The Book Of Abstracts

CATE|2023

COMFORT AT THE EXTREMES

This page has been left blank.

COMFORT AT THE EXTREMES

Conference on 13/14/15 December 2023

CATE 2023 CONFERENCE

[THE BOOK OF ABSTRACTS]

CEPT UNIVERSITY

Ahmedabad, Gujarat

CEPT UNIVERSITY
FACULTY OF TECHNOLOGY

CARBSE CENTER FOR ADVANCED RESEARCH IN BUILDING SCIENCE AND ENERGY

CRDF CEPT RESEARCH AND DEVELOPMENT FOUNDATION

SCIENTIFIC COMMITTEE

Abdul Alshaikh, Imam Abdulrahman bin Faisal University.
Abdullah Nisar, Climate Smart Buildings Programme of Indo German Energy Programme (IGEN), GIZ.
Anissa Kheira Tabet Aoul, United Arab Emirates University.
Bandana Jha, School of Planning and Architecture Delhi.
Brian Hoole Ford, University of Nottingham.
Craig Farnham, Department of Housing and Environmental Design, Osaka City University.
Da Yan, Tsinghua University.
Darren Robinson, The University of Sheffield.
Denise Duarte, University of Sao Paulo.
Dennis Loveday, School of Architecture, Building and Civil Engineering, Loughborough University.
Dong Chen, Commonwealth Scientific and Industrial Research Organisation.
Edward Ng, The Chinese University of Hong Kong.
Hanan Al-Khatri, Sultan Qaboos University.
Hannah Pallubinsky, Maastricht University.
Harvey Bryan, Arizona State University.
Hasim Haltan, Prince Mohammad Bin Fahd University.
Hilde Breesch, Faculty of Engineering Technology, Katholieke Universiteit Leuven.
Hom Rijal, Tokyo City University.
Jarek Kurnitski, Tallinn University of Technology.
Jessica Aguera, Universidad de Sevilla.
Joana Carla Soares Goncalves, Architectural Association School of Architecture.
Lucelia Rodrigues, University of Nottingham.
Madhavi Idraganti, Qatar University.
Marcel Schweiker, RWTH Aachen University.
Maria Kolokotroni, Brunel University.
Mark Olweny, University of Lincoln.
Marta Laska, Politechnika Wrocławska.
Martin Wieser, Pontificia Universidad Católica del Perú.
Mattheos Santamouris, University of New South Wales.
Michael Adebamowo, University of Lagos.
Minu Agarwal, CEPT University.
Ongun Berk Kazanci, Danmarks Tekniske Universitet.
Pamela Fennell, University College London.
Peter Graham, Global Buildings Performance Network.
Peter Holzer, Institute of Building Research & Innovation ZT-GmbH Technische Universität Wien.
Peter Wouters, Belgian Building Research Institute.
Philomena Bluyssen, Delft University of Technology
Rajashree Kotharkar, Visvesvaraya National Institute of Technology
Rajat Gupta, Oxford Brookes University
Rajshekar Elangovan, Indian Institute of Technology Roorkee
Richard de Dear, University of Sydney
Risto Kosonen, Aalto University
Roberto Lamberts, Federal University of Santa Catarina
Rohinton Emmanuel, Glasgow Caledonian University
Runa T. Hellwig, Aalborg University
Ryozo Ooka, University of Tokyo
Samar Thapa, Università Ca' Foscari
Sameer Maithel, Independent Energy & Sustainability Practitioner
Samuel Dominguez, University of Seville
Smita Chandiwala, Energe-se
Sukumar Natarajan, University of Bath
Ulrike Passe, Iowa State University
Veronica Soebarto, University of Adelaide
Wouter van Marken Lichtenbelt,Maastricht University
Yingxin Zhu, Tsinghua University

ORGANIZING COMMITTEE

Yash Shukla, Centre for Advanced Research in Building Science and Energy (CARBSE).
Chirayu Bhatt, Faculty of Management at CEPT University.
Anal Shah, Faculty of Technology at CEPT University.
Shivangie Akhaury, Head of Human Resources at CRDF.
Bhavya Pathak, Healthy Living Spaces | Institute of Occupational , Social and Environmental Medicine | University Hospital Aachen

CONFERENCE CHAIR

Rajan Rawal, Co-chair, CEPT University
Yash Shukla, Co-chair, CEPT Research and Foundation
Susan Roaf, Co-chair, Heriot-Watt University

Conference Office

Asha Joshi, Manish Salvi

Hosted by

CEPT University, Ahmedabad, India

Venue

Balwantrai N Bhrambhatt Hall, CEPT University ,
Kasturbhai Lalbhai Campus, University Rd, Navrangpura,
Ahmedabad, Gujarat, India - 380009.

COMFORT AT THE EXTREMES - CATE 2023

Wednesday - Friday , December 13th - 15th , 2023
CEPT University | Ahmedabad , India

Climate change has introduced extremity in weather events by increasing their intensity and frequency. The recent pandemic has further exacerbated the extremities and added new challenges in addressing climate change.

The current state of affairs demands immediate action in multiple dimensions ranging from climate adaptation and mitigation to climate resilience. Moreover, focusing on the regeneration of resources is equally critical at present.
Climate change affects various geographical, social, cultural, economic, and climatic contexts differently. Additionally, its impacts are visible at extreme physical scales ranging from an individual human body and its physiology to the urban level. And therefore, we need diverse solutions for diverse scales and contexts. The plethora of probable solutions must also be interdisciplinary to demonstrate effectiveness in multiple domains that affect each other.

Building on the success of the international 'Windsor Conferences on Thermal Comfort (1994-2020)' and the 'Comfort at the Extremes Conferences' in Dubai (2019), Oman (2021), and Edinburgh (2022), CATE 2023 at CEPT University, Ahmedabad hopes to bring diverse groups together to deliberate interdisciplinary solutions and strategies oriented toward climate change and associated extreme events at several scales.

A rapidly developing country in the global South, India is a representative of cooling-dominated countries and the challenges they face due to climate change. At CATE 2023, the authors will attend the conference in person in Ahmedabad, India to present their papers. Moreover, live streaming will help take proceedings of the conference to a wider audience worldwide.

SPONSORS

Asahi India Glass Ltd.

A.T.E. Enterprise Private Ltd.

Oorja Energy Engineering

Velux Group

This page has been left blank.

TABLE OF CONTENTS

Keynote Addresses

Invited Speakers

Workshops

Paper Presentation - Session 4 (Day 2, 13:05 - 14:25)

Session 4A - Health and Well-being in buildings

Session 4B - Design Interventions in Buildings for Thermal Comfort

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

Keynote Addresses

Title - Pondering the Performance of the Performance Paradigm.

Ardeshir Mahdavi

Title - Building Sustainable Community: Good Earth Experiment.

Jeeth Iype

Title - Alliesthesia – the other kind of thermal comfort.

Richard De Dear

Title - The Siesta and the Wildfire: Designing Comfort in Times of "Anomalous Weather"

Susab Ubbelohde

Title - Are we tropical animals?

Wouter D. Van Marken Lichtenbelt

Pondering the Performance of the Performance Paradigm

Ardeshir Mahadavi

Institute of Building Physics, Services, and Construction, Faculty of Civil Engineering Sciences, TU Graz, Austria

University Professor Dr Ardeshir Mahdavi is an internationally recognized authority in Building Science. Prior to his current affiliation at the Institute of Building Physics, Services, and Construction at the Faculty of Civil Engineering Sciences, Graz University of Technology (TU Graz), Professor Mahdavi held positions at the Carnegie Mellon University (CMU), Technical University of Vienna (TU Wien), and National University of Singapore (NUS). Professor Mahdavi conducts research in building physics, building simulation, building ecology, and human ecology. Professor Mahdavi has published over 700 scientific papers and has supervised over 65 doctoral students. Professor Mahdavi is the recipient of the prestigious IBPSA Distinguished Achievements Awards.

Performance paradigm is a natural reflection of our interest in the quality and effectiveness of the artifacts we build, whether they are machines, buildings, or whole cities. To this end, performance domains are defined, performance variables are established and included, together with their mandated values in standards and legal documents. We develop methods and tools to predict the performance implications of our interventions and proclaim that performance-based standards liberate stakeholders from the straightjackets of prescriptive mandates. Instead of prescribing professionals how to design and maintain their artifacts in detail, we tell them what performance is expected from those artifacts. However,, looking at the consequences of our interventions across multiple scales we may need to consider if the performance paradigm has been implemented sufficiently and properly. We may even need to consider if the performance paradigm itself is indeed performant.

Building Sustainable Community: Good Earth Experiment

Jeeth Iype

Architect and Co-founder, Good Earth

Jeeth Iype is an Architect and co-founder of GoodEarth. A person of ideas,, he is excited by innovation and translating ideas into architecture. He ispart of the team that conceptualizes the communities. Having gained experience creating vibrant communities that make one feel psychologically and socially secure, he trying to address larger issues like climate change and desertification through regenerative agriculture, and sustainable water and waste management, to add value to its core business of building sustainable communities.

Jeeth and his team at GoodEarth, are engaged in bringing together like-minded people with a common vision of building a sustainable future. They believe that such a community generates a strong sense of belonging while also enabling a collective sense of security and responsibility. They foresee a future where many such communities keep growing, each influencing its neighborhood and context. Their vision is to inspire change in the way people live through our efforts in development. The keynote will narrate Jeeth's journey in making Good Earth a successful experiment.

Alliesthesia – the other kind of thermal comfort.

Richard De Dear

Professor Emeritus, The University of Sydney School of Architecture, Design and Planning, The University of Sydney, Australia

Richard de Dear has been continuously active in the domain of thermal comfort for over forty years in Australian, European, Asian, and North American universities. With over 250 peer-reviewed research outputs on the topic de Dear is currently the most highly cited researcher in thermal comfort (Scopus), and his work forms the basis for ASHRAE's Standard 55 Adaptive Thermal Comfort section (from 2004 till present). Among his current duties are editorships for Nature Scientific Reports, ASHRAE Science and Technology for the Built Environment, and Elsevier Energy and Buildings. He was co-chair of the International Energy Agency's (IEA) Energy in Buildings and Communities Programme Annex 69 Strategy and Practice of Adaptive Thermal Comfort in Low Energy Buildings from 2016 through to its completion in 2022. He serves on the WHO-WMO Indoor Overheating Technical Advisory Group. His thermal comfort research papers have received numerous best paper awards, including Building and Environment (2022, 2018), Energy and Buildings (2018), and ASHRAE Transactions (1999, 1998). He received ASHRAE's Crosby-Field Award (1998) for best research paper across all of its outlets in 1998. In 1993 ASHRAE awarded him the Ralph G Nevins Physiology and Human Environment Award. In 1999 he received the Environmental Design and Research Association's (EDRA) "Places" Research Award, and in 2014 he was inducted into the International Society of Indoor Air Quality's Academy of Fellows.

An overwhelming majority of our knowledge of thermal comfort is confined to relatively simple situations of steady-state and iso-thermal exposures. In this talk de Dear will review thermal comfort, pleasure, and irritation in more complex and non-steady exposures. The talk will begin with the conceptual framework of alliesthesia and its empirical bases, and end with identifying where alliesthesia is most directly relevant including outdoor and semi-outdoor settings, personal comfort systems, vehicle cabins, transition spaces including rapid transit carriages, and station environments.

The Siesta and the Wildfire: Designing Comfort in Times of "Anomalous Weather"

Susan Ubbelohde

Principal Architect of Loisos + Ubbelohde, Alameda, California, USA

Susan Ubbelohde is a founding principal of Loisos + Ubbelohde, an office of unconventional practice based in Alameda, California and a Professor Emerita in the Department of Architecture at University of California, Berkeley. Her practice specializes in high-performance integrated design and is recognized for expertise in daylighting and lighting design, zero-energy/zero-carbon design, energy and thermal comfort simulations, natural ventilation, building monitoring, solar reflections and data visualization, as well as design and fabrication of light sculptures. L+U projects have won over 240 design, sustainability, and lighting awards, including AIA/COTE Top Ten Green Project awards, Platinum LEED Certifications and Zero-Net-Energy projects. Throughout her career, she has served on design and sustainability juries, lectured internationally and published on green design, simulation tools, daylighting, and lighting. An Indo-American Fellowship in Ahmedabad in 1989 supported a study of climate response in Le Corbusier's Sarabhai House and Millowners Building, as well as the classrooms and dormitories of Louis Kahn's IIM. Susan is a graduate of Oberlin College, the University of Michigan and the University of Oregon.

As architects practicing at the cutting edge of low-energy and resilient design, our office of Loisos + Ubbelohde believes buildings should "sail". This means operating with minimal mechanical systems, like sails when they are becalmed can be assisted with a small auxiliary engine. We work in a design process that begins with human comfort delivered primarily by the envelope. But we practice in interesting times. With 2023, the "anomalous weather" that we assumed was sold in the future arrived. Our buildings designed 10 years ago can no longer be counted on to provide comfort and fresh air to the occupants. Germany is looking at Spain's siesta that they previously ridiculed, while Hawaiians need their open houses to transform to spaceships when the fires arrive. Integrated architecture, systems and controls must couple with buildings that can sell open to the world when the breeze is up and the air is temperate. We will need to both survive and remain human in our architecture.

Are we tropical animals?

Wouter D. Van Marken Lichtenbelt

Professor Ecological Energetics and HealthSchool for Nutrition and Translational Research in Metabolism (NUTRIM)Maastricht University, Netherlands

Wouter van Marken Lichtenbelt is head of the research group Thermophysiology & Metabolism at Maastricht University. The fundamental aspect of the research line is the effect of environmental temperatures on physiology and behavior. This ranges from indoor environments in western populations to extreme conditions in Siberia. The study results show significant beneficial effects of excursions outside the thermoneutral zone; i.e. being exposed to heat and cold positively affects metabolic and cardiovascular health and increases resilience to extremes. The applied part of the research puts emphasis on how daily indoor environmental conditions relate to thermal comfort, behavior, health, and prevention of metabolic syndrome. His group searches for an optimal mix of different lifestyles and environmental factors to create a healthy sustainable indoor environment.

Are we better adapted to heat than cold? The presentation will include examples and new results from traditionally living humans and how they cope with extreme environmental conditions. This will be linked to current physiological knowledge about heat and cold acclimation. Finally, there will be food for thought on what extremes of heat and cold we can cope with.

Invited Speakers

Title - From cooled to fresh conditions - Hybrid Cooling for the Dry and Humid Zones

Wolfgang Kessling

Title - Living laboratory insights for low energy, healthy, and resilient built environments - the case of Fairwater, Western Sydney Australia

Leena Thomas

Title - Integrated Design for a Warming Future – Resilience and Well-being in Warm Climates

Ashok B Lall

Title - Impact of Climate Change and Urbanization on Future Building Performance

Drury B. Crawley

Title - Ways forward in thermal comfort prediction for building design and operation

Marcel Schweiker

Title - The Quantum Comfort Leap

Susan Roaf

Title - Harnessing Mixed mode ventilation and Occupant-Centric Control for Energy savings in the Tropics

Adrain Chong

Title - Lodha's approach of delinking growth from emissions by transforming the built environment.

