moderate and statistically significant in eight items. Further analysis compared the effect of the temperature on lighting evaluations. Our results contribute to a better understanding of the implications of formulating questions on subjective responses and might help develop questionnaires for the field of visual comfort.

KEYNOTES

Chair: Rajat Gupta

All you need to know about the indoor environment, its occupants, interactions and effects

Philomena Bluyssen
University of Delft, the Netherlands

BUILDING RESILIENCE AND VULNERABILITY

Chair: Bjarne Olesen

On the front lines of extreme heat: experimenting with innovative strategies & technologies for cooling the hottest US cities

David Sailor

University of Arizona, USA

Beyond Space Heating and Cooling

Bill Bordass

Usable Buildings Trust

Acceptable Temperatures for Naturally Ventilated buildings

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2 London Metropolitan University

The main challenges in our changing climate are two-fold: The most urgent need is to reduce the build-up of greenhouse gases in the atmosphere. Secondly we must all adapt to live in a world that is changing so fast that only the use of existing, known, technologies can hope to keep abreast of the pace of those changes. This paper looks at the currently available comfort related risks and opportunities. It looks at the dangers signalled by the inappropriate understandings of comfort in buildings and suggests ways in which a better understanding of indoor comfort can be used by architects and other building professionals to minimise building impacts on the climate and improve comfort in them. The paper shows how only a proper understanding of the second challenge can be used to help solve the first.

Addressing thermal comfort at the extremes: What advice for older people?

Terence Williamson

University of Adelaide

Design for the elderly during summertime overheating: advice from the UK

Rajat Gupta

Oxford Brookes University

Policies and programmes for reducing the impact of extreme heat events in India

Rajan Rawal
CEPT University, India

Overheating in Australia's new housing stock – a simulation study

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Overheating risks of the new housing stock in Australia were investigated by building simulation using over 320,000 recent residential building designs based on the overheating criteria in CIBSE TM59. Results show that 62.6% of the new dwellings are predicted to fail the overheating criteria. In Northern Territory (NT), South Australia (SA), Victoria (VIC) and Western Australia (WA), over 90% of these new dwellings are predicted to fail the overheating criteria. In general, overheating risk is reduced with increasing house energy efficiency. However, there is no guarantee that a high energy rated dwelling will perform better during naturally-ventilated operation with no air conditioning. This study shows that overheating in the Australian new housing stock is serious and significant efforts are needed to resolve this issue. It is recommended that a separate assessment similar to TM59 should be used in order to minimise the overheating risks in Australian homes.

Thermal environment of dwellings in extreme cold climate of Nepal

Hom Rijal
Tokyo City University

Varying comfort: a different kind of challenge

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Subjective scales of thermal comfort emerged largely from research in contexts with little temporal variation in environmental conditions, clothing and activity. But many people live or work with marked variation in these things. This variation can become a particular kind of extreme. It is questionable how people in these circumstances would give a single comfort rating; I therefore tested an alternative approach. In a pilot study in a UK primary school, I asked staff to report the percentage of the time when it is (a) too cold and (b) too warm (separately for summer and winter, and on the day of the survey). Students reported whether they had felt too hot or too cold at any time during the day. Respondents could answer without difficulty and could state, for example, that a room had been too cold and too warm on the same day. Responses show a logical relationship with other subjective variables and with classroom thermal characteristics in different parts of the school. The survey allowed specific problems with the thermal environment to be identified and for mitigation to be suggested. The findings are discussed in relation to how thermal comfort is balanced with other requirements.

