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Harmony in Architectural Science and Design: Sustaining the Future

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Harmony in Architectural Science and Design: Sustaining the Future.
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Pedagogical benefits of embedding project-based learning into the architectural curriculum: A case study

John Latto

Xi'an Jiaotong-Liverpool University, Suzhou, China
john.latto@xjtlu.edu.cn, ORCID-Number 0009-0009-6817-8423

Abstract:

This paper explores the pedagogical benefits of integrating project-based learning (PBL) into the architectural curriculum, with a specific focus on a case study conducted in collaboration with Roche Diagnostic (Suzhou) Ltd, an international company located in Suzhou, China. The aim of this study is to explore how PBL can enhance the learning experience of architecture students, promote their professional development, and bridge the gap between academia and industry. The architectural profession demands a unique set of skills that extend beyond theoretical knowledge. Architects must possess the ability to think critically, solve complex problems, collaborate effectively, and communicate their ideas clearly. Traditional learning and teaching methods often do not fully develop these skills, as they primarily focus on theoretical concepts that often do not provide students with sufficient real-world opportunities. Embedding PBL into the architectural curriculum does offer a valuable alternative, as it allows students to engage in authentic, hands-on projects that mirror the challenges they will face in practice. The case study presented in this paper focuses on a collaboration with an industry partner which involved the design of a central hub facility.

Optimizing building performance: A systematic literature review on harnessing AI in early design stages

Arianna Brambilla[1], Joanne Andrade[1], Yuqing Du[1] and Christhina Candido[2]

[1]University of Sydney, Sydney, Australia
Arianna.brambilla@sydney.edu.au, yuqing.du@sydney.edu.au

[2]University of Melbourne, Melbourne, Australia
Christhina.candido@unimelb.edu.au

Abstract:

Artificial intelligence has the potential to radically transform how the built environment is conceptualised, designed, measured and constructed. However, the potential of artificial intelligence to improve building performances from the early design stages is yet to be fully understood. This paper provides an overview of the current knowledge, potential benefits and barriers of artificial intelligence-driven design approaches for early-stage design development aimed at improving the overall building performance. It undertakes a systematic literature review of papers focused on improving building design through the use of artificial intelligence in designing, simulations, and testing. This analysis uses the PRISMA reporting methodology to review 1,416 articles, of which 76 are identified as relevant for AI-driven optimisation of design and construction. This study reveals that the integration of machine learning in the early design stages of building projects can mark a transformative leap towards more sustainable, efficient, and cost-effective structures.

Analysis of interior colour schemes in New Zealand architectural spaces

Megan Burfoot
Auckland University of Technology, Auckland, New Zealand
mburfoot@aut.ac.nz

Abstract:

This study analyses interior colour schemes in 20 award-winning New Zealand architectural projects to identify patterns and characteristics in successful designs. Data from project images were analysed with Python to determine the dominant colours, calculate colour distances, and assess colour temperature proportions. The findings indicate a predominant preference for warm hues, moderate saturation levels, and brighter colour schemes. Residential spaces were found to be slightly cooler compared to commercial spaces. These insights can guide architects in creating aesthetically pleasing and colour-efficient interiors that enhance both functionality and occupant well-being. Future work should consider expanding the scope, increasing the sample size and exploring historical trends.

Oasis effect for cooler cities?

Daniela A. Ottmann[1, 2] and Fernanda Parnenzini[2, 3]
[1]Faculty of Society and Design, Bond University, Gold Coast, Australia
[2] Cities Research Institute, Griffith University, Gold Coast, Australia
dottmann@bond.edu.au
[3] Zayed University, Desert Culture Research Cluster, UAE
ferparnenzini@gmail.com

Abstract:

Desert and dryland climates are experiencing significant changes due to climate change, rapid population growth, and ambitious net-zero city plans. This study investigates the "Oasis Effect," a phenomenon where vegetation and water bodies create cooler microclimates, in the context of urban heat stress in hot arid regions such as Jeddah, Kingdom of Saudi Arabia (KSA) and Dubai, United Arab Emirates (UAE). Using ENVI-met simulations, the study assesses the impact of green spaces, such as tree canopies, and proximity to water bodies on mitigating this heat stress under various future scenarios. Findings reveal that while vegetation provides some localized cooling, its overall impact on reducing PET, humidity, and air temperature is limited. Water bodies demonstrate a more pronounced cooling effect, emphasizing the need for integrated cooling strategies that combine green and blue infrastructures. The study underscores the importance of exploring urban morphological and geometrical parameters, alongside green spaces, to enhance the Oasis Effect. Future research should focus on optimising the spatial configuration of urban environments to maximize cooling benefits, incorporating both traditional and modern approaches to create resilient and sustainable cities capable of achieving net-zero emissions in the face of escalating climate challenges.

Building-integrated photovoltaics (BIPV) in building performance research - A systematic literature review

Aanuoluwapo Oguntade and Marco Cimillo
Xi'an Jiaotong-Liverpool University, Suzhou, China
A.Oguntade23@student.xjtlu.edu.cn, Marco.Cimillo@xjtlu.edu.cn

Abstract:

A systematic search was conducted in Web of Science and Scopus databases to retrieve research on BIPV building performance published in the last 15 years and identify recent advances and trends. The reviewed papers were classified into themes based on two dimensions: 1) building element application of BIPV and 2) broad objectives. Six themes were identified based on building element application of BIPV: 'roof', 'shading device', 'window', 'double-skin façade', 'façade wall' and 'others'. Four themes based on broad objectives were identified: 'building energy', 'simulation methodology and design optimisation', 'thermal comfort', and 'visual comfort'. Based on such classification, the various methodological approaches were discussed. Limitations and shortcomings of the current research and design approaches were also discussed. This paper offers insights into the existing research and emerging trends and a consolidated analysis of the different research methodologies in BIPV building performance research. The outcomes from the examined study revealed that BIPV can improve visual and thermal comfort, reduce building energy consumption, and generate energy provided the design is optimised correctly.

Workshopping architectural acoustics pedagogies

Michael Mack
The University of Melbourne, Parkville, Australia
michael.mack@unimelb.edu.au, ORCID-0009-0000-3815-875X

Abstract:

This paper develops a framework to document the design and delivery of a prototype workshop activity that introduces applied acoustics to architectural designers. Motivated by the gap in cohesion about the delivery of applied architectural acoustics, this workshop illustrates pedagogical strategies that can be further tested and implemented within architectural design education. The three-hour workshop activities involved participants learning and applying acoustic design workflows to a design task and comparing how they translated acoustic knowledge in the design process. This paper emphasises the design of the workshop's structure, theoretical content, design tasks, and how I utilised them to achieve specific learning outcomes. I provide reflections and feedback from participants about the design of the content and the workshop format itself, so that the teaching activity can be adapted and tested in other contexts.

Heat-exposure risks in the construction industry: An analysis of fatal and non-fatal incidents in the United States between 2000 and 2023

Seyed Armin Mirhosseini, Ruidong Chang and Hossein Omrany

University of Adelaide, Adelaide, Australia
seyedarmin.mirhosseini@adelaide.edu.au,
ruidong.chang@adelaide.edu.au,
hossein.omrany@adelaide.edu.au

Abstract:

Construction activities frequently expose workers to extreme weather conditions. This exposure can lead to severe health issues such as heat stroke, kidney diseases, heat cramps, and even fatalities. Heat-exposure incidents often lack clear precursors other than the climatic conditions on the day of the incident. This complicates the identification of at-risk employees and the prediction of such events. However, by analyzing incident reports, researchers can identify significant relationships between the conditions leading to heat-exposure incidents. Therefore, this study examines 370 fatal and non-fatal heat-exposure incidents reported on the Occupational Safety and Health Administration (OSHA) website of the United States from 2000 to 2023. Climatic data were also gathered from diverse national websites for each incident's date. This research aims to uncover patterns in heat-exposure incidents within the construction industry. Humid Subtropical Climate is the climate zone with the most incidents among these 370 reports. The age of injured workers plays a significant role in determining the severity of heat-related illnesses (HRIs). Employers' penalties, as well as maximum and average daily temperatures, are not significant factors in determining the degree of HRIs. The findings will be invaluable for safety managers providing insights into potential high-risk construction sites and workers.