Aun Abdullah

From cooled to fresh conditions - Hybrid Cooling for the Dry and Humid Zones

Wolfgang Kessling

Director, Transsolar KlimaEngineering, Germany

Wolfgang Kessling holds a doctorate in physics and is a partner at Transsolar Energietechnik, Germany. He is an expert in climate-friendly building design and adaptive comfort concepts. The focus of his work is the development of innovative comfort concepts for both, indoor and outdoor spaces. He lectures regularly at universities and international conferences on sustainable design, thermal comfort, and zero-energy projects. In Asia, he was involved in the design of the first Zero Energy Office in Malaysia, in the climate and energy concepts for the cooled conservatories at the Gardens by the Bay in Singapore. The environmental concept of the School of Design Buildings 4 and recently opened 1&3 at NUS, Singapore became a highly recognized example of a tropical high comfort net positive energy design. These projects have been instrumental in laying the grounds for designing with higher indoor temperatures compensated by elevated air speeds and changing the code of practice in Singapore. The so-called Hybrid Cooling concepts are also implemented in the new BRAC University Campus building in Dhaka, Bangladesh, or in the Atlassian high rise in Sydney, Australia.

Where conventional low-temperature air conditioning represents the well-established standard, leaving traditional paths and introducing a high comfort design with higher room air settings in combination with breeze poses a challenge to clients and design teams. There are very few buildings designed on purpose with this concept. Adaptive Comfort concepts deliver excellent comfort but with lower reliance on mechanical systems. With Hybrid Cooling concepts, the ventilation and cooling systems can be substantially downsized, reducing investment costs as well as substantially reducing energy demand for ventilation and space cooling. The presentation will include examples of projects with Hybrid Cooling in Asia and explore innovations in design for comfort in the tropics: indoors, mid-doors, and outdoors.

Living laboratory insights for low energy, healthy and resilient built environments - the case of Fairwater, Western Sydney Australia

Leena Thomas

Professor, Faculty of Design Architecture and Building, University of Technology Sydney, Australia

Professor Leena Thomas is a sustainable architecture academic and research expert with experience in Australia and India. Her research and teaching focus on transforming development and design practices in response to global concerns for climate change and sustainability. Leena's presentation will focus on her research into workplace and living environments where she has pioneered the use of detailed post-occupancy evaluation to investigate the role of the built environment in delivering energy efficiency, comfort, productivity, health and well-being, and sustainability. Through her research findings, Leena argues for the consideration of the social dimension of user experience alongside technical performance and the value of linking public health with planetary health.

Building on detailed post-occupancy evaluation and living laboratory approaches, this presentation will highlight opportunities and barriers for strengthening climate resilience at the scale of buildings and precincts. It provides insights from the Fairwater Living Laboratory that focused on an 850-home development in western Sydney that is home to Australia's largest-scale geothermal air-conditioning installation and achieved a 6-Star GreenStar Communities rating. Covering a three-year period to include one of Sydney's worst summers as well as the pandemic, the research draws on precinct-level data, community and household surveys, as well as the detailed monitoring of 40 homes. Research findings have shown energy savings and electrical demand reduction attributable to the geothermal air-conditioning and the added impact of house size in driving consumption. Other findings in relation to the rebound effect from installed air-conditioning and installed rooftop PV in some homes and adaptive practices in others point to the importance of designing sustainable practices amongst users. Precinct-based findings include the cooling effect of light-colored roofs and trees and vegetation as well as the health and well-being benefits for residents in spite of extreme weather and pandemic conditions. Through these findings, we argue for the consideration of the social dimension of user experience and community engagement alongside technical performance, the value of linking public health with planetary health, and the benefits of a precinct-based approach for the built environment.

Integrated Design for a Warming Future – Resilience and Well-being in Warm Climates

Ashok B Lall

Architect and Founder,
Ashok B Lall Architects,
India

Ashok Lall, graduated from the University of Cambridge U.K. in Architecture & Fine Arts and obtained the Architectural Association Diploma in 1970. His architectural firm (estd. 1981) is committed to an architectural practice based on the principles of environmental sustainability and social responsibility. Engaged in architectural education since 1990, he has developed curricula and teaching methods to address environmental issues. He has published many articles and presented papers on
environmentally sustainable design and has been an active member of institutions and groups promoting awareness and building competence in the sustainable design of buildings.

Given the rapid rates of urbanisation, the challenge for the developing economies of the warm climate zones dealing with Climate Change is two-fold: to provide resilient shelter with improved quality of life for growing urban populations, and to mitigate climate change while doing so. The key lies in urban morphology. We seek a framework for urban growth and regeneration that is affordable, achieves basic comfort and well-being for poor citizens, and does so with limited embodied and operational carbon emissions while optimizing the potential for integrating renewables with the urban fabric. Parallel lines of research are presented that converge toward a high-density low-rise morphology as the optimum. This is accompanied by a menu of passive design principles that need to be mandated by regulation with standards for sufficiency of thermal comfort accounting for heat waves and UHI. Case studies of housing, institutional, and commercial buildings are presented. The level of comfort sought is a cultural phenomenon. Greater the expectation - greater the need for complex integration of building and cooling systems. We see a possibility of convergence around an expectation of sufficiency met with low carbon means.

Impact of Climate Change and Urbanization on Future Building Performance

Drury B. Crawley

Director of Building Performance
Bentley Systems Inc, USA

Dr. Drury B. Crawley, Ph.D., AIA, Fellow ASHRAE, BEMP, is a Bentley Fellow and Director of Building Performance with Bentley Systems Inc., focusing on building performance, decarbonization, zero-energy buildings, sustainability, and smart cities. With more than 45 years of experience in energy efficiency, renewable energy, and sustainability, Dr. Crawley has worked in engineering software development, government research, and standards development organizations, as well as building design and energy consulting companies.

With the increasing interest in climate change driven by human activity, recent research has focused on the impact of climate change or urban heat island on building operation and performance across the world. But this work usually aggregates the energy and peak demand impacts across a broad sector. In a recent study, impacts on the operating performance of an office building were estimated based on climate change and heat island scenarios in 25 locations (20 climate regions). This presentation presents the variation and differences among the 20 regions when climate change is introduced. The focus is on changes in comfort conditions, building equipment operation as well as daily patterns of energy performance using prototypical buildings that represent typical, good, and low-energy practices around the world. Other issues such as fuel swapping as heating and cooling ratios change, impacts on environmental emissions, and how low-energy building design incorporating renewables can significantly mitigate any potential climate variation are also presented.

Ways forward in thermal comfort prediction for building design and operation

Marcel Schweiker

Professor
Healthy Living Spaces, Institute
for Occupational, Social, and
Environmental Medicine, Germany

Marcel Schweiker leads the Research and teaching area Healthy Living Spaces at the Institute for Occupational, Social and Environmental Medicine of RWTH Aachen since April 2020. Previously, he was working at the Institute of Building Design and Technology, Karlsruhe Institute of Technology. Marcel does research in Environmental Engineering, Architectural Engineering and Mechanical Engineering with a focus on thermal comfort and human adaptation. One of the current projects is 'International Energy Agency Energy in Buildings and Communities Programme, Annex 79: Occupant-Centric Building Design and Operation.

Thermal comfort predictions are essential during building design and operation to aim for high satisfaction rates. Standardization currently includes two approaches to such predictions: predicted mean vote (PMV) based on Fanger's heat balance model, and predicted acceptable ranges of operative temperature based on regression based adaptive thermal comfort models (ATCM). Both approaches have advantages and disadvantages such as poor predictive accuracy for individual comfort votes and neglect of certain adaptive components of PMV and the neglect of variations in influencing factors such as air speed or clothing levels of ATCM. At the same time, research includes a much larger variety of methods and models for thermal comfort prediction including combinations of heat balance and adaptive approaches like the adaptive thermal heat balance (ATHB) approach, detailed multi-node thermo-physiological models, and individualized predictions based on machine learning approaches. The objective of this talk is an overview of these approaches and their suitability for building design and operation. Based on a large field dataset from India, some of these approaches are assessed and ways forward in theory-based data-driven modelling approaches including individual adaptive mechanisms and design characteristics demonstrated. The talk ends with open points to be discussed among research community and standardization bodies.

The Quantum Comfort Leap

Susan Roaf

Emeritus Professor
Heriot Watt University, Edinburgh
UK

Sue Roaf (B.A.Hons, A.A. Dipl., PhD, ARB, FRIAS) is Emeritus Professor Heriot Watt and an award winning architect, teacher, author and activist she has written and edited 22 books on solar and sustainable design, thermal comfort and climate change adaptation and is currently looking at extreme design in hot dry deserts and Antarctica.

The notion of Quantum Evolution refers to an "all-or-none reaction" where the transitional forms of an evolving species are unstable, perishing rapidly so that is left with is what the species finally has morphed into. The term describes the comparatively rapid transition from one stable type of species adaptation to another distinctly different type under the influence of some strong selection pressure. This paper outlines the need for a Quantum Leap in what we considered to be 'comfort conditions' today to ensure we can adapt to survive in the coming decades of climate heating. As the temperatures soar populations will have to rapidly set against the rising pressures of energy scarcity and costs, globally flat-lining economies and rising levels of fuel and food poverty. Individuals can accommodate only so much in terms of personal thermal adaptation. It has to be buildings that become the first bastion of protection against extreme weather. To avoid wasting time, their intermediate unstable transitional forms will have to be side-lined as designers try and anticipate what the final form of buildings must evolve into to protect populations from extinction. Most current design tools are inadequate for this task. Designers will have to rely on their own intelligent intuition and foresight to create buildings in which people can remain comfortable in a very different future. This requires a Quantum Leap of both Faith and Comfort Thinking.

Harnessing Mixed mode ventilation and Occupant-Centric Control for Energy savings in the Tropics

Adrain Chong

Assistant Professor
Department of the Built Environment
College of Design and Engineering
National University of Singapore,
Singapore

Dr. Adrian Chong is an IBPSA Fellow and Assistant Professor in the Department of the Built Environment at the National University of Singapore (NUS). At NUS, he leads the IDEAS Lab (https://ideaslab.io), a multidisciplinary group that leverages building performance simulation, real-time data, and machine learning to improve building energy efficiency and occupant comfort. Adrian also serves as a subject editor for the journal Building Simulation and holds the role of Early Career Board Member for the journal Building and Environment.

According to the IEA, buildings account for 30% of global final energy consumption, with energy demand for space cooling tripling since 1990. This escalating demand and climate change necessitates we rethink how we currently cool our buildings. Mixed-mode ventilation emerges as a promising solution to significantly reduce energy consumption through the integrated use of natural ventilation and air-conditioning. However, the application of mixed-mode ventilation in tropical climates has been constrained by a prevailing preconception of its limited effectiveness. This skepticism stems from challenges posed by consistently hot and humid conditions, which are thought to limit the potential of operating in natural ventilation. In this talk, I will share ongoing work at my research group to achieve effective mixed-mode ventilation in the tropics. Our approach, focusing on systems integration and occupant-centric controls, aims to address the skepticism surrounding mixed-mode ventilation in such climates. Preliminary findings underscore the promise of a more sustainable way to cool our buildings in the tropics through mixed-mode ventilation.

Lodha's approach of delinking growth from emissions by transforming the built environment.

Aun Abdullah

Vice Deputy President
Lodha Group
India

Aun Abdullah leads sustainability/esg at Lodha and has been instrumental in shaping the sustainability strategy at the group. He comes from a building services and infrastructure design/design management background, with experience on large/very large landmark projects in India and the Middle East (UAE and Qatar). Abdullah has led the formation of Lodha Net Zero Urban Accelerator, which focuses on embodied carbon, passive designs, equipment efficiency, renewable integration, green mobility, and green finance - with the intention of making net zero carbon the new normal for the built environment. Abdullah isam interested in cleantech and ideas that have the potential to become cost-effective (for the developer as well as the end-user) given the scale and growth opportunities in our operations.

This talk explores the pivotal role of the built environment in navigating India's impending growth while addressing climate risks. Emphasizing resilience and decarbonization, it delves into the critical business case for climate action within the built environment sector. By examining the challenges and opportunities in supply chain transformation, the presentation advocates for sustainable practices that not only mitigate environmental impact but also foster economic growth. The intricate relationship between India's development trajectory, climate resilience, and the imperative for transformative actions in the built environment will be addressed.

Workshops

Climate Resilient Energy Efficient Design in Architecture

Sukumar Natarajan

Preparing for climate change – a perspective on humans and buildings

Marcel Schweiker and Hannah Pallubinsky

Grounded Energy Modelling for Equitable Urban Development

Pamela Fennell and Paul Ruyssevelt

Urban Energy Modelling in the Global South

Pamela Fennell and Paul Ruyssevelt

Climate Resilient Energy Efficient Design in Architecture

Sukumar Natarajan

The goal of the CREEDA manual is to immerse you in the process of designing buildings that are resilient to a changing climate whilst also being highly energy efficient. The approach we take in the manual is one of "learning by doing". That is, rather than teaching you concepts or calculations, we show you how to reason out a strategy for the design of your building at a very early stage in the design process – maybe before you even have drawings. Thus, we wish you to learn how to PLAY with these types of tools through a process of self-education. The manual contains a series of case study buildings, all based on real buildings at different stages of construction. We show you how to transform data for such buildings into a free-to-use tool called ZEBRA, use current and future weather data for any part of India at a 25 km spatial resolution and leverage existing knowledge and practices within India to achieve our goal of a truly low-energy climate resilient building. We take each case study building through carefully selected changes to expose the ramifications of designing them differently – in effect showing you how to PLAY with your own designs.

Preparing for climate change – a perspective on humans and buildings

Marcel Schweiker and Hannah Pallubinsky

The increasing frequency of extreme heat events we have witnessed and endured across the globe over the past years highlights the seriousness of the situation we find ourselves in. Available data and projections indicate that the average global temperature is rising sharply, further increasing the risk for more extreme weather events, which pose a considerable risk to human health and well-being. It is becoming very clear that climate change will affect each and every one of us in the future, and we must prepare for the consequences in our daily lives. In this workshop, an overview of the 'status quo' and a look into the future regarding climate change and temperatures in homes and workplaces will be provided and discussed. We aim to draw attention to alternative avenues of coping with climate challenges, both with respect to modification of the built environment and human active and passive reasons. It will then be debated, actively involving the audience, if allowing more thermal variation indoors seasonally and daily, though it may seem counterintuitive, can aid in enhancing the resilience and health of human occupants, while also saving precious resources, decreasing the negative impact of building CO2-footprints.

Grounded energy modelling for equitable urban development

Pamela Fennell and Paul Ruyssevelt

This workshop is intended to engage policy-makers and property developers, encourage active participation, and facilitate the translation of research findings into actionable outcomes. It will include a mix of presentations, panel discussions, group activities, and opportunities for networking and collaboration. The ultimate goal is to develop a list of changes to design, policy, and engagement practices that can improve energy efficiency and thermal comfort and garner commitment from participants to implement these changes.

Urban energy modelling in the Global South

Pamela Fennell and Paul Ruyssevelt

Large-scale models of building energy consumption are well-established tools in the global North, whereas their use in the global South is less common. This workshop aims to explore the challenges and opportunities for the application of Urban Building Energy Models in cities in the global South through case studies using real-world data. The workshop will include presentations on Footprint extraction, Tax Data, Using Vignettes to Model Occupant Behavior, and Exploring Thermal Comfort in UBEM. This workshop targets Building Performance Simulation (BPS) practitioners, researchers, and local government representatives.