Designing for individual needs not the average

Nigel Oseland
Workplace Unlimited

The effect and influence of personalised ceiling fans on occupants' comfort and physiological response

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Personal environmental control systems (PECS), such as fans, have been widely implemented as an effective strategy to increase energy efficiency and occupants' satisfaction with indoor environmental conditions. This paper explores significant differences between thermal sensation votes and participants' physiological responses when using personal ceiling fans. In an experimental study in summer of 2018, 45 participants were exposed to two thermal conditions (28°C and 31°C) and different airflow speeds and directions in a climate chamber that simulates a typical office environment. Indoor environmental, psychological and physiological responses (skin temperature and heart rate) were recorded during the entire session. We tested differences in physiological responses between different demographic, contextual groups and airspeed levels. Results showed that at 31°C, participants had a significantly higher distal skin temperature and that airspeed helped reduce proximal skin temperature. Overweight participants showed a significantly lower proximal skin temperature than average weight participants. Heart rate results yielded statistically significant differences between age groups. Besides, findings suggest that skin temperature follows indoor temperature changes. By increased airspeed, physiological adaptations can be stimulated to restore comfort. Overall, personal ceiling fans are an effective cooling solution that can target occupants' body parts and individual characteristics to increase their comfort.

Natural ventilation: a comparative profile of the opening/closing frequency of windows in Spanish homes before and during COVID-19

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Almost all Spanish homes were built before the Technical Building Code (2006), which firstly adopted aspects on Indoor Air Quality (IEQ). Ventilation of occupied housing depends on the will and the culture of their users. In this questionnaire, prepared during the confinement of the first wave of COVID-19, the compared frequency of opening/closing windows before and during the COVID-19 pandemic was analysed, participating 1,763 households. The explanatory variables were sought to characterize the household profile according to ventilation frequency. The results yielded interesting insights: firstly, people staying at home were more likely to ventilate frequently, both before and during the pandemic. In contrast, people with a caregiver role declared lower ventilation rates, even before the pandemic. For cooking, liquefied fuels, coal or biomass, were related to poor ventilation. Ventilation was inversely proportional with thermal comfort. Likewise, adaptive preferences showed to be related to ventilation frequency. Therefore, this analysis of homes' profile from its use frequency of windows allows to understand the phenomenon from a cultural, occupational and behavioural perspective, as well as possible energy saving criteria to achieve thermal comfort or personal awareness. This can help establish multi-scale strategies on natural ventilation, in building renovation, promoting mechanical or hybrid systems.

Thermal comfort provision in naturally ventilated buildings: a comparison between Brazil and North American standards

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As temperatures increase due to climate change, the need for cooling to satisfy occupant comfort in the built environment has also increased. In North America, mechanical systems are often adopted as a main cooling strategy to provide thermal comfort. However, in Brazil – a predominantly warm and humid climate – occupants rely mostly on natural ventilation. Yet, Brazilian thermal comfort standards do not have clear guidance on how to provide comfort in naturally ventilated spaces. In this paper, we reviewed Brazilian thermal comfort standards – ABNT NBR 15220, 16401, and 15575 – and compared them to ASHRAE 55. Despite natural ventilation being recommended in seven out of the eight bioclimate zones, Brazilian standard only specifies acceptable thermal conditions based on ASHRAE 55's Predicted Mean Vote (PMV), which is known to underestimate thermal sensations in naturally ventilated buildings. ASHRAE 55 also has specific provisions for naturally ventilated buildings using an adaptive model that accounts for adjusted comfort expectations of occupants with operable windows. To evaluate the applicability of ASHRAE's adaptive model in Brazilian climate, we analysed the weather data from 192 Brazilian cities. We concluded that the adaptive model can be applied to the Brazilian context as a significant area of the country is within the model's applicability limits.

Automation system for setpoint temperatures based on adaptive comfort: an in-depth guide of ACCIS capabilities running with EnergyPlus

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The possibility for energy savings from implementing setpoint temperatures based on adaptive comfort has recently been investigated. This can be achieved by using the recently proposed Adaptive-Comfort-Control-Implementation Script (ACCIS), that is a computational approach which extends the air-conditioning usage to adaptive comfort. According to both an Input Data File (IDF) and the setup supplied by the user, ACCIS turns PMV-based into adaptive setpoint building EnergyPlus models. Originally, ACCIS was an EnergyManagementSystem (EMS) script, but its capabilities have been expanded, and it has been nested in the Adaptive Comfort Control Implemented Model ("accim") Python package. This study focuses on the development of ACCIS, and provides a deeper view of the operation of the computational approach based on the relationship between the objects that compose it. As a result, ACCIS brings up new possibilities for conducting energy simulations on a global scale rather than merely on a national or continental size, since all weather file quantity limits have been tackled and now studies can be developed based on millions of simulations. Also, ACCIS could be applied to energy management, or coupled with artificial intelligence to develop smart thermostats