Impact of virtual reality on interior design project assessment: A comparative study at the University of Buraimi, Oman

Ahmed Kandil and Rehab Moussa
University of Buraimi, Buraimi, Oman
ahmad.k@uob.edu.om, ORCID-0000-0001-7599-0502
rehab.m@uob.edu.om, ORCID-0009-0006-2076-8991

Abstract:

This study investigates the impact of Virtual Reality (VR) on the evaluation of interior design projects within higher education institutions, specifically at the University of Buraimi in Oman. The research compares traditional 3D printed perspectives and VR perspectives using Oculus Quest 2 across ten evaluation criteria. Forty participants, divided into two groups, assessed three interior spaces through these different methods. Quantitative data were gathered using a Likert scale, while qualitative data were collected via open-ended questions. Results indicate that VR perspectives allow students to identify more detailed areas for improvement, reflected in lower scores for furniture distribution, space utilization, and other criteria. However, higher scores in interaction, ease of understanding, and immersion suggest that VR enhances student engagement and integration into the design process. These findings highlight the potential of VR to provide a deeper, more immersive evaluation experience, offering valuable insights for advancing interior design education.

Examining the spatio-cultural characteristics of ethnic communities: A combined syntactic and semantic approach

Ling Zhou, Ju Hyun Lee, and Michael J. Ostwald
School of Built Environment, Faculty of Arts, Design & Architecture, The University of New South Wales, Sydney, NSW, Australia
ling.zhou2@unsw.edu.au, juhyun.lee@unsw.edu.au, m.ostwald@unsw.edu.au

Abstract:

Building Performance Simulation (BPS) is a powerful tool for predicting how buildings will perform under various conditions. However, complex BPS models need to be reliable representations of reality. One approach to achieving this is by calibrating the model with real-world data. When focusing on overheated apartments, the calibration process needs to be much more detailed than those aimed at predicting annual and monthly energy use. Previous studies have highlighted significant gaps in research on residential buildings, mainly due to the unpredictable behaviour of occupants, known as epistemic uncertainties. This paper discusses lessons learned from calibrating a simulation model with data from two overheated apartments in Auckland, New Zealand. The study closely examined how indoor environmental factors influenced by occupant behaviour (OB) were reflected in the measured data. The results showed uniform OB patterns that likely contribute to discrepancies between the simulation and actual performance. In summary, this detailed calibration against real-world data highlights the importance of considering OB in BPS models to enhance their accuracy and reliability, particularly in the context of overheated apartments.

Lessons learned from calibrating the simulation model using measured data

Hirda Lailani Khalid, Michael Donn and Joanna Merwood-Salisbury
Victoria University of Wellington, Wellington, New Zealand
hirda.khalid@vuw.ac.nz, michael.donn@vuw.ac.nz, joanna.merwood-salisbury@vuw.ac.nz

Abstract:

Artificial intelligence has the potential to radically transform how the built environment is conceptualised, designed, measured and constructed. However, the potential of artificial intelligence to improve building performances from the early design stages is yet to be fully understood. This paper provides an overview of the current knowledge, potential benefits and barriers of artificial intelligence-driven design approaches for early-stage design development aimed at improving the overall building performance. It undertakes a systematic literature review of papers focused on improving building design through the use of artificial intelligence in designing, simulations, and testing. This analysis uses the PRISMA reporting methodology to review 1,416 articles, of which 76 are identified as relevant for AI-driven optimisation of design and construction. This study reveals that the integration of machine learning in the early design stages of building projects can mark a transformative leap towards more sustainable, efficient, and cost-effective structures.

Towards an immersive design experience: initial user requirements to integrate parametric design with virtual reality

Hamidreza Sakhaei, Adam Drogemuller, Rongrong Yu, Andrew Cunningham, Bruce H. Thomas and Ning Gu

University of South Australia, Australian Research Centre for Interactive and Virtual Environments, Adelaide, Australia

Hamidreza.Sakhaei@unisa.edu.au, Adam.Drogemuller@unisa.edu.au, Rongrong.Yu@unisa.edu.au, Andrew.Cunningham@unisa.edu.au, Bruce.Thomas@unisa.edu.au, Ning.Gu@unisa.edu.au

Abstract:

This paper investigates the integration of Parametric Design and Virtual Reality technologies, focusing on how immersive environments can improve design processes. While both technologies offer benefits, their combined potential as Parametric Virtual Reality remains underexplored. Through conducting a SWOT analysis in focus group sessions with architectural designers, we assessed the current state and integration of these technologies to identify user needs and challenges. Key findings show that while Parametric Design offers efficiency and flexibility, it has a steep learning curve and potential design limitations. VR is praised for its immersive and collaborative qualities, enhancing real-time collaboration and design accuracy when integrated with Parametric Design. However, Parametric Virtual Reality must address usability and accessibility concerns to reach its full potential in architectural design.

What are smart cities good for? What city-building professionals say about the 'smart city'

Fanni Melles, Jeni Paay[1] and Ian Woodcock[2]
fanni.melles@gmail.com,
[1] Swinburne University of Technology, Melbourne Australia
jpaay@swin.edu.au
[2] The University of Sydney, Sydney, Australia
ian.woodcock@sydney.edu.au

Abstract:

Despite the enthusiasm of public and private entities, the smart city concept has no clear definition in academic research and design practice contexts for the past 30 years. This paper seeks to understand the ways Melbourne-based city-building professionals understand smart cities through analysis of 43 semi-structured interviews. Findings show that the smart city's practical meaning seems highly fragmented. Although, for many, the smart city is part of the future of urbanism, it is not the only focus; it is often questioned and seen as a marketing tool. Simultaneously, the supporting research is rarely directly applied, creating more confusion and controversies.

Housing Tomorrow: Challenges and opportunities for prefabricated medium density housing in New Zealand

Megan Scholtz and Guy Marriage
Victoria University of Wellington, Wellington, New Zealand

Abstract:

Affordable housing is a global issue, with numerous influencing factors and wide implications. This study unfolds against the backdrop of growing interest in understanding the future of Aotearoa's housing industry, where intensification and prefabrication are both advocated as potential solutions to increase supply. While existing research clearly demonstrates their respective benefits, little attention has been given to their intersection. This research investigates the challenges, opportunities and overlaps of these systems. A literature review provides foundational knowledge surrounding these topics, while a small sample study provides numerical information regarding residential construction in New Zealand. Though challenges persist for both strategies, recent developments indicate a shift in industry which encourages new discussion. Findings, though indicative only, largely support the literature. The significance of this research lies in its contribution to designers, contractors and developers as they seek to understand how these systems may begin to interact and blend to innovate New Zealand's building industry.

Sizing up new housing in Victoria: An interdisciplinary perspective on housing sufficiency

Nicola Willand[1], Robert Crawford[2], Michael Ambrose[3], Peta Ashworth[4]
[1] RMIT University, Melbourne, Australia, Nicola.willand@rmit.edu.au, ORCID-0000-0003-0604-1906
[2] The University of Melbourne, Melbourne, Australia, rhcr@unimelb.edu.au, ORCID-0000-0002-0189-3221
[3] CSIRO, Australia, Michael.ambrose@csiro.au, ORCID-0000-0001-8157-8311
[4] Curtin University, Australia, Peta.Ashworth@curtin.edu.au, ORCID-0000-0003-4648-7531

Abstract:

This study seeks to stimulate discussion on metrics for evaluating housing sufficiency. As sufficiency aims to minimise energy and material demand while ensuring essential living standards, achieving Australia's housing targets will necessitate balancing space allowances and social objectives. However, sufficiency has thus far received scant attention in housing policies, and there is limited understanding of how homes in Victoria adhere to sufficiency principles and how these are influenced by socioeconomic factors. The study examined the relationship between space allowances (m²/person) and social status. FirstRate5 certificate data for 334,077 houses/townhouses and 65,779 apartments across Victoria, Australia, were compared with the Australian Bureau of Statistics' Index of Economic Resources and Social (Dis)advantage's decile rankings at the postcode level. The results showed that social status was positively associated with space allowance in both types of dwellings. Kitchens, total living areas, and floor space for ensuite bathrooms or walk-in wardrobes were considerably larger in houses than in apartments or those considered in social housing design guidelines. Generally, space allowances in new Victorian homes were relatively generous and may be seen as excessive or unfair. Given the variety of construction materials, there is a need for new housing indicators that incorporate environmental and social metrics.