Paper Presentation - Session 4 (Day 2, 13:05 - 14:25)

Session 4A - Health and Well-being in buildings

- Occupant satisfaction: a measure of Green Building Performance
- Enhancing Indoor Air Quality and Occupant Well-being in Split Air-Conditioned Bedrooms through Integrated Ventilation
- The daylight almanac of Indian hoseholds: A case of Ahmedabad
- Field study on measuring indoor air quality in certified green-rated urban Indian residences

Session 4B - Design Interventions in Buildings for Thermal Comfort

- Contemporary Vernacular Architecture in The Brazilian Tropical Savana: The Case-Study of the Children's Village in the Canuana Farm, in Tocantis.
- Impact of Naturally Ventilated Residential Units on Heat Stress
- Designing dwellings to cope with extreme heat in low-income communities
- The Future of Responsive Facade for Multi-Storey Residential Buildings in Tropical Climates

Session 4C- Nature-based solutions

- Influence of Hygroscopic Property of Lime and Cement Plaster on Building Energy Consumption for Different Climate Zones of India.
- Learnings from the extreme thermal comfort adaptation of Jain ascetics during the summer and the monsoon months in India
- Perception of the impact of biophilia on the health and well-being of occupants in a hospital setting.
- The Green Side of Passive Cooling: Building Facades Inspired by Evapotranspiration in Trees

Session 4D - Climate Resilience Buildings and Communities

- Role of urban morphology in enhancing the outdoor thermal comfort: A case of Mumbai
- Onsite Thermal Energy Storage for Efficient and Resilient Air-conditioning in Indian Buildings
- Assessing the Integration of Building Science in Higher Education Curricula: Implications for Climate Change Adaptation in the Built Environment
- The energy saving potential of using adaptive setpoint temperatures: a case study for offices in India

Note: The Presenting Author has been marked with an asterisk (*)

Occupant Satisfaction: A Measure of Green Building Performance

Authors - Ashima Grover[1*], Tejwant Brar[1], Anshul Gujarathi[2]
1: Sushant University, Gurugram, 2: Eco Solutions, Pune
Email - ashima.archi@gmail.com

Green building certification is standard practice for ensuring positive performing buildings during their construction and operational phase. Throughout the lifecycle of the building, the major consumption of resources occurs in the operational phase, when occupants interact with the building systems and spaces for their comfort and productivity. Building performance is largely a measure of the number of natural resources it consumes for its work and the quality of spaces it provides for its occupants. Occupant perception and satisfaction within an environment is an implicit parameter that has a huge impact on building performance. This parameter of performance is hardly attempted for comprehension or quantification by building operators, managers, and owners by conducting post-occupancy evaluation (POE) studies. This lacuna in building industry practice leads to a gap in anticipated building operational performance. Therefore, this paper is an attempt to highlight the significance of occupant satisfaction in achieving green building performance targets.

Keywords. Building operational energy Performance, Occupant Satisfaction, Post Occupancy Evaluation (POE).

Enhancing indoor air quality and occupant well-being in Split Air-conditioned bedrooms through integrated ventilation

Authors- Nilabhra Mondal[1], Ajith Nair[1], Krithika Panicker[1], Prashant Anand[1]*, Ardeshir Mahdavi[2]

1: IIT Kharagpur, India; 2: TU Graz, Graz, Austria

Email - mondal.nilabhra@gmail.com

Maintaining Indoor Air Quality (IAQ) and ensuring the well-being of individuals in split air-conditioned indoor spaces such as bedrooms can be challenging, primarily due to the increased risk of airborne infection transmission and high CO2 concentration. To address these issues, pertinent guidelines recommend ensuring adequate ventilation with fresh air, as it effectively mitigates the spread of indoor pollutants. However, split air-conditioned spaces often lack a continuous supply of fresh air. The resulting indoor air quality deterioration can cause occupants to resort to opening doors and windows. This, in turn, can result in an unnecessary increase in heating or cooling energy use. The objective of this study is to address the limitations of existing air cleaning and air- conditioning systems, which may include insufficient ventilation, excessive recirculation of indoor air, limited effectiveness, and the inability to dynamically respond to indoor pollutants in an energy-efficient manner. It has been observed that occupant's open doors and windows for fresh air ventilation in response to a feeling of stuffiness for a considerable fraction of the total operational hours of a split AC in a bedroom. The present study suggests that by integrating ventilation and air-conditioning in a coordinated manner, IAQ and hence occupants' well-being in bedrooms can be enhanced in an energy-efficient manner.

Keywords - Bedroom Ventilation, CoVID-19, Split AC, Energy Efficiency, Occupant Behaviour, IAQ

The Daylight almanac of Indian households: a case of Ahmedabad

Author - Minu Agarwal
CEPT University, India
Email - minu.agarwal@cept.ac.in

The aim of this study is to assess the daylight access levels (vertical illuminance) in Indian homes. Daylight access levels in an occupied space on a given day are dependent on three main factors, the prevailing weather conditions, the design of the home, and occupant behavior. This study aims to isolate the effect of occupant interventions that result in lowering the daylight levels inside the home. The occupants may intervene intentionally or unconventionality in ways such as using curtains, hanging laundry, putting up screens, adding plants to balconies, furniture placement, and infrequent cleaning of windows. In this study, these are treated as occupant behavior traits that may impede daylight access.

12 homes in Ahmadabad (hot and dry climate) were monitored for a week each (data logged at 15-minute intervals, October 2022- Jan 2023) for daylight levels received in the living room. The use of electric lighting and activities being carried out by occupants were also monitored. The ideal potential of the home to provide daylight access, if no occupant interventions were present, is estimated using computer simulation. The frequency and duration of occupant interventions are estimated by running correlation tests between prevailing weather and indoor daylight levels.

Keywords - Daylighting, Daylight access, Residential buildings, Vertical illuminance, Occupant/ User behaviour

Field study on measuring Indoor Air quality in certified Green-rated urban Indian residences

Authors - Rajat Gupta*, Yuanhong Zhao
Low Carbon Building Research Group, Oxford Brookes University, United Kingdom
Email - rgupta@brookes.ac.uk

India has the second largest registered green building footprint in the world, however, there is growing recognition that green building rating and certification systems do not always ensure better indoor air quality (IAQ) over conventional buildings. Moreover, residents spend a substantial fraction of their lives indoors, yet IAQ in homes has been studied far less than air quality outdoors, especially in urban India. To verify the actual IAQ performance of green-rated buildings built to sustainability standards, this study uses a socio-technical building performance evaluation (BPE) approach to empirically assess daily trends and variations in IAQ parameters measured across a sample of twelve green-rated urban Indian residences (high-income group) co-located in an apartment complex in Delhi. Using internet-enabled Airveda devices, time-series monitoring data at 30' intervals were gathered for indoor temperature, relative humidity, CO2, PM2.5 and PM10 for 7 days during the summer season when air conditioning was prevalent. Contextual data about the physical and social aspects of residences were gathered using household surveys. Results were compared against the recommended ISHRAE and WHO standards to observe any deviations. Given the paucity of empirical data, an online interactive dashboard (RIAQ) for visualising IAQ in green-rated homes was developed to enable further research.

Keywords - Indoor air quality, post-occupancy evaluation, green-rated residences, visualization

Contemporary vernacular architecture in the Brazilian Tropical Savana: The case-study of the children's village in the Canuana Farm, in Tocantis.

Authors - Leticia Hein Hsiao[1], Joana Carla Soares Goncalves[2*], Alessandra R Prata Shimomura[1], Carolina Girotti[1], Lucélia Rodrigues[3], Lorna Kiamba[3], Roberta Kronka Mulfarth[1]

1: Department of Electrical Engineering, University Carlos III of Madrid, Madrid, Spain;
2: Department of Building Constructions, University of Granada, Granada, Spain;
3: Department of Building Constructions II, University of Seville, Seville, Spain

Email - carlosrubio@us.es

Completed in 2017, the building complex Moradias Infantis de Canuanã (Canuanã Children's Village) is located in the city of Formoso do Araguaia in Tocantins, in Brazil. Its architecture is strongly influenced by the local savanna climate which is characterised by distinct hot-dry and hot-mid seasons. In this study, the authors evaluated the buildings thermal conditions and the potential of natural ventilation using analytical procedures supported by computer simulations. Air movement in the transitional spaces was also simulated with CFD techniques. The findings reveal that during the hottest periods of the year, the key habitable spaces (bedrooms) in the building have temperatures 10 oC below the outdoors. Primarily, this performance is attributed to the influence of thermal mass, combined with natural ventilation and shading. Additionally, a positive impact of natural ventilation on indoor conditions requires a combination of wind driven and buoyancy effects. In the courtyards, the distance between blocks is enough to allow perceivable air-speeds. Overall, this study has shown that the holistic design employed at the Children's Village building complex in Tocantins works well to maintain the indoor thermal environment at acceptable conditions.

Keywords - Vernacular Architecture, Tropical Savanna, Thermal Conditions, Natural Ventilation, Analytical Study.

Impact of naturally ventilated residential units on heat stress

Authors - Sreeparna Ghosal*, Rajan Rawal
CEPT University, India
Email - sreeparna.pbe21354@cept.ac.in; rajanrawal@cept.ac.in

In recent years, the adaptive model of thermal comfort has gained traction as a more robust alternative to fixed set-point-driven design, which considers various factors that impact human comfort, such as humidity, air velocity, mean radiant temperature, and ambient temperature. Nonetheless, it is crucial to recognize the limitations of such models and the potential for discomfort and stress. This research employs simulations to systematically evaluate WBGT as a parameter to measure heat stress in residential buildings in Bhubaneshwar, India, comparing ventilation scenarios. The study assesses three building envelope materials: Conventional (RCC and Brick) and Innovative (EPS Core). The ECBC-R[11] standard and a dynamic method derived from regression analysis predicts heat stress, analysing natural ventilation in residential units using the IMAC-R [7] and ISO 7243 [1] benchmark. Heat stress profoundly affects well-being in hot climates. With the rise of energy-efficient, naturally ventilated buildings, understanding their impact on heat stress is crucial. This is particularly significant in countries like India that are grappling with climate change induced heat waves. The study focuses on the factor of heat stress in adaptive thermal comfort models, emphasizing the need for a more holistic approach to indoor comfort factors. Insights gained can lead to improved strategies for optimal thermal comfort and reduced heat stress risks, vital for occupant health. Indoor WBGT ranged from 16°C to 33°C for various envelopes, averaging 28°C (RCC), 24°C (Brick), and 22°C (EPS). Indoor air velocity of 0.9-1.8 m/s lowered WBGT by 0.15°C or 0.27°C annually. Discomfort hours were ~5,000 (RCC), 3,600 (Brick), and 3,200 (EPS), peaking in May-June at 40°C outdoor DBT. Proper insulation and ventilation are crucial for comfort and heat stress reduction. By considering diverse factors affecting indoor comfort, it offers insights to create safe and comfortable indoor environments, especially in regions prone to heat stress. The findings advocate a balanced approach that combines effective insulation and ventilation strategies for optimal occupant well-being.

Keywords - Heat Stress, Natural Ventilation, Thermal Comfort, Climate change, WBGT

Designing dwellings to cope with extreme heat in low-income communities

Authors - Ben M. Roberts[1*], Kevin J. Lomas[1], Katherine V. Gough[1], Raymond Kasei[2], Frederick W. Manu[3], Efi Spentzou[1], Robert L Wilby[1]

1: Loughborough University, United Kingdom;
2: University for Development Studies, Tamale, Ghana;
3: Building and Road Research Institute, Kumasi, Ghana

Email - b.m.roberts@lboro.ac.uk

Designing effective passive cooling interventions for dwellings in low-income communities exposed to tropical climates is vital to ensure occupant health and comfort in a warming climate. More knowledge is needed, however, on which interventions would be culturally acceptable, affordable, and effective in reducing high indoor temperatures. Four experimental buildings were built in Ghana to evaluate such interventions. Their initial design was based on a typical home for low-income urban residents in northern Ghana. A multi-disciplinary team contributed to the design and the proposed cooling interventions. Using dynamic thermal simulation, engineers predicted indoor temperatures for different construction materials, shading, and ventilation strategies. Social scientists provided input on the cultural acceptability of the proposed designs. The study showed how simple interventions can achieve worthwhile reductions in indoor temperature. In future work, the dynamic thermal models will be calibrated using data collected inside the real experimental buildings.

Keywords - Extreme heat, overheating, tropical climate, thermal comfort, passive cooling.

The Future of responsive facades for Multi-Storey Residential buildings in tropical climates

Authors - Paloma Suzan Marques de Souza[1], Juan Vallejo[1]*, Joana Carla Soares Gonçalves[2], Rosa SCHIANO-PHAN[1]

1: University of Westminster;

2: Architecture Association School of Architecture

Email - Joana.Goncalves@aaschool.ac.uk

The design study seeks to comprehend the principles and elements of a Responsive Facade and how they affect user comfort and energy efficiency for space cooling in multi-story residential buildings in extreme hot conditions. The research is based on precedent studies, occupant behavior, and a critical analysis of challenges in existing building facades, having a tropical hot and dry city in Brazil as case study. It identifies the different factors that interfere in the internal thermal conditions and building performance to build passive strategies that will optimize facade design proposal and energy saving. As a result, a facade was proposed with ceramic being the main material to make perforated and opaque panels that function as a second layer of shade and permeable envelope that moves in response to the sun or under occupant's control. The impact on the internal conditions is seen in a reduction of 4°C of the internal resultant temperature, leading to a reduction of energy demand for space cooling of 44% .

Keywords - responsive facades, multi-storey residential building, tropical climate user comfort, energy efficiency.

Influence of hygroscopic property of lime and cement plaster on building energy consumption for different climate zones of India

Authors - Divya Mullick[1]*, Rashmin Damle[1], Nikhil Bhesaniya[2], Yash Shukla[2], Rajan Rawal[2]

1: Faculty of Technology, Master's in Building Energy Performance Program, Centre for Environmental Planning and Technology (CEPT) University, Ahmedabad 380009, India;

2: Center for Advanced Research in Building Science and Energy (CARBSE), CEPT University, Ahmedabad 380009, India

Email - mullickdivya@yahoo.com

Lime and cement are the commonly used walling materials in India. They are used as wall mortar and wall finish materials. Lime is a sustainable material with qualities such as breathability and better moisture transfer properties. Though it is a natural material, in contemporary construction practices, lime mortar or lime plaster has been replaced by cement mortar and cement plaster. To predict the impact of the moisture-buffering ability of building materials, hygrothermal simulations are carried out. It is a simulation-based study where the two numerical models of EnergyPlus are studied: Conduction Transfer Function (CTF) and Combined Heat and Moisture Transfer (HAMT). The study quantifies the annual energy consumption in a low-rise office building for five climate zones of India. Preliminary work shows that lime-plastered building has lower indoor relative humidity by 6 - 10% and the indoor conditions were 6% more comfortable. The results show that building having cement plaster is more energy consuming than lime. The moisture-buffering capacity of lime helped in reducing overall energy consumption by 12 – 23 kWh/m2 for the five climate zones of India.

Keywords - Heat and Moisture Transfer, Lime Plaster, Cement Plaster, Energy Consumption.