Design of airflow ventilation in a confluent jets system

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In this study the airflow obtained inside a virtual chamber equipped with a horizonal confluent jets system is analysed. The horizonal confluent jets system consists of an inlet system and an outlet system. The inlet system considers four vertical ducts with a set of consecutive nozzles, placed in the wall corner. The exhaust system considers a vertical duct, located in the central area of the space. This numerical study is carried out using a Computational Fluids Dynamics numerical model. The three-dimensional air velocity components field, the air turbulence intensity and the turbulent variables were obtained in this work. The results show the airflow topology, promoted by the horizontal confluent jets ventilation system, near the wall surface. The air velocity is distributed along the ground, then follows, with an increasing value, an upward direction towards the exhaustion.

Embodied Carbon Viability of Prefabricated Retrofit Modules for Passivhaus-EnerPHit Standard – a Case Study in Istanbul, Turkey

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The building sector has yet to take drastic steps to lower its carbon emissions to meet net-zero emissions targets by 2050. Although various methods exist to design new buildings with low operational carbon impacts, this is not always true for existing buildings. Improving the operational energy performance of an existing building is difficult, and reducing the overall refurbishment times for existing occupied buildings is challenging. Therefore, prefabrication methods for retrofitting were investigated in this research. The feasibility of using prefabricated retrofit modules that meet the rigorous Passivhaus-EnerPHit standard in Turkey's warm-temperate climate was explored. An existing residential building in Istanbul was modelled in the thermal simulation software DesignBuilder, and calibrated against on-site measurements. The impact on operational energy performance of applying prefabricated retrofit modules to the digital twin was then tested. Carbon emissions related to the production phase of the modules were assessed using OneClick LCA software. Multiple material replacement scenarios were applied to the prefabricated modules to find the optimum solution with low embodied carbon impact. The results showed that, although the prefabricated retrofit modules were successful in decreasing operational energy and carbon, they were not viable in terms of the cost of the modules in the Turkish context.

How do occupants perceive thermal comfort in a hybrid office space? A case study of a co-working space in London

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The work pattern has been reshaped towards a hybrid style since the lockdown in the pandemic, while the office design needs to be evolved with the change in working mode. It is important to understand how to design the workspace to meet the new demand. This study investigates the environmental performance of a flexible co-working space in London by a longitudinal field study, with a specific focus on thermal comfort and lighting sensations and preferences. The field study is composed of a questionnaire survey about occupants' thermal comfort sensations and environmental preferences and a concurrent measurement of indoor environmental data (temperature, relative humidity, air velocity and illumination level). This paper presents a preliminary analysis of the data collected in spring 2022. A total of 79 responses are recorded over three months. The findings in this study are expected to provide new insight into environmental design solutions for the hybrid and flexible work setting.

Life cycle carbon assessment of a contemporary house in the UK built to zero carbon

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This research presents for the first time the Life cycle assessment (LCA) of a contemporary zero energy terraced house built using MMC in the UK and compares the results with a traditional terraced house. The UK has set a net-zero target and the pace of achieving the target depends on how the contemporary houses are built. The current regulations by the government focus only on reducing the operational carbon of houses rather than looking from a life cycle perspective. This leads to an increase in embodied carbon emissions in newly built houses. There are 244000 houses built every year approximately in the UK and many are overlooked as zero-carbon houses which are only zero operational energy use, and the embodied emissions are unknown. Therefore, a real-life contemporary (zero energy) terraced house built using MMC in Liverpool, UK is chosen as a case study and LCA was conducted using one-click LCA software to calculate the lifetime carbon emission. Though operational carbon has achieved net zero by MMC, it is identified from this research that the embodied carbon of contemporary houses (62tCO2e) has increased by 2.3times the traditional house (26tCO2e). Further, Strategies and methods to reduce embodied carbon were discussed.