Thermal comfort evaluation of an indoor thermal environment control algorithm using a metabolic rate estimation model

Ji Young Yun, Eun Ji Choi, Tae Won Kim, and Jin Woo Moon
Chung-Ang University, Seoul, Republic of Korea
yjyyjy5350@cau.ac.kr, ejjchl77@cau.ac.kr, xngilsh@naver.com, gilerbert73@cau.ac.kr

Abstract:

Increasing urbanisation has led to a surge in the proportion of time spent indoors by individuals, making indoor environmental conditions particularly critical for ensuring occupant health and productivity. Traditional systems for indoor temperature control are designed to maintain temperatures at fixed values, failing to accommodate individual differences and making it challenging to ensure occupant comfort. To address these issues, studies have focused on occupant-centric control systems that incorporate various personal factors of occupants such as their metabolic rates (METs), which play a significant role in ensuring thermal comfort. While recent studies have attempted to estimate MET values through posture recognition, they often struggle to distinguish between similar postures with varying MET values. To overcome this challenge, a new MET estimation model combining object detection with posture classification has been introduced. The current study aimed to validate the effectiveness of a predicted-mean-vote-based control algorithm using this MET model. Experiments demonstrated that the proposed algorithm improved occupant thermal comfort by 8% to 59% compared to traditional temperature-based control methods. Hence, this algorithm is anticipated to serve as a key technology for enhancing occupant comfort, health, and well-being in indoor environments.

Rethinking building energy use from the occupant aspect

Shuyang Li[1,2], Xing Zheng[3], Xinzhe Wang[4], Zhen Han[5], Hongxiu Liu[6] and Rudi Stouffs[1]
[1] National University of Singapore, Singapore, shuyangli@u.nus.edu, stouffs@nus.edu.sg
[2] Singapore-ETH Centre, Singapore, shuyang.li@sec.ethz.ch
[3] City University of Hong Kong, Hongkong, China, x.zheng@cityu.edu.hk
[4] Tongji University, Shanghai, China, wangxinzhe@tongji.edu.cn
[5] Tianjin University, Tianjin, China, zhan@tju.edu.cn
[6] Southampton University, Southampton, UK, liuhongxiu1994@gmail.com

Abstract:

The causal relationship between occupants and building energy use is a critical part of sustainable building design and management. However, occupant-related factors are often oversimplified and overlooked in building energy simulations. This study employs both quantitative and qualitative methods to characterize occupant behaviours and occupancy patterns based on Wi-Fi connection data and an on-site survey. The energy simulation results are compared with meter data to analyse the impact of occupant-related factors on energy use. By introducing 'realistic' occupancy schedules into the building energy simulation, the deviation between simulation results and meter data can be reduced from 24% to 5%. This study reveals the importance of reliable occupancy data for accurate predictions of building energy use during the operational stage. Besides, the study explains the intricate relationships between the number of occupants and energy use, suggesting that designers should prioritize improving the utilization of shared spaces during the design development phase.

Comparison of process-based and hybrid life cycle inventory data for environmental benchmarks of residential buildings

Lise Mouton[1,2], Robert H Crawford[1], Damien Trigaux[2,3] and Karen Allacker[2]
[1] University of Melbourne, Melbourne, Australia
rhcr@unimelb.edu.au, 0000-0002-0189-3221
[2] KU Leuven, Leuven, Belgium
lise.mouton@kuleuven.be, ORCID-0002-9387-2224
damien.trigaux@kuleuven.be, ORCID-0000-0001-8305-4861
karen.allacker@kuleuven.be, ORCID-0000-0002-1064-0795
[3] EnergyVille, Genk, Belgium

Abstract:

Building regulations are increasingly implementing Life Cycle Assessment (LCA) requirements, including reference values or benchmarks. These benchmarks are typically based on LCAs of buildings using process(-based) life cycle inventory (LCI) data. Process LCI data, while most widely available, suffers from truncation errors. Hybrid LCI methods counter this but are rarely applied in practice today, partly due to lack of awareness of the degree and relevance of the underestimation by conventional process LCI. This study compares the use of process and hybrid LCI data to calculate the upfront (i.e. production stage A1-3) global warming potential (GWP) of Belgian dwellings. Hybrid environmental flow coefficients were developed for conventional building materials following the Path Exchange (PXC) method. The results show differences up to a factor of 20 between the process and hybrid coefficients. In addition to developing the first set of hybrid coefficients for Belgium, this research compares the application of process and hybrid coefficients to the largest set of individual buildings known to date. The hybrid coefficients were used to substitute corresponding process data in the LCA of 39 buildings. On average, the LCA results consisted of 77% hybrid data, and revealed an increase of 17% in building upfront GWP. The influence of building geometry as well as the system boundaries, functional unit, and scope are discussed, and the relevance of hybrid data in the context of benchmarking is demonstrated.

Integrated assessment of the life cycle greenhouse gas emissions and life cycle costs of a smart heating, ventilation and air conditioning control system for an office building

Praddeep Gobinath[1], Robert H. Crawford[1] and Marzia Traverso[2]
[1] The University of Melbourne, Parkville, Australia
p.gobinath, rhcr@unimelb.edu.au
[2] RWTH Aachen University, Aachen, Germany
marzia.traverso@inab.rwth-aachen.de

Abstract:

The greenhouse gas (GHG) emissions mitigation potential of smart control systems for heating, ventilation, and air conditioning (HVAC) systems has been well established in the literature. While promising, the embodied emissions associated with the raw material extraction, production and end-of-life phases of the control hardware are often overlooked. Scepticism about the financial benefits of these systems over traditional control systems remains, given the lack of studies that comprehensively evaluate the economics of their implementations. This study quantifies and compares the life cycle GHG emissions and costs of a traditional and a smart HVAC control system in an Australian office building. A reference office building is first defined, in terms of the geometry as well as the types and layout of spaces. The characteristics of both control systems are then specified, which enabled the necessary hardware to be deployed. The life cycle GHG emissions of the control hardware are computed using a hybrid life cycle inventory (LCI) approach, while the life cycle costs are calculated using the net present cost (NPC) method.

Thermal performance of three common steel facade profiles

Ricardo Lionar[1], David Kroll[1], Veronica Soebarto[1], Ehsan Sharifi[1], Marina Aburas[2]
[1] The University of Adelaide, Adelaide, Australia
ricardo.lionar@adelaide.edu.au, ORCID-0000-0003-0054-9637
david.kroll@adelaide.edu.au, ORCID-0000-0003-3447-0775
veronica.soebarto@adelaide.edu.au, ORCID-0000-0003-1397-8414
ehsan.sharifi@adelaide.edu.au, ORCID-0000-0003-1309-925X
[2] Bluescope Building Components, Adelaide, Australia
marina.aburas@bluescope.com, ORCID-0000-0001-5403-6904

Abstract:

The energy demand for building heating and cooling is significantly influenced by the design of their envelopes, including roofs, windows, walls, and other components. This paper investigates the thermal performance of three common steel cladding profiles—Profile 1 (Standing Seam), Profile 2 (Corrugated), and Profile 3 (Interlocking)—under solar radiation in Adelaide. Physical models with varying orientations and rib directions (horizontal or vertical) were tested, and surface, cavity, and internal temperatures were recorded at 15-minute intervals. The results revealed that Profile 1 consistently exhibited the highest cavity temperature, indicating the least favourable thermal performance. Conversely, Profile 2 (Corrugated) showed the best performance when oriented horizontally, with significantly lower cavity temperatures. Profile 3 (Interlocking) achieved the lowest cavity temperature when the recess was oriented vertically. Notably, the study found that airflow influences the resulting cavity and internal temperature based on the shapes of the profile, the ribs' direction and orientation. These findings offer a foundation for further research into optimizing cladding designs, including parameters such as corrugation amplitude, frequency, and thickness, to enhance energy efficiency and thermal comfort in buildings.