Learnings from the extreme thermal comfort adaptation of Jain ascetics during the summer and the monsoon months in India

Authors - Jay Dhariwal*, Sonal Gangrade, Payal Dhariwal

IIT Delhi, Delhi, India

Email - jay@design.iitd.ac.in

Heat waves are rising in intensity and frequency. They could break the human survivability limit in India in the coming years. The goal of this paper is to understand the extreme thermal comfort adaptation of ascetics from Jain Svetambara sects in hot and dry as well as warm and humid weather in India to help the vulnerable populations beat the heat. A total of 65 subjects were interviewed in Delhi, Jodhpur, Siriyari and Ahmedabad between May and September 2023. Surveys were carried out with measurements of the indoor environment according to the adaptive thermal comfort methodology. Around 75% of the subjects had a neutral or a cooler thermal sensation while the thermal comfort index, UTCI, was in the strong to very strong heat stress range. Ninety percent of the subjects found these thermal environments to be acceptable. Two-third of the subjects preferred no change in the humid conditions when more than 50% of them acknowledged the presence of higher humidity in their indoor environment. An adaptive thermal comfort model proposed in this study suggests that it is possible to go beyond the IMAC-R model to further reduce the cooling needs of the warming world.

Keywords - adaptive thermal comfort, ascetics, UTCI, health and wellness, IMAC-R.

Perception of the impact of biophilia on the health and well-being of occupants in a hospital setting

Authors - Unati Kumar Watwani*, Namrata Atul Dhamankar
Dr Bhanuben Nanavati College of Architecture,Pune, India
Email - watwaniunati@gmail.com

Individual perceptions are essential while evaluating the well-being benefits of nature. This study predicted biophilia's influences on the occupant's health and well-being in a building. The study was conducted in a healthcare building in the city of Pune- a case of a hospital designed on the principles of biophilia was taken such that a comparison of observation and perception of occupants was analyzed. A biophilic design framework developed by Kellert in 2008 was adopted and a questionnaire was prepared based on the elements and attributes present in the case building based on diligent on-site observation of the whole campus of the case hospital. The survey was conducted with the prepared questionnaire based on the elements and attributes present using a Likert scale of 1 to 5 based on dissatisfaction and satisfaction level where 1 stands for extremely dissatisfied and 5 is extremely satisfied. Perception of 100 occupants is taken by further dividing them into 3 main categories based on their nature and daily workflow, the inpatients; the outpatients and visitors; and the staff. Results reveal 57.7% of the staff,76 % of the outpatients, and 84.36% of the inpatients were satisfied with the presence of biophilic elements and attributes present in the campus and state having improved health and well-being, however, few attributes like connection to place, natural shapes, and form contain mixed reviews due to lack of understanding of the attribute. Also, the results state that each element and attribute are interlinked, and a group of attributes is such a form dividing them into 6 categories. Few recommendations have been made based on the elements and attributes for enhanced health benefits. Accordingly, the study recommends that with the successful implementation of biophilic design principles, hospital buildings can be transformed into healing places that will boost and bring many benefits to the occupant's health and well-being.

Keywords - biophilic design, nature based solutions, hospital building, health and well-being.

The green side of passive cooling: building facades inspired by Evapotranspiration in trees

Authors - Monish Siripurapui*, Pranjal Maheshwari

Ant Studio Pvt Ltd, India
Email - monish.siripurapu@ant.studio

Buildings suffer from uncontrolled heat gain through their skin, which creates an urgent need for thermal comfort. In hot climates such as India, a growing economy with a rising per capita income is leading to an expected rise in cooling demand—by 11 times in the next two decades. The use of passive cooling strategies to reduce direct heat gain through building envelopes is an integral step in reducing the energy demand for cooling. The system works as a shading device similar to adjustable louvers, moreover, the terracotta's porosity mimics cooling evapotranspiration. It adapts to sun angle, building orientation, and design. It combines terracotta and water to effectively cool, especially in multi-story buildings. The efficiency of the proposed passive cooling system was tested in the composite climatic regions of Raipur and Hyderabad, the nature-inspired passive cooling system reduced cooling energy needs by 30% and 47% respectively. The future of space cooling in buildings can benefit by using efficient passive cooling envelopes that can reduce the heat gain in the buildings. Climatically adaptive designs hold the potential to influence the shape of future buildings, landscapes, and cities, perhaps with earthy tones.

Keywords - Envelope Cooling, Passive Cooling, Building Façade, Climate Responsive, Biomimicry

Role of urban morphology in enhancing outdoor thermal comfort: A case of Mumbai

Authors - Kritika Vidyashankar[1]*, Srushti Rahigude[1], Lilly Rose Amirtham[2]
1: CEPT University;
2: School of Planning and Architecture, Vijayawada
Email - srushti.ud@gmail.com

In recent years, the city of Mumbai has been experiencing the pressing challenge of urban heat islands, affecting the thermal comfort of its high-density urban environment, impacting both air and surface temperatures. The Intergovernmental Panel on Climate Change (IPCC) projected that climate change would adversely affect 27 million people in Mumbai (6th assessment report). Understanding the intricate relationship between the built environment and its influence on microclimates and thermal comfort was imperative for creating climate-sensitive designs. This paper investigated the role of urban morphology in improving the thermal comfort of a typical neighborhood in Mumbai. The analysis was based on simulations conducted using ENVI-met, a 3D urban climate modeling tool. The research aimed to comprehend how open spaces, aspect ratio, setbacks, and plot boundary conditions within the neighborhood affected outdoor thermal comfort. The objective was to underscore the significance of urban designers and planners in assessing the impact of built environments on microclimates and leveraging microclimatic insights for the design of public spaces. Air temperature, relative humidity, wind speed, and mean radiant temperature were measured at 15 locations within the neighborhood, Matunga east, and its primary street in February 2023. The recorded data were used to validate the Envi-Met model . Two distinct scales were analyzed: neighborhood-level and plot-level iterations. Neighborhood-level iterations focused on block-level modifications, while plot-level iterations examined street and boundary conditions. Each iteration was evaluated using EnviMet to assess changes in thermal conditions relative to the current site conditions (Base case). The analyses were conducted for the critical summer month (May). The study ultimately revealed that the introduction of road networks in prevailing wind directions and the incorporation of green open spaces within the urban fabric could reduce overall heat stress duration from 12 hours to 6 hours. Smaller-scale interventions, such as 50% porous pavements and strategically placed trees, also yielded positive outcomes. This research aspired to provide urban planners with a comprehensive framework that integrated outdoor thermal comfort as a pivotal aspect in the design of future urban landscapes.

Keywords - Outdoor thermal comfort, Climate resilience, Urban morphology, EnviMet

Onsite thermal energy storage for efficient and resilient air-conditioning in Indian buildings

Authors - Soumyadip Bhattacharyya[1,2], Shyam Amrith[3], Pamela Fennell[3], Anurag Goyal[1*]

1: Thermal Systems Research Laboratory, Department of Mechanical Engineering, Indian Institute of Technology Delhi, New Delhi-110016, India;

2: Department of Civil Engineering, Indian Institute of Technology Delhi, New Delhi, India;

3: Bartlett School Environment, Energy & Resources, University College London, London, WC1E 6BT, UK

Email - agoyal@mech.iitd.ac.in

Thermal energy storage (TES) systems enable storing energy during off-peak hours (low demand) and release it in peak hours (high demand), improving the energy efficiency and resiliency of buildings. We present a simulation methodology to assess the performance of the TES system integrated with heating, ventilating and air- conditioning (HVAC) systems. We use a validated thermal load profile of the building in a detailed thermodynamic simulation framework to assess the feasibility of TES systems. TES coupled with HVAC systems can help improve the capabilities of building energy simulation platforms by enabling simulations of load shaving potential of TES systems and selecting the optimal material for storage. Our model can analyse the feasibility of TES for any residential or commercial building, which will help identify the most impactful categories for implementing energy storage. Our results show a load-shaving fraction of up to 38% can be achieved for a medium office building in Ahmedabad. It will help reduce the size of the vapor compression system, leading to a significant reduction in the initial capital investment and demand charges.

Keywords - thermal energy storage, building energy efficiency, load shaving, grid-interactive buildings

Assessing the integration of building science in higher education curricula: implications for climate change adaptation in the built environment

Authors - Rajashree Shashikant Kotharkar[1]*, Riddhi Sarda[1], Roopal Deshpande[2]
1: VNIT Nagpur, India;
2: SMMCA Nagpur, India
Email - rskotharkar@gmail.com, rskotharkar@arc.vnit.ac.in

This study critically examines the readiness of professionals in India to address the consequences of climate change. With a focus on architecture education, 15 institutes offering undergraduate courses were identified. The study solely assesses course syllabi on crucial building science topics related to climate change adaptation. The alignment of building science with the model curriculum guidelines provided by COA is also examined. The findings reveal certain building science topics are present in the syllabi only in a fundamental manner. However, there are gaps in in-depth coverage, integration with design studios, and practical skill development. The implications of these findings highlight the need for curriculum enhancements in architecture education, ensuring a comprehensive understanding of building science principles and their application in addressing climate change challenges. The study's application extends to guiding higher education institutions in revising their curricula to align with the urgent climate change impacts. Future research directions involve qualitative analyses and cross-country comparisons to enrich the discourse on integrating building science principles and climate adaptation into architecture education.

Keywords - Built Environment, Higher Education Institutes in India, Climate Change, Education of Building Science, COA.

The energy saving potential of using adaptive setpoint temperatures: a case study for offices in India

Authors - Daniel Sánchez-García[1], David Bienvenido-Huertas[2], Carlos Rubio-Bellido[3*]

1: Department of Electrical Engineering, University Carlos III of Madrid, Madrid, Spain;

2: Department of Building Constructions, University of Granada, Granada, Spain;

3: Department of Building Constructions II, University of Seville, Seville, Spain

Email - carlosrubio@us.es

Adopting setpoint temperatures guided by adaptive thermal comfort models offers an efficient approach to conserving energy. Current research gives consideration to global models like ASHRAE Standard 55 and EN16798-1, which incorporate adaptive setpoint temperatures. However, this study follows a distinct path by incorporating a localized Indian adaptive comfort model, specifically the India Model for Adaptive Comfort for Commercial buildings (IMAC-C). This research delves into the energy-saving potential linked to the utilization of setpoint temperatures derived from IMAC-C. A comparative analysis is conducted, juxtaposing these temperatures with those based on the worldwide ASHRAE Standard 55 adaptive model and PMV-based setpoint temperatures aligned with the National Building Code for India. Comprehensive building energy simulations have been executed, encompassing all of India's climate zones and accommodating both naturally-ventilated and full air conditioning operational modes for buildings. The outcomes highlight that applying setpoint temperatures grounded in the IMAC-C adaptive comfort model in full air-conditioning mode could potentially lead to energy savings ranging between 9% and 26% in most of the climates. Consequently, it is conclusively determined that the integration of setpoint temperatures rooted in the Indian local adaptive comfort model represents a highly effective strategy for achieving energy conservation.

Keywords - Adaptive setpoint temperatures, adaptive thermal comfort, accim, computational approach

Paper Presentation - Session 6 (Day 2, 16:35 - 17:55)

Session 6A - Circular Economy Building Materials and Methods

- Pitch to Policy program in India and Indonesia - a co creation approach towards decarbonisation
- Circular Economy, Building Materials and Methods
- An experimental investigation on the impact of lime and cement mortar/ plaster material on the indoor hygrothermal environment of test spaces
- Assessment of the thermal performance of alternative wall and roof assembly in buildings: A case in Vijayawada

Session 6B - Thermal Comfort Models and Metrics and Resilience

- Characteristics of thermal comfort in the warm and humid climate of North-East India
- Applicability of existing models for predicting thermal comfort in sports facilities through the analysis of a case study
- Thermal comfort and occupants' behavior in Japanese condominium

Session 6C - Low Energy Cooling Technologies

- Development of simulation-based strategy for mixed-mode operation of buildings
- Thermal performance analysis of thermoelectric radiant panel system for indoor space heating
- Passive Cooling Strategies For A Better Comfort During Weather Extremes – Adapting the Existing Building Stock In German Cities To Future Climatic Conditions
- Experimental assessment of various control algorithms for direct evaporative cooling systems

Session 6D - Human Physiology and Adaptation

- Revisiting hotels: A holistic approach to increase guest comfort and save energy for hotels in North India
- Skin temperature and thermal perceptions over the day: a case study in a hybrid-ventilated living lab
- Impact of Climate Change on the Sociocultural Landscapes of Barsana Town in Braj Region
- Study on behavioral adaptation for the adaptive thermal comfort and energy saving in Japanese office buildings

Note: The Presenting Author has been marked with an asterisk (*)

Pitch to policy program in India and Indonesia - a co-creation approach towards decarbonisation

Authors - Peter Graham[1,2], Craig Alexander Burton[1]*, Ari Seligmann[1]
1: Faculty of Art, Design and Architecture, Monash University, Melbourne, Australia;
2: Global Buildings Performance Network, France
Email - craig.burton@gbpn.org

Across the world the building and construction sector contributes 37% of energy use and 39% of energy and process related carbon emissions [1]. In order to keep global warming below 1.5 °C the buildings sector must halve its emissions by 2030 and be net-zero by 2050 [2], yet emissions were their highest ever in 2021 [1] because rates of new construction and increases in energy demand were far greater than efficiency gains delivered by new building regulations and other policy reforms. Global Buildings Performance Network (GBPN) and Monash University Australia conceived and implemented the Pitch to Policy (P>P) programme as an innovative experiment aimed at validating crowdsourcing, co-creation and systems thinking approaches to promote inclusive policy making for climate action. The program brought relevant government departments, policy makers and entrepreneurs together to co-create innovative solutions for decarbonizing the buildings sector. The program was piloted in two growing economies - India and Indonesia, in partnership with local organisations. A total of 25 teams of professionals participated in the program and 6 finalist teams were awarded seed funding. Some teams have gone on to win contracts, initiate important industry efforts and trial their inventions. Future work will build on post-P>P government engagement for winning teams

Keywords - Built environment, innovation competition, public policy, India, Indonesia

Circular economy, embodied energy, embodied carbon

Author - Arun Bhandari
eCUBE Solution, India
Email - arynum@gmail.com

The concept of circular economy is gaining prominence as a sustainable approach to resource management and environmental protection. According to the Ellen MacArthur Foundation, circular economy is "an economy that is restorative and regenerative by design, and which aims to keep products, components, and materials at their highest utility and value at all times" (Ellen MacArthur Foundation, 2013). The circular economy model emphasizes the efficient use of resources, reduction of waste, and promotion of closed-loop systems to create a sustainable and resilient economy. This research paper tries to understand the application of circular economy principles in the building design and construction methods in India. The study will analyse the existing manufacturing methods for brick, cement, and steel bars in India, identify market trends and innovative policy and regulatory practices related to circular economy principles. The paper argues the need for service level innovations and market transformation in the building material production process, Eco-labelling policy and whole building Embodied Carbon indicator and informed consumer behaviour as well as environmental product declaration recommendations as the long-term strategies for the circular economy in the building design and construction industry.