Further, the top five carbon contributing building elements of the case study were identified and different scenarios were proposed to understand the potential impact of choosing low carbon products and organic materials as alternatives.

The influence of indoor thermal environment on the performance of university students

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Cooling buildings in all year-round high temperatures associated with Saudi Arabia's extreme climatic conditions has become increasingly expensive. To reduce the operating cost of its HVAC system, Taibah University has introduced an energy and cost saving programme in its facilities. The aim of the programme is to adjust indoor thermal conditions while maintaining comfort at acceptable levels for the majority of occupants. Considering the importance of thermal comfort for the health and productivity of students, this paper evaluates thermal comfort conditions in three architectural studios in the Department of Architectural Engineering at Taibah University. The studio environments were assessed both objectively and subjectively and their influence on students' productivity was evaluated. The objective assessment included measuring indoor air temperature, globe temperature, air velocity, and relative humidity, whereas the subjective assessment questioned the students' thermal sensations and preferences to assess their general comfort conditions. It was found that 59.3% of the investigated students were (slightly cool), (neutral), or (slightly warm); yet, an equal percentage preferred to be (a bit cooler), which highlights the influence of the climatic and cultural background. It is worth mentioning that around 54.7% and 53.5% reported overall discomfort state and unacceptance of their thermal ambience. The relation between the thermal conditions and productivity was statistically insignificant. Applying Griffiths' method revealed a comfort temperature of 24.3 ± 2.76 °C and 23.4 ± 2.76 °C in terms of indoor air and globe temperatures, respectively. Apparently, the energy saving programme has no negative effect on the students' thermal perception or productivity. Yet, this may be due to the usage of self-reported questions about productivity. Future research is highly recommended to investigate the students' productivity applying other measures and to explore the environmental and economic impact of the followed energy saving programme.

Impact of building design variables on natural ventilation potential and thermal performance: An evaluation in New Delhi, India

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Natural ventilation (NV) potential is a crucial factor in determining the indoor environment quality and occupant comfort of residential buildings. Optimisation approaches focused on energy efficiency do not always guarantee sufficient natural ventilation for health and comfort. This paper presents an optimisation framework for simultaneously enhancing the building's NV potential and energy performance. A mid-sized residential apartment unit located in the composite climate of New Delhi (Köppen climate classification: BSh) is considered. Particle Swarm Optimization (PSO) algorithm coupled Energy Plus simulations is employed for optimising building orientation, thermal property of wall & window, and window size parameters. PSO is implemented over a population of 50 solutions for 25 generations using a flexible graphical user interface to define the design variables, performance objectives and optimisation settings. We present a comparative assessment of the natural ventilation, indoor comfort and energy demand of solutions obtained from single objective and multi-objective optimisation approaches. The solution obtained using the proposed optimisation framework has significantly higher natural ventilation with a marginal increase in energy use. This study highlights the need to consider NV potential in building performance studies and highlights its relevance to the present-day context.

The thermal and energy performance of the glazed studio apartments under the current and future climate scenarios in São Paulo

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The number of residential apartments has grown since the approval of the Strategic Master Plan of the City of São Paulo in 2014, and a significant part of these launches are one-bedroom apartments with small useful area. Given the increase in local air temperature around 1.6°C in the last 30 years, overlaid with the occurrence of the urban heat island, it is essential to characterise and study the thermal performance of small glazed apartments in future scenarios considering climate change. Therefore, this work aims to catalog and analyse the stock of apartments of residential buildings of up to 50m² newly launched or built in São Paulo. The objective is to evaluate the comfort of users in two Studio apartments standards of a residential building through thermodynamic simulation in the TAS software to analyse the thermal performance of the apartment considering the current and future weather scenarios, and the longer periods of permanence of residents at home, caused by the change of habits arising from the pandemic. The smaller studio (19m2) has a worst performance than the bigger studio (25m2) for the present and future climate scenarios. To improve the thermal performance, the authors suggest an increase in shading device size, better glazing material and the inclusion of openings for cross ventilation.