Optimizing landfilling fees for construction waste: A dynamic multi-objective optimization approach balancing environmental and economic performance

Wenbo Zhao and Jian Li Hao

Xi'an Jiaotong-Liverpool University, Suzhou, China
Wenbo.Zhao22@student.xjtlu.edu.cn, Jianli.Hao@xjtlu.edu.cn

Abstract:

Construction waste management is a complex and dynamic process involving multiple stakeholders, including contractors who prioritize economic profits and government entities that emphasize environmental sustainability. Effective waste management requires balancing both economic and environmental performance, with landfilling fees playing a crucial role in influencing carbon emissions and overall costs. This paper develops a dynamic multi-objective model that simulates the environmental and economic performance of construction waste management from 2010 to 2030, aiming to determine the optimal landfilling fees. First, a system dynamics model is generated to investigate how variations in landfilling fees are influenced by other factors and how these variations impact simulation outcomes. Then, based on the simulation results of five scenarios, the optimal scenarios were identified through a multi-objective optimization approach. The results show that in the optimal scenario, the landfilling fee is 1000 yuan per ton, with a landfilling rate of 22.96%, a recycling rate of 76.77%, and an illegal dumping rate of 0.27%. This scenario results in a reduction of carbon emissions by 9.1303×10^9 tons compared to expected levels, with the overall cost amounting to 20.8443×10^{12} yuan. This paper can guide policymakers in developing optimal landfilling fees that balance government requirements with contractors' interests.

Enhancing and harmonizing environmental sustainability and circularity through timber hybrid building

Bigyeong Shin, Young Uk Kim, Jihee Nam and Sumin Kim
Building Environment and Materials Lab, Seoul, Republic of Korea
shinbi@yonsei.ac.kr, yuk92@yonsei.ac.kr, namghee@yonsei.ac.kr, kimsumin@yonsei.ac.kr

Abstract:

The circular economy (CE), alongside environmental impact, is becoming a crucial factor in sustainable development within the construction sector. The use of timber in buildings offers a sustainable alternative in terms of both environmental impact and circularity. However, there is a paucity of studies that simultaneously analyse the environmental impact and circularity of timber in construction. It is necessary to quantify and validate the effects of timber application in buildings concerning both environmental impact and circularity. This study examines the environmental impact and circularity potential of timber used in actual public buildings (including structures, walls, and roofs). Life Cycle Assessment (LCA) was conducted in accordance with ISO and EN standards, using existing literature, Korean LCI data, and other relevant sources. Furthermore, by incorporating environmental impact into the Building Circularity Indicator (BCI) calculation, a method for integrating LCA results with the BCI is proposed to assess building sustainability. These findings provide valuable insights for designers and policymakers during the initial planning stages. Moreover, by demonstrating the integration of environmental impact into the BCI framework, this study helps bridge the gap between circularity indicators and environmental considerations.

Re-designing the Australian dream: Homeness imaginaries in emerging residential typologies

Caroline Dahl[1], Per-Johan Dahl[2] and Guillermo Aranda-Mena[3]
[1] Swedish University of Agricultural Sciences, Alnarp, Sweden, caroline.dahl@slu.se
[2] Lund University, Lund, Sweden, per-johan.dahl@abm.lth.se
[3] RMIT, Melbourne, Australia, guillermo.aranda-mena@rmit.edu.au

Abstract:

Housing provisions in the Western world, Australia included, are characterised by several challenges. New residential typologies are needed to cope with, for example, environmental and economic considerations of land use, escalating construction cost, and the lack of affordable housing. Urban form determines measures of density. It also spurs our common imaginaries of urban life. Hence, to calibrate urban form with new residential typologies, we need to upgrade the prevailing homeness imaginaries. This paper explores new narratives of housing density generated through contemporary transformations of the urban fabric, and draws on cultural implications when increasing density. Proposing Melbourne as object of inquiry, it takes Ian H. Thompson's scholarship on imaginaries in landscape architecture as a theoretical framework to extrapolate means of upgrading the Australian Dream of homeness. While these planning operations bring together disparate imaginaries – the convention of cosmopolitan urban lifestyle in the inner city versus the family-oriented lifestyle in the wider outer suburbs – they also tell a story about the coexistence of multiple imaginaries in contemporary global cities, such as Melbourne. This paper will discuss findings from studies on Swedish waterfronts and American suburbs to draft a research proposal concerning emerging residential typologies feasible to be applied to Australian cities.

Reducing traffic noise for indoor comfort: Wing Cheong Estate, Hong Kong – Improvements with different inclination angles

Ferdinand Oswald[1], Ada Fung[2]
[1]The University of Auckland, Auckland, New Zealand
ferdinand.oswald@auckland.ac.nz, ORCID-0000-0003-3415-5126
[2]Hong Kong Housing Authority, Hong Kong, VAR China
adayfung2001@yahoo.co.uk

Abstract:

Natural ventilation can make an important contribution to improving thermal comfort and reducing air-conditioning usage in tropical and subtropical climate areas. In response to heavy noise emission due to road traffic affecting some residential buildings in Hong Kong, the Hong Kong Housing Authority (HKHA) developed an architectonical solution for noise mitigation within the living spaces. This concept is expected to reduce noise emission in the interior spaces and allow the façade openings to remain open in order to guarantee natural ventilation and the thermal comfort of living spaces. The development of acoustic balconies in Hong Kong can contribute to the enhancement of thermal comfort while the problem of noise pollution can be mitigated with the usage of glass swords. This research measures the acoustic performance of the acoustic balconies on-site in the case study Wing Cheong Estate, Hong Kong. To measure the decibel values, a digital multimeter sound level measurement device was used. As a recommendation for further improvements, the result suggests modifying the inclination angle of the glass swords, taking into account different floor heights in proportion to the noise source.

Exploring social sustainability in the built environment: definitions, dimensions, and implications

Azra Ahamed[1,2], Farzaneh Haghighi[1] and Paola Boarin[1,2]
[1]Te Pare School of Architecture and Planning, Waipapa Taumata Rau University of Auckland, New Zealand
[2] Future Cities Research Centre, Waipapa Taumata Rau University of Auckland, New Zealand
azra.ahamed@auckland.ac.nz,ORCID-0009-0006-0531-2726
f.haghighi@auckland.ac.nz,ORCID-0000-0001-9697-5387
p.boarin@auckland.ac.nz, ORCID-0000-0003-3252-5699

Abstract:

Social sustainability is a less explored concept compared to environmental and economic aspects within the sustainability discourse. One of the major reasons is the lack of a clear and coherent definition of the concept. This paper aims to establish a more robust, well-defined and contextual understanding of social sustainability through its detailed exploration and definition within the built environment disciplines. First, the paper traces the evolution of social sustainability within the built environment. Second, it situates the concept within the context of architecture by defining specific parameters at a housing scale. Analysing social sustainability at the housing level can uncover specific challenges and opportunities within residential areas, enabling more focused and impactful interventions. Drawing upon a qualitative review of the multidisciplinary literature on the topic, this paper explores the various definitions and interpretations of social sustainability, suggesting a definition. This paper defines social sustainability at the housing level as creating communities where people's housing needs are met, improving the quality of life for residents, and providing households with access to essential amenities and opportunities and participation in community life. This definition contributes to understanding, situating, and promoting the concept within the housing context by identifying appropriate dimensions for its contextualisation at a housing scale.