Keywords - Life Cycle Assessment, Circular Economy, Embodied Carbon, Eco-Labelling

An experimental investigation on the impact of lime and cement mortar/ plaster material on the indoor hygrothermal environment of test spaces

Author - Ayushi Singh*, Rashmin M. Damle, Nikhil Bhesaniya
CEPT University, Ahmedabad, Gujarat, India
Email - ar.ayushisingh@gmail.com

The study's objective was to investigate and quantify the heat and moisture transfer through two walls of a 1m2 area facing south, located in Ahmedabad, Gujarat, India. One of the walls was constructed with lime mortar, and the other with cement mortar and XPS (Extruded Polystyrene) blocks of size 230 x 100 x 75 mm, coated with an inner plaster layer of the same materials. Other walls were made up of EPS (Expanded Polystyrene), thus limiting the heat and moisture transfer only through mortar layers. The mortar joints on the exposed wall accounted for 17% of the total surface area of the wall. The study monitored the temperatures, relative humidity, and surface temperatures inside the two identical test cells of 1 m3 volume each for 54 days from 1st March to 23rd April 2023. Also, a 3-day moisture test was carried out to check the effect of vapor permeability.

The research questions are as follows.
- Is the hygrothermal environment different for cement and lime mortar cells?
- Will the cement mortar produce higher heat ingress due to high conductivity?
- Will the higher thermal mass of cement make a difference in the hygrothermal environment of the cells?

Keywords - Lime plaster & mortar, hygrothermal behaviour, moisture buffer, thermal bridging, vapor transmission

Assessment of the thermal performance of alternative wall and roof assembly in buildings: a case in Vijayawada

Authors - Yeswanth N*, Lilly Rose Amirtham
School of Planning and Architecture, Vijayawada
Email - ar.yeswanth.n@gmail.com

The world's climate, natural systems, and public health are all negatively affected by conventional building materials and construction methods. Buildings are highly resource-intensive, resulting in over exploitation of raw materials. The evolution and use of alternative building components to improve thermal performance has witnessed an increasing trend due to the growing awareness of energy efficiency and sustainable building techniques worldwide. This research paper focuses on a comprehensive assessment and evaluation of alternative wall and roof assemblies, such as natural materials, biomaterials, and salvaged materials. A wide range of alternative materials for the wall and roof assemblies were chosen for a residential building in Vijayawada based on their availability, featuring diverse combinations of insulation materials, thermal masses, and cladding options. Detailed modelling of heat transfer processes within the building envelope, including conduction, convection, and radiation, analysis is possible with software, while accounting for external weather conditions. The U-value, Time lag, decrement factor and heat gain / loss of the assembly were assessed through Opaque 3.0, developed by the Society of Building Science Educators (SBSE). A comparative analysis of alternate materials with conventional materials in the field of construction was performed to improve thermal performance for indoor occupant comfort to reduce energy consumption in a naturally ventilated residential building in Vijayawada. Further, suitable wall and roof assemblies based on their compliance with ECBC (Energy Conservation Building Code) standards were identified.

The findings offer useful information on how different wall and roof systems perform in comparison to the conventional materials. Straw bale with mud and lime plaster of U-value of 0.17 W/m2.K performs best with a time lag of 9.9 hr among the various alternatives analyzed. Similarly, Mangalore tile with Palymra beam, which has an inclination of 45°, performs best comparatively, with a lowest U-value of 2.2 W/m2.K and a time lag of 11 hours. It provides insight into the efficiency of advanced methods of construction in improving interior comfort, lowering energy use, and developing sustainable building design. In order to satisfy the demands of a continuously changing and energy-conscious built environment, the outcomes of this study provide architects, engineers, and policymakers with invaluable insights into the selection of suitable building assemblies.

Keywords - Alternative building materials, Building Envelope, Opaque 3.0, Thermal transmittance, Time Lag, Heat gain.

Characteristics of thermal comfort in the warm and humid climate of North-East India

Authors - Manoj Kumar Singh[1*], Pravin Diliban Nadarajah[2], Sanjay Kumar[3], Jyotirmay Mathur[4]

1: Shiv Nadar Institution of Eminence, India;
2: Shiv Nadar Institution of Eminence, India;
3: Dr. B R Ambedkar National Institute of Technology;
4: Malaviya National Institute of Technology

Email - mksinghtu@gmail.com

The building sector is considered to be one of the most energy-intensive sectors across the world. The building sector consumes about 40% of the world's primary energy and is responsible for a third of total CO2 emissions. Unprecedented high temperatures and heat waves experienced in many parts of India have disrupted everyday life and increased the energy consumption of buildings further. This posed a big question on the persisting indoor environment quality. North-East India is developing very rapidly, and the government of India is also looking to develop it as a hub to connect South Asian countries. The present study is conducted in Tezpur's naturally ventilated office buildings in warm and humid North-East India. Year-long thermal comfort surveys were carried out in 12 naturally ventilated office buildings, collecting 790 samples from July 2016 to June 2017. Data analysis shows that for Tezpur, neutral temperature through regression analysis and Griffiths method is 26.4°C. Tezpur offices' preferred temperature and relative humidity are 24°C and 55%, respectively. Probit analysis showed that occupants are more adaptive toward the warmer side of the thermal sensation scale. It was also found that the office subject's clothing behaviour was a non-linear function of temperature and impacted by local discomfort, creating a temperature difference between the occupant and back wall surface temperature. Data analysis also concluded that ceiling fan use increases exponentially as the indoor globe temperature in the offices reaches 24°C and plateaus or reaches almost 100% at the indoor globe temperature of 32°C.

Keywords - Adaptive thermal comfort, Offices, North-East India, Probit analysis, Preferred temperature.

Applicability of existing models for predicting thermal comfort in sports facilities through the analysis of a case study

Authors - Giulia Lamberti[1,2*], Fabio Fantozzi[2], Francesco Leccese[2], Giacomo Salvadori[2]
1: University of Pisa, Italy;
2: Institut de Recherche en Constructibilité, Université Paris-Est, France
Email - giulia.lamberti@phd.unipi.it

Ensuring thermal comfort within sports facilities is crucial for occupants' well-being. However, often indices designed for sedentary spaces are applied, leading to inaccurate comfort assessments. Hence, this study examines the adaptive capacities and model applicability in sports facilities, using a fencing hall located in Pisa as a case study.

Data encompassed 142 subjective responses correlated with environmental parameters. Athletes' neutral and preferred temperatures were notably lower than sedentary individuals' (15.1°C and 16.8°C, respectively). Fanger's PMV tended to overestimate thermal sensation at high metabolic rates, and occupants felt more varied sensations than predicted, displaying greater acceptance of warmth than cold. Athletes' adaptive capacities differ from sedentary occupants', with neutral temperatures frequently below comfort standards. This study underscores the necessity of analysing athletes' comfort and exploring adaptation possibilities due to distinct needs and preferences compared to sedentary occupants.

Keywords - Thermal comfort, Indoor environmental quality, Predicted Mean Vote, Adaptive model, Sports facilities

Thermal comfort and occupants' behavior in Japanese condominium

Authors - Naja Aqilah[1]*, H.B. Rijal[1], Kazui Yoshida[2]
1: Tokyo City University, Japan;
2: Tokyu Fudosan Holdings Co., Japan
Email - najaaqilah16@gmail.com

Occupant behavioral setting is one of the parameters that can affect indoor comfort. This research aimed at investigating the thermal adaptation of residential occupants in Japanese condominium. Therefore, a field survey on occupants' behaviors for adaptive thermal comfort together with indoor air temperature measurement was conducted from November 2015 to November 2017, in which 32,988 votes were collected. The data was categorized into free-running (FR), heating (HT), and cooling (CL) mode. The results showed that the indoor air temperature was highly correlated with outdoor air temperature in FR mode. In CL mode, the mean indoor air temperature was 27.2°C, which was close to the recommended air temperature for summer in Japan (28°C). In HT mode it was found that indoor air temperature was maintained at an average of 20.4°C. The occupants' thermal sensation votes were most likely to be neutral. The mean clothing insulation was 0.43 clo in summer and 0.82 clo in winter during FR mode. The occupants were found to take passive adaptive measures along with the use of air conditioning unit for cooling. The findings can be useful in designing more suitable residential spaces which can lead to the reduction of energy consumption.

Keywords - Indoor environment, Thermal comfort, Residential building, Thermal adaptation, Occupant behavior

Development of simulation-based strategy for mixed-mode operation of buildings

Authors - Harshal Singh*, Dr. Maddali Ramgopal
IIT Kharagpur, India
Email - 22420.harshal@gmail.com

This study examines optimal operation strategies for mixed-mode buildings located in 8 tropical Indian cities. In order to evaluate the potential for mixed-mode operation, a small, single storey building with provision for natural ventilation (NV) is considered. The building performance is simulated using OpenStudio-EnergyPlus. EnergyPlus Typical Meteorological Year (TMY) data is used for generating the results. Depending upon the predicted inside conditions, decisions are taken whether to operate the building in non-air conditioned mode or air conditioned mode. PMV-PPD based thermal comfort model is used when the building is operated in air conditioned mode, while suitable adaptive thermal comfort model is used when the building is operated in non- air conditioned mode. An algorithm for optimal mixed-mode operation is developed, utilizing simulation data to guide window usage and HVAC systems. The algorithm enables users to input location, date, and time to determine whether to keep windows open or closed and whether to use mechanical cooling or heating systems. Results show that mixed-mode operation has a huge potential for saving energy without sacrificing thermal comfort.

Keywords - Mixed-mode buildings, Thermal comfort, Algorithm, OpenStudio-EnergyPlus, Indian tropical climate.

Thermal performance analysis of thermoelectric radiant panel system for indoor space heating

Authors - Gaurav Mishra*,Satyendra Prajapati, Jyotirmay Mathur, Aneesh Prabhakar
Centre for Energy and Environment, Malaviya National Institute of Technology Jaipur, India
Email - 2021ren9565@mnit.ac.in

The study is focused on the thermal performance analysis of a thermoelectric radiant heating panel (TERHP) system in a test chamber for cold climatic conditions. Three radiant panels with eight thermoelectric modules (TEM) each are installed on the three different walls of the study chamber to evaluate the performance of the panels to achieve the thermal comfort temperature inside the chamber of 1.2 × 1.2 × 2 m. All TEMs in a single TE panel of size 0.75 x 0.50 m are attached in a triangular arrangement to obtain a uniform temperature. The water block is used as a heat sink to maintain the temperature difference between the cold and hot sides of TEMs. The water circulation circuit with the "I" configuration has been used. Hot water at a constant temperature is supplied to the water block, and cold water obtained at the outlet is collected and circulated back after thermoregulation in a closed loop. The experiment is conducted by supplying inlet water at 18°C and applying operating voltages to the TERHP system of 12 V, 16 V, and 20 V. The surface temperature of panels, mean radiant temperature, operative temperature, air temperature, heating capacity, and coefficient of performance are measured on these inputs.

Keywords - Thermoelectric module, Thermal performance, Radiant heating, Heating capacity, Low energy heating.

Passive cooling strategies for better comfort during weather extremes – adapting the existing building stock in German cities to future climatic conditions

Author - Alexander Kader
LXK Kader + Architekten, Germany
Email - alexkader@gmx.de

Global warming is causing a shift in climate zones. Focusing on German cities, this phenomenon is leading to changes in precipitation patterns, strengths of storms and to the duration and intensity of hot and cold periods. A large part of the built environment in German cities is not prepared to handle these changes. This paper aims to explore how existing buildings can be upgraded to incorporate passive cooling strategies to ensure comfortable indoor environments even during extremely hot periods. The study highlights the pressing need for such strategies and underscores their effectiveness. The techniques include thermal massing, cross ventilation, improved insulation, better window sealing and the use of suitable building materials. First, the passive enhancements are analyzed independently and subsequently evaluated in terms of their collective efficacy. Through a prioritisation process, it is demonstrated that the most efficient outcomes are achieved by relatively simple and cost-effective approaches. To substantiate the viability of the proposed interventions, a case study serves as demonstration and provides an illustrative model for retrofitting efforts aimed at adapting the existing building stock to the challenges which are expected to be posed by climate change. The findings underscore the feasibility of passive cooling strategies.

Keywords - Climate change adaptation, retrofitting, building performance analysis, passive cooling

Experimental assessment of various control algorithms for direct evaporative cooling systems

Authors - Shreya Nigam*, Yash Shukla
CEPT University, India
Email - sn.shreya@gmail.com

The use of air conditioning systems for comfort and space cooling is a major driving factor for the rising energy demand, currently accounting for nearly 10% of all the global electricity consumption today, and expected to be tripled by 2050 (International Energy Agency, 2018). Direct evaporative cooling systems are an energy-efficient alternative to conventional air conditioning systems. The evaporative coolers offer a significant reduction in indoor air temperature while maintaining a desirable indoor air quality. However, maintaining indoor relative humidity levels in a comfortable range is a challenge with evaporative cooling systems.

The aim of the study was to explore the potential for improving the comfort hours offered by the direct evaporative cooling system, operated through control algorithms. Various control logics were developed based on outdoor and indoor conditions, to modulate the system performance through fan operation, airflow rate or water pump operation. The experimental assessment of an evaporative cooling unit was conducted in a controlled environment to generate a characteristic performance curve for the system. To estimate the realistic benefits, the simulations for control algorithms were conducted using the theoretical as well as the experimental performance data.

Keywords - Direct evaporative cooling, Control Algorithms, Thermal comfort

Revisiting hotels: a holistic approach to increase guest comfort and save energy for hotels in North India

Authors - Apurv Aggarwal[1,2*], Simos Yannas[1]

1: Architectural Association School of Architecture, London, UK;
2: Foster + Partners, London, UK

Email - apurv1403@gmail.com

Hotels with their high energy demand and reliance on air-conditioning present significant design challenges. The paper draws upon occupancy patterns, guest surveys and energy use in built precedents to conduct detailed research on indoor and outdoor design strategies that balance guest comfort with minimal energy usage. These combine passive and mixed-mode approaches that invite protected use of outdoor and transitional spaces and a courtyard. Balconies feature elements such as jaalis, optimized facades, ceiling fans, and misting for comfort. Findings from extensive analytical studies show that use of non-renewable energy can be reduced by 70% while thermal comfort conditions in and around the hotel premises can be improved. The final design offers an attractive, immersive, and energy-efficient experience to guests while providing cost-saving options for hoteliers. It sets an example for future hotel designs in similar urban settings, inspiring sustainability in architecture and energy efficiency.

Keywords - Hotels, Subtropical Climate, Passive Cooling, Adaptive Thermal Comfort, Innovative Design

Skin temperature and thermal perceptions over the day: a case study in a hybrid-ventilated living lab

Authors - Mateus Bavaresco*, Liége Garlet, Natasha Gapski, Brenda Loeser, Ana Paula Melo, Roberto Lamberts

Federal University of Santa Catarina, Brazil

Email - bavarescomateus@gmail.com

This study assesses the dynamic relations between thermal perceptions and skin temperatures across the day in a hybrid-ventilated office environment. Data were collected during the morning (from 9:00 up to 12:00) and afternoon (from 13:30 up to 16:00) across the summer, autumn, and winter. Through the experiments, participants reported their thermal perceptions of the environment every 30 minutes via online surveys. Results indicated that mean skin temperatures were influenced by time of day and participants' gender, with afternoon temperatures generally higher than morning temperatures. Results also supported that the skin temperatures of female subjects varied more rapidly according to the operative temperature, especially during the afternoon. Finally, participants tended to prefer warmer conditions when skin temperatures were lower and vice -versa. The findings emphasize the complex interplay between thermal comfort, occupants' gender, and circadian rhythms, highlighting the importance of in-depth characterizations of occupants' thermal preferences.