Balancing increased ventilation and thermal comfort in educational buildings: a case study

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The pandemic situation has recently led to an increased focus on the importance of indoor air quality. Indeed, enhanced ventilation can lead to a reduction in the infection probability in indoor environments, resulting in a healthier environment. However, many buildings are naturally ventilated, as are often classrooms, so the only way to ensure ventilation is to open windows. This can be particularly critical during the winter period, as increased ventilation can lead to considerable thermal discomfort. This paper investigates the conditions of air quality and thermal comfort before and during the pandemic using naturally ventilated university classrooms as a case study. The effect of the increased ventilation on thermal comfort and indoor air quality was analysed by studying changes in thermal neutrality due to students' adaptation to the new conditions. It was found that adaptation affects people's thermal neutrality, lowering the neutral temperatures of the students. This adaptive capacity can be correctly exploited to improve indoor conditions and balance air quality and thermal comfort even in the post-pandemic period.

Taking into account occupant behaviour during heatwaves in building simulation

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Occupants have a strong impact on the indoor environment through their presence and actions. Their behaviour is therefore taken into account in an increasingly detailed way in building performance simulations. However, most of the researches have focussed on the heating period, due to the impact of behaviours on energy consumption. Heatwaves represent a particular context during which occupants prioritize their thermal comfort. However, occupant behaviour during heatwaves is still rarely studied. These extreme events are likely to become more frequent and intense with climate change. The air conditioning equipment is already increasing all over the world, also highlighting the problem of summer energy consumption. Through its impact on the indoor environment, the future climate will also affect behaviour. Finally, the urban context generates urban heat islands but also nuisances (noise, pollution, insecurity, etc). This article identifies the latest advances, but also the blocking points in considering occupant behaviour during heatwaves, as well as the perspectives of development.

Climatic, energy retro-fit and IEQ mitigation scenario modelling of the English classroom stock model

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Health and cognitive performance in UK school classrooms is dependent on building fabric performance as well as heating and ventilation system operation in maintaining Indoor Environmental Quality (IEQ), comprising thermal comfort and air quality. While archetype models can be used to simulate IEQ for different stock-wide location and construction eras, a predictive approach also necessitates the use of longitudinal scenarios. As a key component of the UK's decarbonisation strategy, these scenarios should account for fabric retro-fit adaptations to reduce carbon emissions, and changes in operation of the building for overheating mitigation as well as changes in external climatic conditions.

The IEQ of three representative classroom archetypes, representing the stock of 18,000 English schools, have been analysed for 24 pair-wise retro-fit and operational scenarios across three climatic scenarios. Retro- fitting, while effective in reducing energy demand, may risk compromising indoor air by requiring ventilation at times of the day when external conditions are least conducive to air quality and overheating. Additionally, while North facing classrooms can tackle overheating through single effective IEQ mitigation measures, South facing and 2080 climates will necessitate cumulative effects of multiple measures to be realised. Future work involves incorporating educational and construction stakeholder preferences through multi-criteria decision analysis, to derive suitable metrics.

Evaluation of the current indoor environment using physical measurement and a questionnaire in an educational space in a hot climate

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Indoor Environmental Quality (IEQ) can be considered an important indicator of the health and productivity of the occupants, especially in educational buildings where students spend the majority of their time indoors. Different studies highlighted the importance of studying IEQ in classrooms where the indoor environment can be linked to the student's academic performance. Although Oman is located in a region with extreme climatic conditions, there is no published research that addresses the evaluation of indoor environmental quality in educational institutions. In an attempt to fill this gap of knowledge, the paper at hand aims to evaluate IEQ in an educational space in Sultan Qaboos University (SQU), Oman, exploring the occupants' perception of the relative importance of the IEQ parameters for them. Physical measurements were conducted along with a questionnaire where the students were asked to evaluate their sensation, satisfaction, and preference regarding thermal, visual, acoustic, and air quality conditions. Different IEQ parameters were measured including air temperature, globe temperature, humidity, air velocity, CO 2 concentration, illuminance level, and sound level. The results show that students are satisfied with all IEQ aspects except visual conditions. Meanwhile, investigated studio shows comfortable internal conditions except for visual conditions. The findings of this study will be useful in enhancing the student's educational experience in SQU. Further, they can be used as a reference for further investigations of IEQ for educational buildings, especially in hot climates.