Will humans replace AI? A design dilemma

Dermott McMeel, Surendar Jayachandran and Charles Walker
School of Future Environments, AUT University, Auckland, New Zealand
dermott.mcmeel@aut.ac.nz, surendar.jayachandran@autuni.ac.nz, charles.walker@aut.ac.nz

Abstract:

Artificial Intelligence (AI) is a rapidly growing area in design, yet debates are polarized. Proponents highlight AI's potential to alleviate menial tasks and aid solving complex problems, while critics fear the rise of super-intelligence. Some view AI as part of a predictable automation trajectory, while others argue it marks a paradigm shift in human-machine interaction, rendering past lessons irrelevant. This paper challenges these binary views, advancing the conversation. Drawing on Wittgenstein and Marx, it situates creativity and design within a hermeneutic cycle of externalization and play, both problematic for AI. Through case studies of AI-supported design, the paper argues that AI provides cognitive labor rather than creativity, aligning it with Marxist concepts of machine automation. This reframes design as comprising both explicit, complex problems fit for AI resolution and tacit creative practices—rooted in play and externalization—that remain predominantly human. The paper suggests a roadmap for navigating a discipline increasingly shaped by AI tools, while emphasizing that architecture is undergoing an irreversible transformation. We are at the threshold of a paradigmatic shift that will require new skills and fundamentally reshape the human-machine relationship in design.

Analysis of commercial building solar admittance measures for the next National Construction Code of Australia

Paul Bannister[1], Hongsen Zhang[2] and Ignacio Alcalde[3]
[1] Delta Q Pty Ltd, Canberra, Australia, paul.bannister@dqcs.com.au
[2] Enerefficiency Pty Ltd, Canberra, Australia, hongsen.zhang@enerefficiency.com
[3] Northrop Consulting Engineers Pty Ltd, Sydney, Australia, IAlcalde@northrop.com.au

Abstract:

Section J of the National Construction Code (NCC) of Australia (Volume 1) sets requirements for energy efficiency for non-residential buildings. This paper reports the results of analyses undertaken to revise the glazing solar admittance requirements for the next update of the NCC. In these analyses, a series of daylighting simulations calculating the spatial Daylight Autonomy (sDA) for a grid of window wall ratio and visual light transmission combinations was used to derive minimum visual solar admittance figures (WWR*VLT) compatible with a nominated minimum daylighting performance. A database of available glazing products was then used to convert these visual figures to equivalent thermal solar admittances (WWR*SHGC). Dynamic thermal simulation was then used to test whether these solar admittances coincide with minimum energy consumption. It was found that this is true in all climate zones other than climate zone 8 (Alpine). Based on this, the new requirements can be expressed as a simple table of solar admittance versus climate zone. The results lead to a recommendation to tighten the deemed-to-satisfy solar admittance requirements for commercial buildings in the next edition of the NCC.

A rapid prediction model for building facade solar radiation using random forests

Chan Jun Hao and Rudi Stouffs
Department of Architecture, National University of Singapore, Singapore
chan.jun.hao.e0421461.01@u.nus.edu, stouffs@nus.edu.sg

Abstract:

Urban Heat Island (UHI) effects and the optimization of solar energy efficiency are critical challenges in rapidly urbanizing cities like Singapore. Existing simulation tools, such as Ladybug and Honeybee-Radiance, either lack accuracy in accounting for material properties and light bounces or are computationally intensive. This study aims to develop an enhanced simulation tool using Random Forest regression to predict solar radiation on building façades with higher accuracy and efficiency. By generating synthetic training data from Radiance simulations of various real-world urban environments in Singapore, the model incorporates three-dimensional spatial relationships and material properties, including concrete, glass, and wood. The results demonstrate a clear improvement in predictive performance with larger training datasets, achieving a Mean Absolute Error (MAE) of ±26.21 kWh and an R^2 of 0.973 using 1,000 simulations. While the model effectively captures the impact of different materials, predicting solar radiation for glass surfaces remains more complex due to their unique optical properties. The study concludes that expanding the training dataset and enhancing computational resources could enable the model to surpass existing tools in both accuracy and scalability. This would provide architects and urban planners with a more precise and practical tool for designing energy-efficient buildings and mitigating UHI effects.

Analysing the impact of interest rates on the feasibility of using different window classes in residential buildings

Mikael Gilbert, Khalegh Barati and Xuesong Shen
University of New South Wales, Sydney, Australia
mikael.gilbert@unsw.edu.au, khalegh.barati@unsw.edu.au, x.shen@unsw.edu.au

Abstract:

Minimising thermal loads is essential for reducing the environmental impact of residential buildings. However, there is a trade-off between energy efficiency and cost when designing buildings. lifecycle cost analysis considers the future costs of different design options and is used to select the most cost-optimal option. Yet, interest rate fluctuations may change the discount rate used during the Lifecycle cost analysis. This paper aims to compare the impact of varying discount rates on the cost-benefit analysis of different window properties. Thermal load simulations and lifecycle costings were conducted for a case project involving various window properties with U-values ranging between 0.97-6.59 W/m2K. Additionally, as energy price continues to rise, Exponential Smoothing (ETS) was used to predict the energy costs over the building's lifetime. Next, different discount rates were applied to the lifecycle cost analysis. Results indicate that the optimal window U-value for most discount rates lies between 1.5-2.0 W/m2K as they generally provide the highest net present value. Furthermore, better-performing windows have higher initial capital costs, increasing their vulnerability to higher interest rates. The significance of this research lies in its contribution to aid designers in selecting more financially robust design solutions to ensure the economic sustainability of their designs.

Life cycle greenhouse gas emissions of energy retrofitting strategies for residential buildings in India: A case study

Nayanika Bora, Robert H. Crawford and James Helal
The University of Melbourne, Melbourne, Australia
nayanikab@student.unimelb.edu.au, ORCID-0000-0002-0716-2075
rhcr@unimelb.edu.au, ORCID-0000-0002-0189-3221
james.helal@unimelb.edu.au, ORCID-0000-0002-8211-1454

Abstract:

Significant research and regulatory efforts have focused on reducing operational emissions in new residential buildings. However, the consideration of broader life cycle greenhouse gas (GHG) emissions of these buildings has been limited in the context of India, due to insufficient publicly available data. Energy retrofitting is a conventional approach for reducing the operational emissions of building, however, the impacts of embodied and life cycle GHG emissions are rarely considered. In this research, a low-rise reinforced concrete residential building located in the temperate climatic zone of India is assessed to analyse the net life cycle GHG emission implications of 216 retrofitting scenarios, each resulting in a distinct retrofitted building model. Streamlined life cycle assessment, along with DesignBuilder for dynamic energy simulation, are used to quantify the life cycle GHG emission impacts of the adopted scenarios. A total of 213 retrofitting scenarios resulted in a net life cycle benefit, whereas 3 scenarios associated with combined strategies of fenestration weatherstripping, and roof insulation did not yield any life cycle GHG benefits when compared to the base building. This may help inform the development of targeted policies, and actions to more consciously improve India's existing residential stock.

Towards a comprehensive definition of circular building through qualitative meta-synthesis

Fernando Pavez [1,2], Duncan Maxwell [1,2] and Victor Bunster [1,2]
[1] Building 4.0 CRC, Caulfield East, Victoria, Australia;
[2] Monash University, Melbourne, Australia.
fernando.pavezsouper@monash.edu

Abstract:

The Circular Economy (CE) approach to the built environment gathers growing interest from scholars, practitioners, and policymakers. However, there needs to be more clarity and consensus on the concept formulation, principles, strategies, and actions that define CE in building. The lack of conceptual clarity hinders progress in the field. This paper aims to advance towards a comprehensive definition of Circular Building (CB) by conducting a meta-synthesis of review papers published in peer-reviewed journals. Reviews published in the last ten years were analysed through thematic analysis, and trustworthiness was established through well-established research methodologies. The definitions were coded, organised and synthesised to define CB, its component concepts and their interrelationships. The definitions and the hierarchical structure of relationship patterns are expressed in written summaries and concept map diagrams. The taxonomy of concepts and their relationships allow a more accurate discussion about what is and is not comprised under the CB concept umbrella, eliciting progress in the field for scholars, policymakers, and practitioners.