Keywords - Circadian rhythm, Thermal perception, Skin temperature, Thermal comfort.

Impact of climate change on the socio-cultural landscapes of Barsana town in Braj region

Authors - Anupama Bharti[1]*, Mohit Kumar[2]

1: Landscape Architect | Educator | Writer | Department of Landscape School of Planning and Architecture Bhopal, Madhya Pradesh India;

2: Landscape Architect | Researcher | Department of Landscape School of Planning and Architecture Bhopal Madhya Pradesh India

Email - anupama.bharti@spabhopal.ac.in

The aim of the present study is to provide nature-based solutions for the fragmented and disconnected sacred landscape systems and revive the historic hydrological linkages and water infrastructures by mapping the overwhelming impacts of climate change caused by urbanization, human intervention, and tourism, on the socio-cultural landscapes of Barsana town and to create an environment through a sensitized landscape management framework similar to the past.

In the post historic period the habitation growth and development growth of the civilization have highly pressurized the identity and unique values of these sacred and cultural landscape systems. Management of these landscape systems is the minimum contribution, which one can do in respect of the laws of nature, which are being destructed at a terrifying rate.

The overwhelming tourism activities and disastrous, susceptible urban developments by the Braj Foundation and Smart City Mission has transformed the built environment of these landscape systems erroneously into a picture of a distressed landscapes, quite evident and exhibiting the blurred image of developed town instead of conserved landscapes continuously contributing to the climate change of Barsana. The forests, hills, sacred gardens and kunds are losing their unique identities due to insensitive decision-making politicians and discourtesy to these vulnerable landscapes.

Keywords - sacred and cultural landscape systems, Hindu Mythological Gardens, water infrastructures, chauka systems, outstanding universal value.

Study on behavioral adaptation for the adaptive thermal comfort and energy saving in Japanese office buildings

Authors - Hom Bahadur Rijal[1*], Supriya Khadka[1], Katsunori Amano[2], Teruyuki Saito[3], Hikaru Imagawa[4], Tomoko Tomoko[5], Kahori Genjo[6], Takata Takata[7], Kazuyo Tsuzuki[8], Takashi Nakaya[9], Daisaku Nishina[10], Kenichi Hasegawa[11], Taro Mori[12]

1: Tokyo City University, Japan; 2: Haseko Corporation;
3: Nagoya University; 4: Osaka Institute of Technology;
5: Mukogawa Women's University; 6: Nagasaki University;
7: Hiroshima Institute of Technology; 8: Kansai University;
9: Shinshu University;10: Hiroshima University;
11: Akita Prefectural University; 12: Hokkaido University

Email - rijal@tcu.ac.jp

Office workers use a variety of adaptive opportunities to regulate their indoor thermal environment. The behavioural adaptations such as window opening, clothing adjustments, and use of heating/cooling are important factors for adaptive thermal comfort. It is well-known that they are the most important contributors in the adaptive thermal comfort model. Thus, if we understand the behavioural adaptation properly, we can explain the mechanism of the adaptive model. The indoor thermal environment is often adjusted using the air conditioning in Japanese office buildings to improve thermal comfort and productivity. Thus, it is necessary to conduct research on the behavioural adaptation in the offices because the occupant behaviour is different from behaviour in dwellings. In order to record the seasonal differences in behavioural adaptation and to develop an adaptive algorithm for Japanese offices, we measured temperatures in seven office buildings and conducted the thermal comfort and occupant behaviour survey for over a year. We collected 1,228 samples. The proportion of 'open window' is significantly high in the free running and air conditioned modes. The behavioural adaptation is related to the outdoor air temperature. The clothing adjustments, heating and cooling use can be predicted by regression equations. These findings can be applied to building thermal simulation to predict the behavioural adaptation and energy use in office buildings.

Keywords - Office buildings, Occupant behaviour, Window opening, Clothing adjustment, Heating and cooling use.

Paper Presentation - Session 11 (Day 3, 13:05 - 14:25)

Session 11A - Health and Well being in Buildings

- Analysing indoor thermal comfort in LIG housing with respect building materials and openings, a case of Trivandrum
- Perceptions of IEQ, well-being and work performance in work-from-home settings
- Evaluation of the occupant perception of air quality within the indoor setting in the composite climate of Delhi
- Study on WBGT for heat stroke evaluation during summer in Japanese living rooms

Session 11B - Urban Heat Island and Outdoor Comfort

- The climate spatial variability and its impact on the thermal energy simulation of buildings: a case study of São Paulo, Brazil
- An assessment of the Universal Thermal Climate Index of Urban Outdoor Spaces- A case study of Central Business District (CBD), Ahmedabad
- Study on the role of vegetation towards thermal comfort in outdoor urban areas
- Impact of extreme weather events on the thermal comfort of vulnerable populations in the city of Sao Paulo

Session 11C - Climate Resilience Buildings and Communities

- A reinterpretation of vernacular strategies for building envelopes in hot and arid climates: cuidelines for façade design
- Reducing extreme discomfort in the global South – Comparison of a calibrated model and locally measured data from informal housing in Peru
- Urban Oasis for Adaptation to Climate Change: Analysis of Climate Adaptation Plans (CAP) around the world
- Energy Usage in Buildings for future climate: A case study of Concordia University Buildings in Montreal

Note: The Presenting Author has been marked with an asterisk (*)

Analysing indoor thermal comfort in LIG housing with respect building materials and openings, a case of Trivandrum

Authors - Fahmida Sherin P M*, Deepa Rani R

Department of Architecture and Planning, College of engineering Trivandrum, Kerala, India

Email - ar.fahmidasherin@gmail.com

In India, population growth, demand for housing, and rapid urbanisation have led to higher energy consumption in the building sector. According to the Government of India report, 80% of the buildings that will exist by 2050 are yet to be constructed and a larger percentage is contributed by the housing sector, the population using affordable housing is higher compared to other developed countries. The occupants tend to achieve the desired level of thermal comfort by personal adjustments and mechanical means. Using energy-intensive methods for comfort is not feasible for a country, like India, with a low-energy economy. This study analyses indoor thermal comfort in low income group housing with respect to the building materials and openings used. Two typologies of low income housing were identified - a row housing constructed using conventional materials and a vertical stacking multi-dwelling constructed using Laurie Baker's sustainable construction technology. The first section of the study explores the current scenario of housing based on a thermal comfort field study to understand the current scenario by questionnaire survey and onsite measurements (following ASHRAE class II protocol) and a detailed analysis of the results from the computed data. The second part of the study is software simulation of the existing case with different approaches to improve thermal comfort using design builder simulation. And analysing the results to understand the improvement in indoor thermal comfort with respect to the existing model. From the results, it can be concluded that building material with higher thermal mass can cause a significant reduction in indoor temperatures and PMV thus improving indoor thermal comfort. Passive design strategies to improve indoor thermal comfort with respect to envelope material and openings for future projects at the study area under the low-income housing category, without breaking the concern of cost-effectiveness in affordability, are developed.

Keywords - Thermal comfort, low-income group housing, adaptive comfort, neutral temperature, window-to-wall ratio.

Perceptions of IEQ, well-being and work performance in work-from-home settings

Authors - Sanyogita Manu[1]*, Adam Rysanek[1,2]

1: Department of Mechanical Engineering, Faculty of Applied Sciences, University of British Columbia, Vancouver, Canada;

2: School of Architecture and Landscape Architecture, Faculty of Applied Sciences, University of British Columbia, Vancouver, Canada

Email - sanyogita.manu@ubc.ca

In the final week of March 2020, approximately 4.7 million employees in Canada shifted to a work-from-home (WFH) arrangement in response to the pandemic. A similar transition occurred on a global scale. With the growing trend of remote work and the shift towards home offices, understanding the effects of objective and subjective indoor environmental quality (IEQ) on individuals' well-being and productivity is crucial. Much of the existing research has been conducted in traditional office environments rather than in WFH settings. This paper aims to provide an analysis of the subjective evaluation of IEQ conditions within WFH settings and their perceived influence on both work performance and well-being. The analysis is based on a field study conducted in the summer of 2022, which involved 94 participants. The most prevalent features available in the workspaces of these individuals included access to exterior views, operable windows, ample daylight, and sufficient workspace. Notably, these features not only received the highest satisfaction ratings from the participants but also appeared to exert a positive impact on both work performance and well-being. Conversely, the most frequently encountered challenges by WFH employees were associated with disturbances originating from street noise and family members, as well as unwanted interruptions. These issues were found to have a more pronounced effect on workers' well-being compared to their impact on work performance. Furthermore, the study revealed significant correlations between overall workspace satisfaction and performance, as well as between well-being and performance, underscoring the interconnectedness of these factors in the WFH context.

Keywords - Indoor environmental quality (IEQ), Work-from-home (WFH), Subjective assessment, Well-being, Work performance, Productivity

Evaluation of the occupant perception of air quality within the indoor setting in the composite climate of Delhi

Authors - Pooja Agarwal*, Jay Dhariwal
IIT Delhi, India
Email - ddz208074@iitd.ac.in

In India, the ill effects of a poor indoor environment are seen as the cause of about 2 million premature deaths per year, wherein 44% are due to pneumonia, 54% from chronic obstructive pulmonary disease (COPD), and 2% from lung cancer. Conventional studies typically take lesser consideration of indoor occupancy than would be found in real surroundings. These studies often evolve in artificial conditions, which lack authenticity. This work uses field research and a data-driven approach to assess contaminants in inhabited indoor spaces, such as carbon dioxide (CO2) and particulate matter (PM2.5) along with indoor climate measurements of Indoor Operative Temperature (IOT), Relative Humidity (RH), and air velocity. This paper reports the findings of a pilot field study carried out to understand the effect of CO2, IOT, PM2.5, RH, age, sex, general health condition, and perception of odours on occupant's perception of IAQ and perceived thermal comfort, during the summer monsoon season in the composite climate of Delhi. Participants were asked to rate their perceived thermal comfort on standardized scales and provide PIAQ votes based on their satisfaction with indoor air quality. Data analysis included correlation analyses and multiple regression modelling. Our findings reveal a statistically significant inverse relationship between perceived Indoor Air Quality (PIAQ) votes and perceived thermal comfort. Building occupants who rated the indoor air quality more favourably (higher PIAQ votes) tended to report lower levels of perceived thermal comfort, while those who expressed dissatisfaction with indoor air quality reported higher thermal comfort levels.

Keywords - Thermal Sensation, Perceived Indoor Air Quality, Correlation, CO2, PM2.5

Study on WBGT for heat stroke evaluation during summer in Japanese living rooms

Authors - Nokuto Mizutani*, Naja Aqilah, Supriya Khadka, H.B. Rijal

Tokyo city university, Japan

Email - mizutani.nokuto@gmail.com

As the number of heat stroke cases in residential buildings has increased countermeasures have to be taken. Although there are many studies on the relationship between heat stroke and outdoor environment, there are only a few studies which used Wet-Bulb Globe Temperature (WGBT) for the evaluation of heat stroke in the dwellings. The main objective of this study is to evaluate the risk of heatstroke occurrence using WBGT for the indoor environment during summer. A field measurement was conducted in summer of 2021 and 2022 in 33 dwellings to measure the indoor air temperature, relative humidity, and globe temperatures for every 10 minutes in the living room. Outdoor WBGT data was obtained from the Japan Meteorological Agency. The result suggests that indoor WBGT was 23 - 27°C in 2021 and 22 - 26°C in 2022, indicated that the risk of heatstroke occurrence is low in investigated dwellings. In both years, a correlation was observed between indoor air temperature and WBGT. The result showed that when indoor air temperature increased, WBGT is also increased.

Keywords - Living room, Summer, Field survey, WBGT, Heat stroke

The climate spatial variability and its impact on the thermal energy simulation of buildings: a case study of São Paulo, Brazil

Authors - Matheus K. Bracht*, Natasha H. Gapski, Matheus Geraldi, Ana Paula Melo, Roberto Lamberts

UFSC - Federal University of Santa Catarina, Brazil

Email - matheus.s.geraldi@gmail.com

This study evaluated the impact of different weather stations on building energy simulations (BES) concerning local environmental factors. The investigation focused on eight distinct weather stations in São Paulo, Brazil, comparing their data's influence on thermal autonomy and cooling load in a low-income dwelling. Employing EnergyPlus for computational simulations, the outcomes were compared against the surrounding urban fabric and natural coverage indexes. The analysis revealed noteworthy differences between the weather stations with more natural vegetation and those densely urbanized. These disparities were particularly pronounced, with differences of up to fivefold observed in cooling degree hours (CDH) between these locations. Consequently, these discrepancies in weather inputs impacted cooling load predictions, portraying urbanized regions with markedly elevated cooling requirements relative to the more naturally covered areas. Regarding the correlation between the surrounding indexes, site coverage and vegetation cover were more impactful in predicting thermal autonomy and cooling load.

Keywords - Urban overheating, social housing, Brazilian climatic conditions, urban climate.

An assessment of the universal thermal climate index of urban outdoor spaces - a case study of Central Business District (CBD), Ahmedabad

Authors - Jahnvi Mehta[1*], Rajan Rawal[2], Yash Shukla[2]

1: CEPT University, India;
2: Center for Advance Research in Building Science and Energy, CRDF, Ahmedabad, India

Email - jahnvi.pbe21147@cept.ac.in

This study is conducted to assess the transition in outdoor thermal comfort (OTC) due to the synergistic effects of high-density high-rise development in urban regions and increasing global temperature. The shifting climate of urban spaces impacts Outdoor thermal comfort (OTC), thus human behaviour and accessibility to outdoor spaces. Central Business District (CBD), located in the centre of a growing metro city, Ahmedabad, in a hot and dry climate, is the case study site. The on-site measurement and simulation method has been adopted to analyze the microclimate condition for current and future development scenarios of 2050 with increased Floor area ratio (FAR) and tree cover. To understand and quantify the heat stress on the human body produced by the surrounding meteorological circumstances, the Universal Thermal Climate Index (UTCI) has been used. The on-site collected data and simulation results provide a basis for studying the physiological and physical attributes related to OTC. The results suggest a significant impact of the sky view factor and the role of mean radiant temperature on OTC in all development scenarios. The shading due to the increased height of building stock imparts a favourable impact on thermal stress in outdoor urban areas.

Keywords - Outdoor Thermal comfort, Universal Thermal Climate Index, Urban Heat Island, Microclimate, ENVI-met

Study on the role of vegetation towards thermal comfort in outdoor urban areas

Authors - Rupendra Subedi[1]*, H.B. Rijal[1], Supriya Khadka[1], Naja Aqilah[1], Prativa Lamsal[2]

1: Tokyo City University, Japan;
2: Institute of Engineering, Tribhuvan University

Email - rupendrasub@gmail.com

Urban heat islands have a direct impact on the areas where people are suffering from heat stress during the hot climatic conditions. In order to get relief from heat stress, many researchers have explored various strategies that have given more importance to green spaces i.e. vegetation. Urban greenery such as parks, gardens, and street trees helps to improve outdoor thermal comfort. Several research in different countries have given approaches to vegetation as improving methods for outdoor thermal comfort of urban open spaces. The main goal of this study is to analyze the human perceptions of outdoor conditions in Ratna-park, Kathmandu, Nepal through field survey and to establish the relationship between meteorological parameters. 78% of the visitors voted for neutral which shows that they are highly satisfied with the park. Additionally, the mean comfort temperature was found to be 29.1oC. People are well adapted to the thermal environment of the urban park, and thus the comfort temperature was significantly high in summer.