The Effect of Climatic Background on Users' Thermal Comfort in University Buildings

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Long-term memory may influence people's thermal experience and expectations of their environment. Educational buildings, such as university libraries, are places where people from different cultural and climatic backgrounds come together. However, it is questionable whether the comfort standards and environmental management of these buildings offer equal comfort conditions to people from different climatic backgrounds. To explore this issue, a longitudinal study investigated the effect of cultural and climatic backgrounds on the thermal perception of users of the Sydney Jones Library at the University of Liverpool. Dataloggers in a study area recorded environmental factors such as temperature and relative humidity. Simultaneously, library users participated in an online survey that sort to understand factors affecting user thermal comfort and their views on the environmental conditions of the space. Statistical analysis of winter-time results from the survey suggested that the thermal perceptions and expectations of users varied depending on their different climatic backgrounds. In addition, the mechanical ventilation and cooling system in the study area negatively impacted upon the thermal comfort of users, while also causing unnecessary heat and energy losses. The average temperature of the study area was measured as 19°C. Although the recommended winter comfort temperature for computer rooms in CIBSE Guide A is 19-21°C, this temperature was found to be slightly cool for the majority of respondents.

Investigating the effect of indoor environmental quality (IEQ) variables on comfort by a subjective assessment in university classrooms

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In buildings, the indoor environmental quality (IEQ) is determined by the collective influence of four factors, namely thermal conditions (TC), visual conditions (VC), acoustical conditions (AcC), and air quality conditions (IAQ). IEQ is an important aspect of the built environment that can positively or negatively affect the health, wellbeing, and productivity of buildings' occupants. Considering classrooms, the association between IEQ conditions and the students' health, comfort, and productivity is well documented. However, there is no clear conclusion regarding the weight of each of the four factors of IEQ on the overall indoor comfort level. The majority of the studies that investigated this issue were reported from the temperate climate. The paper at hand aims to investigate the individual effect of IEQ factors by conducting a subjective assessment in a hot dry climate region. The assessment investigates the opinion of the faculty members of the College of Engineering at Sultan Qaboos University, Oman, regarding the thermal, visual, acoustical, and air quality conditions of the university classrooms. The collected data were analysed using the Analytic Hierarchy Process (AHP) to quantify the weight of each factor on comfort level. The results indicated that TC is the most important factor with a weight of 0.286 followed by VC with a weight of 0.245. The weights of the IAQ and AcC were 0.242 and 0.226, respectively. On a larger scale, quantifying the weight of these four factors guides the architects and engineers to design comfortable and energy-efficient buildings.

Comfort in Antarctic Bases: Design Lessons from the Extreme Cold

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In 2020 a short study was undertaken of the thermal performance of the Chilean research base at Escudero on King George Island, Antarctica. The aim of the study was to use a range of interrogation methods to understand how this building performed in an extremely cold climate. A comfort survey delved into its use and functions and perceived comfort in it. Measured temperatures shed light on the thermal interactions between the climate, building and occupants. A thermal imaging survey highlighted the very different ways in which cold penetrated the structures and spaces of the building. The study emphasised the need for designers from warmer climates to understand that the thermal pathways of heat and cold through the building in the extreme cold can often produce counter-intuitive thermal landscapes indoors. Vernacular examples of 'cold buildings' are used to emphasise that design lessons for extreme climates may be in front of our faces, but due to lack of experience in such climates we cannot read them. Further studies of Polar bases are needed to explore such lessons and to enable all designers to achieve maximum comfort, with minimum energy use both in extremely cold climates and for emerging freak cold weather events elsewhere.