An exploration of energy outcomes in 32 homes in Victoria

Pabasara Wijeratne, Nicola Willand and Jan Hayes
RMIT University, Melbourne, Australia
pabasara.wijeratne@rmit.edu.au, ORCID-0000-0002-6596-974X
nicola.willand@rmit.edu.au, ORCID-0000-0003-0604-1906
jan.hayes2@rmit.edu.au, ORCID-0000-0003-0127-684

Abstract:

Adopting a consumer-centric approach is crucial for a smooth transition to sustainable housing. This mixed-method study aimed to better understand how dwelling energy efficiency and householder practices shaped energy consumption and warmth during winter in Victoria, Australia. The study involved 32 owner-occupier households with gas heating and hot water systems. Data collection combined monitoring electricity and gas use and indoor temperatures with semi-structured householder interviews and field observations in September 2023. This paper compares energy consumption and indoor temperature metrics of efficient (built after 2005) and non-efficient (older, unrenovated) homes, revealing the impact of outdoor temperatures and heating practices. The mean daily gas use declined with rising daily mean outdoor temperatures in both groups. Switching off the heating overnight was considered normal and cost-saving, leading to cold homes in the mornings. The period of most adequate temperatures was in the evenings when people were home, and both gas and electricity usage peaked. The study confirms that household practices significantly impact gas and electricity consumption, and home design energy efficiency is not a reliable predictor of energy usage. To transition to low-carbon housing, policymakers and industry should consider individual and social energy use practices when determining technological and regulatory requirements.

Cinematic echoes: Exploring the spectrum of misery and dignity in Mexico City's forgotten cinemas

Juan Carlos Dall'Asta
Xi'an Jiaotong Liverpool University, Suzhou, China
juancarlos.dallasta@xjtlu.edu.cn

Abstract:

This study examines the architectural and cultural significance of historic cinemas in Mexico City, exploring how these spaces mirror socio-economic transformations and embody the dualities of "misery and dignity" within urban settings. Focusing on iconic cinemas like Palacio Chino, Cine Ópera, and Cine Lindavista from the golden era of Mexican cinema, the research investigates their transition from vibrant cultural hubs to relics of urban decay, reflecting broader shifts in the city's architectural heritage and societal values. By integrating theoretical insights from Walter Benjamin, Georg Simmel, and Gilles Deleuze, the study offers a multidimensional view of the cinemas as both products and influencers of urban cultural dynamics. These cinemas, once temples of cinematic reverie, now stand as monuments to the city's fluctuating cultural landscape, increasingly challenged by modernisation and conflicting urban policies. The research underscores the importance of integrating cultural heritage preservation in contemporary urban planning, suggesting that acknowledging these spaces could foster a balanced integration of historical significance and modern utility. The findings contribute to broader discourses in urban studies, architecture, and cultural memory, emphasising the role of cinemas in shaping and reflecting urban identity and memory and calling for policies that prioritise cultural heritage alongside economic development.

Temporal synthesis in architecture: Bridging geography, material memories, and urban narratives

Juan Carlos Dall'Asta
Xi'an Jiaotong Liverpool University, Suzhou, China
juancarlos.dallasta@xjtlu.edu.cn

Abstract:

This paper explores the paradigm of "temporal synthesis" in architecture, a design process that integrates time, space, and narrative to address the complexity of modern urban environments. It underscores the importance of respecting urban and material memory and fostering innovative solutions that enhance sustainability while safeguarding against the homogenisation of urban landscapes. Through detailed case studies, including Kengo Kuma's Art's Folk Art Museum in Hangzhou, the research illustrates how architectural practices can deeply root themselves within their environmental contexts, thus reinforcing the narrative of place. The strategic reuse of materials not only bridges past and present but also promotes continuity alongside innovation, creating a dialogue between historical and contemporary contexts. The paper also examines how urban history enriches architectural language with designs that integrate complex layers of urban fabric into coherent narratives. Examples from Rafael Moneo's Museo Nacional de Arte Romano and Foster + Partners' Carré d'Art highlight strategies that effectively integrate architectural forms with their urban settings. Drawing on Mikhail Bakhtin's concept of the chronotope, the study illustrates the convergence of time and space in architecture, enhancing the human experience. This approach positions architecture as a dynamic medium that captures and expresses the evolving continuum of human interaction with space.

Integrative AI in architecture: Towards a conversational design process

Juan Carlos Dall'Asta
Xi'an Jiaotong Liverpool University, Suzhou, China
juancarlos.dallasta@xjtlu.edu.cn

Abstract:

The role of technology in architectural design has progressively evolved from simple tool use to a significant participatory element in the creative process, primarily driven by advancements in digital and parametric design. This shift not only signifies technological advancement but also prompts a reevaluation of Techne (craftsmanship) and Episteme (knowledge) within the discipline. Traditionally, while technology enhanced efficiency, its contribution to conceptual ideation remained limited. The integration of Artificial Intelligence (AI), however, marks a transformative shift, positioning AI as a co-creative force actively engaged in the interpretative and conceptual stages of design. This study explores AI's potential to revolutionise the architectural design process by contrasting conventional practices in education with AI-driven methodologies; the research highlights AI's capacity to generate a more conversational and collaborative process. Though experimental research conducted over four years within architectural education, the study investigates AI's integration into design curriculum and practice, revealing that AI can significantly enhance workflow, creativity, and innovation. AI transcends its role as a tool, emerging as a potential intellectual partner. These findings suggest that AI is poised to reshape the future of architectural design, inviting further exploration into its role in advancing design methodologies and its transformative impact on the discipline.

A comparative study: Vernacular timber construction techniques of Iranian, Japanese, and Spanish granary structures

Farkhondeh Vahdati and Mia Tedjosaputro
Xi'an Jiaotong-Liverpool University, Suzhou, P.R. China
farkhondeh.vahdati23@student.xjtlu.edu.cn , ORCID-0000-0003-1355-0063
Mia.Tedjosaputro@xjtlu.edu.cn, ORCID-0000-0003-1328-3671

Abstract:

The typology of elevated timber structures in different countries illustrates efficient self-built structures made of local materials. The timber structures of Shekili structures provide agricultural dry storage structures for the crops from the farms. The similar structure of the Japanese and the Spanish Horreo do the same function in other countries across the world, as mentioned in this paper. Horreos are traditional rural buildings in Spain used for the desiccation and conservation of cereal grains. This paper explores the construction techniques of these building structures, including the roof, body, and foundation, considering the structures' joints and connections. The research is carried out by conducting a literature review in ScienceDirect and site visits. The focus will be drawn to the 'structure' layer, the load-bearing layer, and their adaptation toward two Design for Disassembly (DfD) principles. This paper's findings rely on using an open building system and structural grids in granary structures and their adaptation to the DfD principles. Moreover, it discusses the construction techniques that highlight resilience from weather and are relatively easy to assemble and disassemble. Future studies focus on implementing these techniques in real-scale prototypes considering holographic construction.

Addressing the 'recovery window': Shifting approaches in post-disaster shelter strategies

Subin Rahman, Paola Boarin and Alessandro Premier
Waipapa Taumata Rau The University of Auckland, Auckland, New Zealand
subin.rahman@auckland.ac.nz, ORCID-0009-0003-6362-6043
p.boarin@auckland.ac.nz, ORCID-0000-0003-3252-5699
alessandro.premier@auckland.ac.nz, ORCID-0000-0002-2565-9923

Abstract:

Sheltering solutions attempt for the recovery of people affected in post-disaster scenarios. These are challenging practices, especially when addressing such provisions after the emergency period and until a permanent setup. While the primary intention is to create a safe and secure environment, shelters also provide a platform for the people affected towards recovery during different stages of achieving permanency. Existing shelter typologies can be classified under these stages, but focus only on few parts of recovery, limiting the opportunity to progress towards a long-term solution for the affected people. Also, the dominance of considering shelters as physical structures only, often undermines the persisting issues in them that affect people's recovery. This requires more than just looking into problems in shelter conventionally. Analysing the recovery window and prioritising on temporary provisions, this literature-based study is aims to address shelter challenges faced within this span of recovery through research and practice-based case studies of different shelter strategies in varying post-disaster contexts. The methodology involves identification and thematic classification of shifting approaches in sheltering which is compared with underlying shelter challenges that informs evidence and pointers for better recovery of affected communities and imply future directions for strategies addressing the recovery window.