Keywords - Outdoor thermal comfort, Field survey, Urban Park, Comfort temperature, Griffiths' method

Impact of extreme weather events on the thermal comfort of vulnerable populations in the city of Sao Paulo

Authors - Alessandro Augusto Dardin*, Leonardo Marques Monteiro
Faculty of Architecture and Urbanism at the University of Sao Paulo, Brazil
Email - aledardin@usp.br

In a context of global warming, heat waves are predicted to become more frequent and intense along the next decades. The elderly are among the most vulnerable groups to extreme heat due to their dysfunctional thermoregulatory mechanisms and propensity to illnesses. This research aims to assess impacts of urban heating on this demographic group, using the ENVI-met V.5 model to simulate microclimatic conditions at a representative neighborhood in the city of Sao Paulo, adopting the PET Index as a comparative variable. Results obtained from historical climate data are compared to those of projections according to the Intergovernmental Panel on Climate Change (IPCC) Representative Concentration Pathways (RCP) 8.5 scenario. After the realization of impacts, urban surfaces albedo modifications were tested, in search for the most effective mitigating adaptations. Results obtained until now show that increasing average albedo of built surfaces can help moderate rising temperatures, but would not be enough to compensate the increase predicted for the coming decades.

Keywords - Heatwaves, Urban Adaptation, ENVI-met, PET Index, Outdoor Thermal Comfort.

A reinterpretation of vernacular strategies for building envelopes in hot and arid climates: guidelines for façade design

Authors - Sara Maria Camagni, Joana Goncalves*
Individual, United Kingdom
Email - Joana.Goncalves@aaschool.ac.uk

In the context of various scenarios of global climate change and the imminent threats posed by escalating global temperatures, architects and urban planners must reflect on the lessons to be learned from the established model of vernacular architecture in arid climates. When closely examined and comprehended accurately, vernacular architecture offers a repository of readily applicable strategies that can be expanded upon and implemented in contemporary construction. This paper focuses on the benefits derived from incorporating height-to-width ratio (H/W) in urban settings, window-to-wall ratios and shading mechanisms inferred from vernacular architecture into envelope design for contemporary residential development. It employs the hot-arid climate of Cairo City, Egypt, as a reference context for this research proposed study. The paper elaborates on the methodologies and processes utilized to transform principles of vernacular strategies into quantifiable benchmark. This is accomplished through the integration of environmental performance simulations, including thermal and daylight conditions, which informed the exploration of potential architectural solutions. The outcome is a characterization of design elements inherent in vernacular architecture, leading to design recommendations for contemporary residential buildings in hot and arid climates, with emphasis on window-to-wall ratios and shading mechanisms.

Keywords - Vernacular Architecture, Hot-arid climate, Adaptation, Passive strategies, Parametric Guidelines.

Reducing extreme discomfort in the global South – A comparison of a calibrated model and locally measured data from informal housing in Peru

Authors - Argyris Oraiopoulos[1]*, Martin Wieser Rey[2], Marion Verdiere[2], Pamela Fennell[1], Paul Ruyssevelt[1]

1: Energy Institute, University College London, London, UK;
2: Pontificia Universidad Católica del Perú, Lima, Perú

Email - a.oraiopoulos@ucl.ac.uk

With most growth in urban population happening primarily through informal urbanisation, it is vital to identify cost effective measures for improving the often-poor housing conditions, which can have adverse health impacts on large parts of the population. The aim of this research is to investigate the indoor environmental conditions of self-constructed houses in low-income informal settlements in Lima, Peru, before and after implementing fabric retrofit strategies. Data loggers were placed in a family house in the informal settlement of José Carlos Mariátegui in Lima, measuring internal temperature and humidity at hourly intervals for two years. At the start of the second year the house underwent fabric improvement measures and particular roof insulation, following the recommendations of a calibrated dynamic thermal model. The results presented in the paper compare internal temperatures before and after retrofit as well as the modelling predictions. Overall, the measured data reveal the extreme indoor temperatures occupants are experiencing daily and the impact roof insulation has on these, with the modelling output predicting the reduction in daily peak internal temperature up to 3-5°C, and the measured data indicating an average of about 5°C on site, during warm months. The application of roof insulation on these self-constructed homes can be carried out by community members and was shown to be a cost- effective measure, accounting between 5-10% of the total cost if it was to be implemented at the start of the construction process.

Keywords - extreme discomfort, internal temperature, retrofit, low-income, fabric insulation.

Urban oasis for adaptation to cClimate change: analysis of climate adaptation plans (CAP) around the world

Authors - Bruna Dallaverde Sousa, Daniel Felipe Outa Yoshida, Denise Helena Silva Duarte*

UNIVERSIDADE DE SÃO PAULO, Brazil

Email- dhduarte@me.com, dhduarte@usp.br

Driven by climate change, especially the increase in the occurrence of heat waves around the world, this work has the objective of systematizing the municipal climate adaptation plans collected according to the criteria outlined in the document Measuring Benefits of Urban Heat Adaptation published in March 2021 by the C40 Group of Major Cities for Climate Leadership. The main results show that out of 259 documents raised, only 154 effectively correspond to Climate Adaptation Plans, as most of these documents are American. Among the actions proposed by C40, mention of mitigation is present in all documents, through the guideline aimed at reducing greenhouse gas emissions. The second most mentioned action refers to green infrastructure at 75%. However, it is important to highlight two other actions: heatwave response planning and development of cooling places are mentioned in only 44% and 34% of the analysed documents respectively. In particular, actions related to cooling places, such as grey built-up structures and water features appear only in more recent plans, mainly since 2015. Therefore, due to the current demand the readaptation of public spaces through the design of a network of refrigeration spaces distributed throughout the city is urgent.

Keywords - Climate Change, Climate Adaptation Plans, Heat Waves, Cooling Places.

Energy usage in buildings for future climate: a case study of Concordia University Buildings in Montreal

Authors - Kartikay Sharma*, Ali Nazemi, Ursula Eicker
Concordia University, Canada
Email - kartikay.sharma@mail.concordia.ca

In light of escalating extreme events and climate change, this research focuses on understanding energy consumption in buildings, specifically under varied weather scenarios including past (2019-2022) and future projections (2061, 2099). Traditional building simulations stemming from representative, using typical year's weather data doesn't capture the intricacies of long-term climate shifts especially for the future. To address this, this study incorporates detailed future climate data from combination of RCMs & GCMs. This data is used in combination with open-geospatial data to create a building geometry. Initial results highlight a shift to warmer temperatures in 2061 and 2099. When contrasted with a typical mean weather scenario (1960-1986), there's a noticeable increase in cooling energy and a decrease in heating energy consumption from 2019-2022. By 2099, overall energy use is predicted to decrease by 10%-30%, which when broken down constitutes to reduction in heating energy and increase in cooling energy. The research underscores the impending shift towards increased cooling demands and reduced heating needs. The findings emphasize the urgency for future building designs to be energy-efficient and resilient in the face of evolving climate conditions.

Keywords - Future energy use, extreme climate, extreme weather, future weather

Paper Presentation - Session 13 (Day 3, 16:35 - 17:55)

Session 13A - Climate Resilience Buildings and Communities

- Balancing Carbon Emissions and Comfort: A Comparative Study of Envelope Materials in Affordable Housing Projects
- Improved burnt clay brick masonry: Lowering upfront embodied carbon, improving thermal comfort and climate resilience of new housing in the Indo-Gangetic Plains
- Integrated evaluation for energy and comfort quantification of windows in a residential apartment of Mumbai
- Slum redevelopment and its gendered implications on thermal comfort – the experiences of female residents in Ahmedabad

Session 13B - Thermal Comfort Models and Metrices and Resilience

- Roadmap to implementation of thermal comfort policies in affordable housing
- Study on thermal comfort zone in MM and HVAC office buildings in Aichi prefecture based on daily survey
- Study on comfort temperature in Autumn season of naturally ventilated office building in Kathmandu

Session 13C - Design Intervention in Buildings for thermal comfort

- Field Studies of Thermal Comfort in Heritage Hotel Buildings in warm humid climate of India
- Historic windows with passive heat loss reduction strategies and their effect on indoor thermal comfort
- Optimising energy efficiency and thermal comfort measures for a low-income residential building in Ahmedabad, India
- Enhancing Net-Zero Energy Buildings: A Comprehensive critical Review of Passivhaus Design in the UK

Session 13D - Health and Wellbeing in Buildings

- Comfort Rating Method for Potential Inclusion in Australia's Nationwide Energy Rating Scheme (NatHERS) – Darwin Climate Zone Case Study
- Furniture layout in residences- The role of thermal comfort
- An assessment of the thermal conditions and users' thermal adaptability in air-conditioned offices in a hot climate region

Note: The Presenting Author has been marked with an asterisk (*)

Balancing carbon emissions and comfort: a comparative study of envelope materials in affordable housing projects

Authors - Awatans Tripathi[1]*, Rajan Rawal[2]
1: CEPT university, India;
2: Centre for Advanced Research in Building Science and Energy, CRDF
Email - awatans47@gmail.com

This study presents a comparative analysis of carbon emissions and thermal comfort in an Indian affordable housing project, employing two envelope materials: EPS core technology and brick-and-mortar construction. The study quantifies embodied and operational emissions through life cycle analysis to establish an emissions- thermal comfort trade-off. Focused on the Bureau of Energy Efficiency design under the Pradhan Mantri Awas Yojana 2022 scheme in Bhubaneswar, Odisha, the study addresses the pressing need to track carbon emissions in this sector. Buildings contribute 39% of energy-related carbon emissions, gaining significance due to urbanisation and affordable housing projects. The study highlights a significant 10.16% reduction in operational carbon for EPS (Expanded Polystyrene) core technology compared to a brick wall assembly construction, driven by its superior thermal performance. But this comes at a cost of a much higher embodied carbon value. Despite higher embodied carbon, EPS achieves heightened comfort with fewer operational emissions over 50 years. Findings underscore the relationship between environmental impact, comfort congruence, and emissions. Results hold location-specific importance for informed decisions in diverse urban contexts across India.

Keywords - Carbon emissions, thermal comfort, life cycle analysis, embodied carbon, discomfort hours

Improved burnt clay brick masonry: lowering upfront embodied carbon, improving thermal comfort and climate resilience of new housing in the Indo-Gangetic Plains

Author - Sameer Maithel
Independent Expert, India
Email - sameermaithel@gmail.com

The urban residential building footprint is expected to increase four-fold during 2020-2050 in the Indo-Gangetic Plains region of India. The business-as-usual construction technology of RCC frame with solid burnt clay brick as the walling material use large quantities of steel, concrete and solid brick and is highly resource and carbon intensive. The region produces 110-140 billion solid burnt clay bricks per year. Brick production is associated with large energy consumption, carbon dioxide emission, air pollution and degradation of agricultural land. The study presents an innovative new burnt clay product – vertically cored interlocking burnt clay block that is being manufactured by a brick manufacturer in the region. The study presents the results of the life cycle analysis (as per EN 15804) and quantifies reductions in carbon and resource consumption for the product and the building element (wall). The analysis is based on the data collected from the industry. The cradle to gate analysis shows a reduction of 31% in the CO2 emissions (kgCO2/m3 of burnt product) and 58% in soil consumption (m3 of soil/m3 of burnt product) for the vertically cored hollow block. A 150 mm thick wall made of vertically cored hollow block results in 55% reduction in the CO2 emissions (kgCO2/m2 of wall) when compared to a 230 mm thick wall of solid brick. In addition, the cement consumption in mortar reduces by 66% and sand consumption by 62% per m2 of wall area. The study further indicates a significant reduction in concrete and steel consumption by extending the analysis to the building level.

Keywords - Low-carbon housing, hollow burnt clay block, life cycle analysis, Indo-Gangetic plains, resource- efficient clay brick industry

Integrated evaluation for energy and comfort quantification of windows in a residential apartment of Mumbai

Authors - Vardan Soi*, Shailee Goswami
Saint Gobain Research India, India
Email - vardan.soi@saint-gobain.com

This paper aims to understand the energy and comfort performance of glazings for residential apartment in Mumbai. Firstly, an integrated workflow was developed on Ladybug tools to conduct thermal, energy and daylight simulations using a single model. Secondly, the developed workflow was deployed to simulate multi- comfort (visual & thermal & energy performance) for a 2 Bedroom, Hall and Kitchen (BHK) apartment as the case study. Two glazing types, clear (U-value 5.6, SHGC 0.85, VLT 0.85) and high performing (U-value 2.5, SHGC 0.27, VLT 0.34) were analysed. The results demonstrated that high performance glazing reduces the energy consumption by 37%, improves the thermally comfortable area from 34% to 85% and also provides better visual comfort (DGP <30%). Lastly, the research was extended to analyse 8 different types of glazings with incremental variation of SHGC and VLT to generate an integrated metric. This metric compares the performance of all glass options in terms of cooling consumption, thermally comfortable area and glare probability in the space, enabling the stakeholders to select an optimal window configuration for their project. The results demonstrate that use of ideal option (G8) is is providing highest thermally area comfortable (80%) and lowest DGP (27%) with reduced energy consumption (47 kWh/m2).

Keywords - integrated metric, energy efficiency, thermal comfort, visual comfort, ladybug tools, residential apartment

Slum redevelopment and its gendered implications on thermal comfort – the experiences of female residents in Ahmedabad

Authors - Janina Fuchs*, Julia Tomei, Rita Lambert
University College London, United Kingdom
Email - janina.fuchs.21@ucl.ac.uk

India is among the countries most affected by climate change and extreme heat. Almost 50% of the urban population lives in low-income settlements, where it is even more challenging for residents to afford and operate cooling devices or draw on other coping strategies. Although slum redevelopment approaches have improved services and delivered weatherproof homes, they also changed heat dynamics for residents, oftentimes negatively depending on their design, implementation, and operation. Those changes disproportionately affect women who spend more time indoors for home-based work and household chores. Such gendered implications have received little attention. This research deploys focus group discussions and household surveys, to capture the practices, experiences and perceptions of female residents related to thermal comfort in slum rehabilitation housing in three areas in Ahmedabad, India. The results illustrate the changes that the move to high-rise housing entails, especially for women: for example, reverse heat retention dynamics during summers, which cause sleeping issues, and thermal comfort inequity, which manifests as flats on higher floors are hotter than flats on lower floors. The results call for decision makers, developers, and researchers to better integrate thermal comfort into building design, and give more consideration to the gendered aspects of thermal comfort in redevelopment.

Keywords - Slum redevelopment, thermal comfort, gender, developing countries, low-income households.