RESILIENT COMFORT IN A HEATING WORLD	**Chairs:** Susan Roaf
When will thermal discomfort result in decreased performance and turn into heat/cold stress?	**Bjarne Olesen** Danish University of Technology
Relaxing indoor climate control: lessons from the extreme	**Wouter van Marken Lichtenbelt** University of Maastricht
Building Science into Action in the Climate Emergency	**Robyn Pender** Historic England, UK
Californian and North American experiences and responses to severe weather/climate change events	**Tom Phillips** Healthy Building Research, Davis, California
Connecting macro and micro climates through ventilation design	**Ulrike Passe** Iowa State University
Cooling people with air movement, a sustainable and affordable alternative to AC	**Stefano Schiavon** University of California at Berkeley, USA

NON-ATTENDING AUTHORS

Occupant Behaviours and Environmental Preferences in Home-Office Environments Versus Conventional Office Environments; Reflections from The Pandemic

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This pandemic has changed our work styles and our everyday interactions with the built environment. This paper focuses on differences in thermal comfort perceptions and behaviours between home-based and conventional office settings and discusses the consequences of its findings on domestic energy use in the UK in the context of extreme circumstances and beyond. Data were collected using a web-based questionnaire and online follow-up interviews. The 106 responses to the questionnaire captured the frequency of some adaptive behaviours. The in-depth interviews revealed a wide range and diverse adaptation strategies that people exercise when working from home, while these coping strategies were very limited in conventional offices. Moreover, discussions with energy and built environment experts shed light on the potential implications of working from home. These implications could contribute to raising awareness of people of energy-efficient houses, this could be buying new energy-efficient properties, refurbishing houses, and installing innovative energy-saving measures. The findings of this study indicate that occupants were satisfied with working from home, and the main elements they prefer for a future home office are energy-efficient airtight windows and good ventilation. Participants tended to apply low-cost strategies, related to the heating routine and practices. For example, reducing thermostat temperature or the heating duration. Further research could usefully propose an energy-efficient home office with the technological and personal behaviours and the upgraded standards revealed in this study

The use of Setpoint temperatures based on local adaptive comfort models as an energy conservation measure: the case of Japan.

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Utilizing adaptive setpoint temperatures, which are setpoint temperatures dependent on adaptive thermal comfort models, has been recently considered and ended up being an energy conservation measure (ECM) with a significant energy saving potential. However, the only method to perform building energy simulations with adaptive setpoint temperatures was manually, and it was very time-consuming and error-prone. To address these inefficiencies, a computational approach, called Adaptive-Comfort-Control-Implementation Script (ACCIS) was developed and nested in an easy-of-use Python package called 'accim', which allows to automate most of the process. Up to now, only international adaptive comfort models have been included in ACCIS and accim, namely ASHRAE Standard 55 and EN 16798-1. However, local adaptive comfort models seem to be more accurate than international models. Therefore, this research presents the application of setpoint temperatures based on a local Japanese adaptive comfort model, and compares the energy consumption resulting from the application of static setpoints and the local Japanese model. The results show significant energy savings ranging between 25 and 52% for cooling, between 30 and 62% for heating, and between 30 and 52% for total energy demand, depending on the climate zone, although the higher energy savings take place at the extreme climates.

PAVEMENTS AND MICROCLIMATIC COMFORT IN REQUALIFICATION DESIGNS OF URBAN PUBLIC SPACES: CASE STUDY OF THE SOUTH LOCAL HOSPITAL SECTOR – BRASILIA/DF

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Thermal comfort in public spaces is one of the main indicators that provides for its enjoyment, and habitability. Considering that the thermal and permeability properties of pavement materials are strongly related to heat intensity perceived in public spaces, the objective of this research is to investigate thermal behavior of different pavement materials for the thermal comfort of its users, by means of microclimatic studies for the requalification of the South Hospital Sector of Brasilia, in both the dry and rainy season. The methodological procedures for this work are: literature review; analysis of environmental surface variables; and analysis of superficial temperature of selected spaces. For data corroboration, simulated scenarios with ENVI-met 5.0 software were analyzed. Results show that material temperatures in the rainy season have a different behavior in relation to the dry period, and a constant relation to the increase in temperature according to the material used, and if exposed to sun or sheltered by shade. During the dry season, “cold” materials performed better in a sun exposed space. Significant differences of up to 22°C were recorded. The simulations corroborated with the fieldwork investigation.

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