Home is where the HRV is: A workflow to proliferate the Passive House standard in Australia

Noah Soderlund
University of Sydney
nsod9087@uni.sydney.edu.au

Abstract:

40% of Australia's greenhouse gas emissions are directly linked to the embodied carbon and operational emissions of buildings, with 57% of those emissions caused by the heating and cooling of internal air. Passive House stands as one of the most promising tools for analysing the thermal performance and energy efficiency of Australian buildings. While the typical Passive House analysis workflow is accurate and replicable, it relies heavily on static and manual workflows without leveraging advances in dynamical building analysis. This results in an inefficient design revision process and an inability to receive early building performance feedback. This project seeks to create a dynamical workflow for Passive House analysis. Designers can receive preliminary energy balance results based on simple 3D models and standard details in far less time. This is achieved through a workflow in Grasshopper. As projects adapt and additional detail is added, synchronised data allows for better informed design decisions at all project stages and improves final buildings as a result. Through describing a dynamical, optimisable and Streamlined Australian Passive House (SAPH) process, this project reduces the analysis cost of projects while also allowing more design flexibility and construction cost reductions.

Nature-experiential archetypes: Learnings from the Gandhi Ashram

Archie Patel, Akari Nakai Kidd and Astrid Roetzel
Deakin University, Geelong, Australia
patelar@deakin.edu.au, ORCID-0000-0002-5161-8236
akari.nakaikidd@deakin.edu.au, ORCID-0000-0002-1456-294X
astrid.roetzel[1]@deakin.edu.au, ORCID-0000-0003-3243-7744

Abstract:

Nature experiences foster multiple benefits ranging from promoting well-being, reducing stress, restoring attention and positively influencing our emotional, cognitive and spiritual development. While existing frameworks offer design guidelines and strategies, they often lack clear practical recommendations on how to configure different architectural elements to create spatial experiences that enhance nature awareness. To address this gap, this paper presents a study that engages in hermeneutic phenomenology as a method and drawing as an analytical tool to examine how different architectural elements at the Gandhi Ashram are composed to foster nature experiences. By doing so, it aims to draw out nature experiential archetypes that enhance nature awareness in the built environment. The study also aims to demonstrate the benefits of conducting hermeneutic phenomenological research and utilizing drawing as tools of analysis in architectural research. The paper concludes with a visually illustrated design framework for creating spatial nature experiences that embody diverse perspectives of nature and enhance the sense of connection with the natural environment.

Assessing the internal thermal comfort of buildings in the Greater Male Region, Maldives: With special reference to building practices and energy demand

Ahmed Jinan, Malthi Rajapaksha and Davithri Wickramatilake
Sri Lanka Institute of Information Technology, Malabe, Sri Lanka
ar23851740@my.sliit.lk,ORCID-0009-0007-8740-767X
malthi.p@sliit.lk, ORCID-0000-0002-3909-7255
davithri.w@sliit.lk, ORCID-0009-0002-9163-1547

Abstract:

Over the past 40 years, energy demand in Maldives has significantly increased to achieve thermal comfort in buildings. However, there is a lack of data on internal thermal conditions in Maldivian buildings. Therefore, this research aims to evaluate internal thermal comfort by examining building techniques and energy usage in the Greater Malé Region. To conduct this study, a multi-case study approach was used to analyse 10 buildings. These buildings consisted of two residential buildings (one with AC and one without) and eight non-residential buildings (four with AC and four without). Data collection methods included photographic surveys, questionnaires, on-site thermal measurements, energy bill analysis, and room temperature assessments. The findings revealed that there is a heavy reliance on air conditioning (AC) in the region, which has significant environmental drawbacks. On the other hand, buildings without AC were found to lack adequate comfort due to insufficient natural ventilation in their designs. Moreover, the study highlighted that current building practices do not effectively address heat gain and energy consumption, emphasizing the need for more naturally ventilated designs. The research provides insights for designers and architects in Greater Malé Region, emphasizing the importance of transitioning to bio-climatic design approaches that enhance sustainability and eco-friendliness.

Formulating an Index for Pluvial Flood Resilience in Colombo, Sri Lanka: A Sponge City's Perspective

Suvani Wickramasinghe, Malthi Rajapaksha and Priyan Sudesh Hettipatharana
Sri Lanka Institute of Information Technology, Malabe, Sri Lanka
ar23568846@my.sliit.lk.,ORCID-0009-0007-0549-2410
malthi.p@sliit.lk, ORCID-0000-0002-3909-7255
priyan.s@sliit.lk, ORCID-0009-0000-4425-3382

Abstract:

Rapid urbanization in Colombo, Sri Lanka, has replaced natural water detention areas with impervious surfaces, disrupting hydrological processes and leading to frequent pluvial floods. Combined with climate change, this has compromised urban resilience. Sri Lanka currently lacks a structured approach to tackle these issues, highlighting the need for systemic initiatives. This research introduces a "context specific", wide-ranging index designed to enhance pluvial flood resilience in Colombo using the Sponge City Concept. The index serves as a strategic tool for effective flood mitigation and improving urban resilience. The research follows a mixed methods approach in three stages: developing a draft index with context-specific indicators from literature reviews, validating it through expert opinions, and testing it against observed flood vulnerabilities via case studies. Validation through expert feedback and real-world testing demonstrates the index's effectiveness in mitigating pluvial floods. This advanced index fills a critical gap in Sri Lanka's current flood management strategies and is a foundational step towards transforming Colombo into a Sponge City. The research offers valuable insights into global urban flood management and provides a replicable model for other cities facing similar challenges specially in the tropics.

Implications of Building Information Modelling (BIM) on project performance in high-end residential projects amidst economic crises: A case study of Sri Lanka (2020 – 2023)

D.H.A Wijesinghe[1], Malthi Rajapaksha[2], Lalith De Silva[2] and Vishva Herath[2]
[1] Liverpool John Moores University, Liverpool, United Kingdom
d.h.wijesinghe@2023.ljmu.ac.uk, ORCID-0009-0000-5289-3494
[2] Sri Lanka Institute of Information Technology, Malabe, Sri Lanka
malthi.p@sliit.lk, ORCID-0000-0002-3909-7255
lalith.d@sliit.lk, ORCID-0000-0001-7112-376X
vishva.h@sliit.lk, ORCID-0009-0002-8086-1988

Abstract:

Impact of the adoption of Building Information Modelling (BIM) on project performance is a well-discussed research area in construction industry. Yet, the study areas are primarily focused on stable economic environments, underexploring the impact of BIM under economic stressors. It is unclear whether the assumed benefits of BIM hold true in such contexts especially in high-end projects, which are development indicators in countries such as Sri Lanka. Using a combination of project performance data of two high-end residential projects employing varying levels of BIM maturity with the interviews of project stakeholders, this study performed a comparative analysis of the impact of BIM-related factors on project performance metrics. The findings revealed that BIM adoption leads to significant improvements in cost, time, and quality control, even amidst economic crises. The paper concluded that the initial investment on BIM and experience level of stakeholders have an exponential positive impact on the project performance indicators, independent of the level of BIM adoption. Contributions to the existing research include the identification of the key BIM-related factors affecting project performance and the significance of BIM adoption in enhancing project performance. It also encourages industry practitioners to invest on BIM to successfully adapt to economic crisis conditions.