Roadmap to implementation of thermal comfort policies in affordable housing

Authors - Surjyatapa Ray Choudhury, Nithya Ramesh*, Priyani Pranab
Jana Urban Space Foundation, India
Email - nithya.ramesh@janausp.org

The residential sector contributes to 24% of India's annual Green House Gas emissions within which 50% comes from heating and cooling needs. India's thermal comfort demands need to be energy-efficient and affordable to meet the 18 million low-income urban housing deficit. Here, we discuss the implementation of thermal comfort policies in affordable housing in India. We cross-examine the current implementation mechanism of thermal comfort and affordable housing policies and identify gaps in (a) clarity of roles and responsibilities of actors, (b) communication channels between actors, and (c) policy support instruments. We hypothesize that the gap between policies and their implementation comes from a lack of standardization and convergence between the two types of policies. We propose a roadmap to implementation via a 4-step approach: 1) outlining redefined roles and responsibilities of actors, 2) establishing a participatory planning process, 3) supplementing policies with implementation support, and 4) providing a framework for capacity building. The proposed roadmap can act as a guide to policy makers at the Union and State level, and implementation actors at the Urban Local Body level.

Keywords - Affordable Housing, Implementation Mechanism, Policy Implementation, Energy-efficient Construction, Thermal Comfort Policies

Study on thermal comfort zone in MM and HVAC office buildings in Aichi prefecture based on daily survey

Authors - Supriya Khadka[1*], H.B. Rijal[1], Katsunori Amano[2], Teruyuki Saito[3], Hikaru Imagawa[4], Tomoko Uno[5], Kahori Genjo[6], Hiroshi Takata[7], Kazuyo Tsuzuki[8], Takashi Nakaya[9], Daisaku Nishina[10], Kenichi Hasegawa[11], Taro Mori[12]

1: Tokyo City University, Japan; 2: Haseko Corporation;
3: Nagoya University; 4: Osaka Institute of Technology;
5: Mukogawa Women's University; 6: Nagasaki University;
7: Hiroshima Institute of Technology; 8: Kansai University;
9: Shinshu University; 10: Hiroshima University;
11: Akita Prefectural University; 12: Hokkaido University

Email - supriyakhadka1996@gmail.com

Thermal comfort has been a discussed subject since 1930. Researchers have looked into understanding the thermal comfort of the occupant's weather at home, offices, educational institution because the occupants have significant effects on their indoor environment. In this study we aim to understand the comfort temperature ranges in Mixed-mode (MM) and Heating, Ventilation, and Air Conditioning (HVAC) types of office buildings in Japan. The field data is collected from six office buildings located in Aichi prefecture from July 2021 to October 2022, where 16,411 responses were collected from 46 occupants. The environmental parameters such as air temperature, relative humidity, and so on were measured along with the responses. The result suggests that the office workers are highly satisfied and they are adapted to the indoor environment, as in the MM office buildings 80 % of the occupants were comfortable at the temperature range of 19 to 29 °C whereas in HVAC office building this range was 22 to 27 °C. MM office buildings had wider range of thermal comfort zone even under HT and CL mode as compared to HVAC buildings which suggests that the MM type of buildings are better than HVAC.

Keywords - Slum redevelopment, thermal comfort, gender, developing countries, low-income households.

Study on comfort temperature in Autumn season of naturally ventilated office building in Kathmandu

Authors - Prativa Lamsal[1]*, Sushil Bahadur Bajracharya[1], Hom Bahadur Rijal[2]

1: Department of Architecture, Pulchowk Campus, Institute of Engineering, Tribhuvan University, Nepal;

2: Department of Restoration Ecology and Built Environment, Tokyo City University, Yokohama 224-8551, Japan

Email - lamsalprativa@gmail.com

Considering the strong connection between thermal comfort and productivity, it is crucial to establish guidelines for creating a comfortable indoor environment in office buildings. As one of the rapidly growing metropolitan areas in Southeast Asia, Kathmandu valley has witnessed notable changes in land use and cover, particularly in the commercial sector. In this context, we conducted a thermal comfort study in the summer season to determine the comfort temperature in free-running office buildings. A total of 148 votes have been collected from a questionnaire survey from four free-running office buildings. Simultaneously, we measured the thermal environment, including air temperature, globe temperature, and relative humidity. We have calculated the comfort temperature from Griffiths' method and found the comfort temperature as 26.9°C. When the fan is on, the comfort temperature is 27.5°C which is 1.3°C higher than when fan is off. These findings provide valuable insights for creating a comfortable indoor environment in office buildings in Kathmandu valley during the summer season.

Keywords - Office building, Free running, Griffiths' method, Comfort temperature

Field studies of thermal comfort in heritage hotel buildings in warm humid climate of India

Authors - Shalini Dasgupta[1*], Priyaleen Singh[1], Shweta Manchanda[1], Sukumar Natarajan[2], Abdullah Alnuaimi[3]

1: School of Planning and Architecture, New Delhi, India;
2: University of Bath, Bath, UK;
3: Qatar University, Doha, Qatar

Email - shalini.dasgupta@gmail.com

Heritage Buildings in India roughly constitute 20% of the existing built stock. Significant energy and carbon savings is possible if these heritage buildings are put to new use. However 'Adaptive Reuse' of heritage buildings is a challenging task where energy use is strongly influenced by occupant behaviour and conservation techniques keeping in mind the historic value and traditional construction techniques of the building. This paper showcases field study findings of occupant thermal comfort for a mixed mode heritage building put to new use as a hotel, located in the warm humid climate of West Bengal, India. A total of 205 subjects were surveyed spread over four seasons. The field data was collected through yearlong monitoring of environmental parameters along with occupant survey through spot measurements and questionnaires. This transverse survey showcases thermal preferences & thermal comfort behaviour of respondents spread over the year indicating roughly 80% of occupants as comfortable with a calculated comfort temperature of 26.7°C. The indoor climatic data was collected by instruments which complied with the accuracy standards of ASHRAE Standard-55 and ISO 7726:2001. The questionnaire was based on standard ASHRAE format for thermal environment. The study showcases the extent of thermal comfort achieved in an adapted heritage hotel along with environmental adaptive design features for suitable thermal adaptation indicating that the environmental adaptive design features alter the outdoor temperatures by an average of 1.2 °C closer to comfort temperature across the summer and winter seasons.

Keywords - Thermal Comfort, Heritage Buildings, Adaptive Reuse, Energy Efficiency, Heritage Hotels

Historic windows with passive heat loss reduction strategies and their effect on indoor thermal comfort

Authors - Dennis Mathew[1,2*], Richard O'Hegarty[1,2], Oliver Kinnane[1,2]

1: UCD Energy Institute, University College Dublin, Dublin 4, D04 V1W8, Ireland;
2: School of Architecture Planning and Environmental Policy, University College Dublin, Dublin 4, D04 V1W8, Ireland.

Email - dennis.mathew@ucdconnect.ie

Ireland's ambitious goal of achieving net-zero emissions by 2050 necessitates significant reductions in operational emissions from its building sector, prompting the government to target the energy retrofitting of a quarter of its building stock by 2030. However, retrofitting historic buildings poses substantial challenges stemming from concerns related to architectural conservation, cost, and technical complexities. In this context, focusing specifically on addressing heat loss through single-glazed historic windows, this study revisits traditional heat loss mitigation techniques that were once prevalent in historic buildings but have since fallen out of common use. With in-situ tests, we investigate the thermal performance of curtains, blinds and shutters on single-glazed wooden sash and case historic windows. We present variations in heat loss through the window and its associated thermal comfort in response to each strategy. Test results show significant heat loss reduction from a combination of traditional strategies which is on par with secondary glazing. These strategies offer viable solutions for energy efficiency and thermal comfort in historic buildings without major interventions on the protected historic fabric.

Keywords - Historic windows, Experimental U-value calculation, Thermal comfort, Historic buildings, Passive retrofit strategies

Optimising energy efficiency and thermal comfort measures for a low-income residential building in Ahmedabad, India

Authors - Tania Sharmin[1*], Md Mizanur Rahman[2]

1: Cardiff University, United Kingdom;
2: Bangladesh University of Engineering and Technology

Email - sharmint@cardiff.ac.uk

This study evaluates indoor thermal comfort conditions in a low-income residential building in Ahmedabad, India, with the aim of identifying passive strategies for reducing summer discomfort. Despite being designed with environmental and passive strategies in mind, the building's indoor temperatures during the summer reached an uncomfortable average of 37.10°C during a 3-day measurement period. The study employs optimisation algorithms and parametric modelling to fine-tune simulation settings and parameters, aligning simulated results with measured data. It utilises energy simulations conducted using Climate-Studio in the Rhino-Grasshopper platform to assess various building parameters like window size, orientation, shading, and ventilation shaft. The results reveal that keeping windows open for natural ventilation significantly reduces indoor air temperatures with a 0.56°C reduction on average over a 3-months period. Moreover, various design scenarios, including changes in window size, shading, and the inclusion of a chimney, demonstrate their potential to enhance thermal comfort. However, it is noted that passive strategies alone may not achieve optimal comfort levels and should be complemented by broader landscape and urban planning strategies on an urban scale to create comfortable indoor conditions. Overall, the study provides valuable insights into improving indoor thermal comfort in low-income housing in hot climates, with implications for sustainable architectural design.

Keywords - Indoor air temperature, indoor thermal comfort, hot climate, design optimisation, passive strategies.

Enhancing net-zero energy buildings: a comprehensive critical review of Passivhaus design in the UK

Author - Harshul Singhal
University of Central Lancashire, United Kingdom
Email - hssinghal@uclan.ac.uk

In the effort to reach the UK's goal of having zero carbon emissions by 2050, this study offers a detailed review of Passivhaus designs in the UK's housing area. This research tries to fill in the gaps in existing studies by closely looking at how much energy and carbon Passivhaus homes use compared to other homes in the UK. Focusing on energy efficiency and carbon emissions, this research plans to set a strong basis for further study stages, including creating a user-friendly online tool for easy access and understanding of the results. Using a step-by-step approach, the study gathers information from a wide range of scholarly articles, showing the Passivhaus design as a new way to create energy-saving homes. Initial findings highlight the great potential of Passivhaus designs in significantly lowering the need for space heating compared to the average UK homes. However, the review also points out the lack of research on indoor air quality and the comfort of residents, marking an important area for further study. Additionally, the study emphasizes the urgent need to update current databases and approach to include a broader view of the energy embodied in materials and its related carbon emissions. As this PhD research moves forward, it plans to deepen the understanding of the sustainability of Passivhaus homes in the UK, with the goal to suggest changes in current Passivhaus standards to fully address the carbon emissions from embodied energy, leading the way towards a cleaner, more sustainable future in the UK's building industry.

Keywords - Passive Houses, Net Zero Energy Homes, Whole-Life Carbon Footprint, Embodied Carbon Footprint, Operational Carbon Footprint.

Comfort rating method for potential inclusion in Australia's nationwide energy rating scheme (NatHERS) – Darwin climate zone case study

Authors - Mahsan Sadeghi[1]*, Terence Williamson[2], Wendy Miller[3], Johanna Kieboom[4], Dong Chen[1]

1: Commonwealth Scientific Industrial Research Organisation (CSIRO), Energy, Melbourne, 3168, Australia; NHMRC Centre for Air pollution, energy, and health Research (CAR), Sydney, 2037, Australia; 2: School of Architecture and Civil Engineering, The University of Adelaide, Adelaide, Australia; 3: School of Architecture and Built Environment, Queensland University of Technology, Brisbane, Australia; 4: Department of Infrastructure, Planning and logistics, Northern Territory Government, Darwin, Australia

Email - Mahsan.Sadeghi@csiro.au

In the face of escalating global temperatures and extreme climate challenges, this study addresses the pressing concern of overheating within homes by introducing a new Comfort Rating Method. Our approach presents a departure from conventional norms in the domain of thermal comfort modelling by incorporating the Effective Temperature index (ET*), which considers not only air and mean radiant temperature but also humidity, essential for holistic comfort assessment. Moreover, we extend our model to account for indoor air movement, a significant contributor to comfort in tropical environments. This method has been embedded in AccuRate, the benchmark software for Australia's Nationwide House Energy Rating Scheme (NatHERS) and validated against real-world data from an extensive Darwin thermal comfort field study. The new comfort calculation method was applied to examine 1,043 dwellings from Commonwealth Scientific Industrial Research Organisation (CSIRO)'s Australian House Data (AHD) sets. We proposed a 10 comfort bands, providing a framework for evaluating comfort in residential settings. This research not only advances thermal comfort knowledge but also offers architects, designers, and stakeholders a tool to create climate-sensitive, resilient residential buildings. While this study focuses on Darwin only, future research can adapt this method to various extreme climates, refining its model based on regional nuances.

Keywords - Thermal Comfort, Effective Temperature, Extreme Climates, Climate-Sensitive Design, Residential Buildings.

Furniture layout in residences- the role of thermal comfort

Authors - Jayasree T K[1,2*], Srinivas Tadepalli[2]

1: National Institute of Technology Calicut, India;
2: National Institute of Technology Tiruchirappalli, India

Email - jayasreetk@nitc.ac.in

People spend most of the active time at home in living rooms. The furniture in living areas is designed based on the multiple activities generally performed in a living space. The objective of the study was to assess the factors influencing the arrangement of furniture layout in the perspective of occupant behaviour research. The behaviour of arrangement of furniture was evaluated in terms of Physical Environmental Triggers (PET), Physical Environmental Factors (PEF), Psychological Factors (PF), Social Factors (SF), Physiological Factors (PHF) and Non-Adaptive Triggers (NAT). The study developed an instrument measuring these factors along with the respondents' satisfaction with the current layout. The collected data was analyzed with Confirmatory Factor Analysis (CFA) and Structural Equation Modelling (SEM). Construct validity of the model has been established by estimating the convergent validity and discriminant validity. The absolute fit indices satisfy the recommended values and indicate that the proposed model has an acceptable fit. Contextual factors which comprises of Physical Environmental Factors, Psychological Factors, Social Factors, and Physiological Factors, are identified as a major factors affecting the behaviour. This study will give an insight for architects regarding the perceptions of an occupant which results in greater satisfaction with space with energy implications of the layouts.

Keywords - Furniture Layout, Residences, Satisfaction, Thermal Comfort, Energy Efficiency.

An assessment of the thermal conditions and users' thermal adaptability in air-conditioned offices in a hot climate region

Authors - Fatema Al-Akhzami, Hanan Al-Khatri*, Saleh Al-Saadi, Chaham Alalouch
Sultan Qaboos University, Oman
Email - khatri@squ.edu.om

Indoor thermal condition is a global concern that plays a major role in the wellness, comfort, and satisfaction of office workers. The thermal environment was evaluated in an office building in a hot region using subjective and objective measurements. Considering the former, a questionnaire was distributed to the employees to assess their thermal perceptions. Specialized instruments were used for the objective measurements to monitor thermal parameters following the guidelines of ASHRAE-55 and ISO-7730. A total of 220 employees took part in the survey, and 207 valid questionnaires were included in the analysis. According to the subjective assessment, the thermal votes of the employees were between (cold) to (slightly warm), and the majority were thermally comfortable and accepted the environment. This implies that a temperature of 22.8 - 1.2°C appears to be a comfortable range. Using the Griffiths method, the comfort temperature (Tc) was calculated as 23.5 - 1.9 °C. Additionally, the employees ranked 11 indoor factors that influence their work productivity. Noise conditions were ranked as the most important factor. The results of the reported study provide a base for further research and useful information on the comfort temperature of office buildings in hot regions.

Keywords - Thermal adaptive model, hot climate, comfort temperature, office buildings

LIST OF PRESENTING AUTHORS

CATE|2023

13-14-15 December
Ahmedabad| India