Social factors driving adaptive behaviours for indoor comfort: Towards a framework for effective integration

Francisca Rodriguez, Valeria Macalupu, Debra Cushing, Glenda Caldwell, and Veronica Garcia-Hansen

School of Architecture and Built Environment, Faculty of Engineering, Queensland University of Technology, Brisbane, Australia
f3.rodriguez@qut.edu.au, v.chira@qut.edu.au, debra.cushing@qut.edu.au, g.caldwell@qut.edu.au, v.garciahansen@qut.edu.au

Abstract:

With the widespread adoption of open-plan layouts, research into human comfort in the workplace has shifted from centralised monitoring to Personalised Energy and Comfort Management Systems (PECMS), which aim to identify personal comfort levels to enhance predictive models for building management. However, achieving personal comfort in shared environments remains challenging due to the influence of social factors on environmental modification decisions. As a result, the integration of personal comfort into centralised systems is suboptimal, affecting workers' productivity and satisfaction with the environment. This study presents findings from a focus group (n = 14) conducted in Brisbane, following a post-occupancy evaluation of a shared open-plan office. The focus group explored intention to modify the workplace environment to achieve personal comfort, along with the social drivers and triggers motivating these behaviours. Data were organised into themes using an open coding approach, and the results were synthesised into a flowchart of environmental adaptations for comfort in shared environments. These findings offer insights into integrating quantitative and qualitative data to effectively address the social dimensions of personal comfort. In doing so, this study underscores the importance of both individual and social factors in designing indoor shared spaces.

Integration of vernacular design principles in contemporary buildings: A comfort assessment of school buildings in Colombo, Sri Lanka

Sankalpa Karunagoda[1], Malthi Rajapaksha[2] and Danushka De Silva[2]

[1]Liverpool John Moores University, Liverpool, UK
SLITKARU@ljmu.ac.uk, 0009-0007-4123-6043

[2]Sri Lanka Institute of Information Technology, Malabe, Sri Lanka
malthi.p@sliit.lk, ORCID-0000-0002-3909-7255
danushka.d@sliit.lk, ORCID-0009-0005-0732-8951

Abstract:

This study compares the thermal comfort and energy efficiency of vernacular and contemporary school buildings in Sri Lanka's tropical climate. Vernacular buildings, known for their passive cooling strategies and bio-climatic architecture, are contrasted with contemporary buildings that rely on energy-intensive mechanical cooling systems. Maintaining thermal comfort in school buildings is increasingly challenging due to rising energy costs and environmental concerns, highlighting the need for sustainable architectural practices. A comparative field study was conducted at Royal College, Colombo (RCC), and CMS Sri Jayawardhanapura College, Kotte (CMSC), which feature both vernacular and contemporary buildings. The methodology included a photographic survey, temperature and humidity measurements, and interviews with school staff and students. The findings reveal that vernacular buildings consistently maintain lower indoor temperatures and offer superior thermal comfort compared to contemporary structures, despite some humidity issues due to maintenance challenges. This research underscores the value of integrating vernacular design principles into modern school architecture in Sri Lanka, promoting better thermal performance, reduced energy consumption, and more conducive learning environments. The study has significant implications for architectural practice and policymaking in tropical climates.

A framework: Assessing elder friendly accessibility in mid-rise residential buildings in Colombo, Sri Lanka

Nesura Bulathsinghala, Malthi Rajapaksha and Priyan Hettipathirana
Sri Lanka Institute of Information Technology, Colombo, Sri Lanka
ar23568532@my.sliit.lk, ORCID-0009-0001-9561-1378
malthi.p@sliit.lk, ORCID-0000-0002-3909-7255
priyan.s@sliit.lk, ORCID-0009-0000-4425-3382

Abstract:

This research addresses the lack of elder-friendly specifications in mid-rise residential buildings in Colombo, Sri Lanka, where nearly a quarter of the population will soon be over 60 (UN Population Statistics). With the over-65 demographic projected to rise from 9% in 2019 to 18% by 2050, there is an urgent need for age-friendly environments. The study proposes a comprehensive framework to assess elder-friendly accessibility (EFA) based on 110 design specifications across 21 key components. The methodology involves three phases: The first phase involves a qualitative systematic review to establish a foundation for evaluating elder-friendly accessibility (EFA), synthesizing literature to identify key design principles like safety, support, cognition, and well-being. The second phase formulates the assessment framework by reviewing international and local standards and localizing through expert consultation. A scoring criterion evaluates each specification's contribution to EFA. The third phase validates the framework through an expert opinion survey and in-depth case studies to test its applicability and accuracy. The outcome is an assessment framework that serves as a tool for promoting inclusive living environments, addresses urban infrastructure deficiencies, and provides guidelines for future development.

Towards Evidence Based Climate-Sensitive Urban Design

YiSong Liu, Mirko Guaralda Tan Yigitcanlar and Veronica Garcia-Hansen
Queensland University of Technology, Brisbane, Australia
yisong.liu@hdr.qut.edu.au, m.guaralda@qut.edu.au

Abstract:

Enhancing urban climates is essential for improving thermal comfort and reducing energy consumption in dense urban areas. Successfully integrating urban climate knowledge into architectural and urban design practices, however, remains a significant challenge. This paper tackles these issues by introducing an evidence-based framework for climate-sensitive urban design at the precinct level, aimed at enabling informed and effective interventions. The framework is developed through a structured, phased action research methodology that commences with an extensive review of how urban climate science is currently applied in practice. This is followed by firsthand insights from architectural and urban design practitioners, which guide the development of a parametric urban climate modelling framework. A parametric methodology using CFD simulations in platforms like Grasshopper is proposed, enabling iterative, scenario-based design testing to support practical, adaptable interventions. The framework is further refined through collaborative design and validated with empirical data.

Innovative Trombe wall technology applicable to north-facing facade for increase energy efficiency of public buildings

Seong Taek Kang[1], Jihee Nam[1], Ji Hun Park[1], Seong Jin Chang[2] and Sumin Kim[1]
[1]Building Environment and Materials Lab, Seoul, Republic of Korea
kst@yonsei.ac.kr, ORCID-0009-0000-4379-7839
namghee@yonsei.ac.kr, 0000-0003-1365-9616
jhp@yonsei.ac.kr, ORCID-0000-0001-6753-8890
kimsumin@yonsei.ac.kr, ORCID-0000-0003-2278-5278
[2] Green Building Lab, Jinju, Republic of Korea
sjc@gnu.ac.kr, ORCID-0000-0002-3499-7692

Abstract:

Urgent climate-change mitigation requires innovative technologies to enhance building energy efficiency and reduce carbon emissions. Buildings account for 35% of global energy use and 38% of greenhouse gas emissions, making advanced strategies essential. Trombe wall technology, typically used in buildings with optimal solar exposure, has significant potential but is underutilized in solar-limited conditions. This study evaluates the effectiveness of a designed Trombe wall in solar-limited buildings, focusing on a north-facing daycare centre in Incheon, South Korea, known for high heating energy consumption and emissions. Initial assessments showed heating energy use at 285.5 kWh/m². Simulations validated with actual building data demonstrated that a standard Trombe wall reduced heating energy to 143.6 kWh/m², while the designed system achieved 178.63 kWh/m², cutting emissions by up to 25%. By incorporating 3D printing technology and reflective panels, innovative Trombe wall enhances solar energy capture, offering a sustainable solution for energy-efficient building design in challenging environments.

Improvement of heat exchange efficiency of combined heat recovery ventilation system with phase change materials for external load reduction

Yongjun Choi, Jihee Nam, Yujin Kang, Sumin Kim
Building Environment and Materials Lab, Seoul, Republic of Korea
cyj_95@yonsei.ac.kr, 0009-0001-7060-7858
namghee@yonsei.ac.kr, 0000-0003-1365-9616
yujin.k@yonsei.ac.kr, ORCID-0000-0002-8093-6292
kimsumin@yonsei.ac.kr, ORCID-0000-0003-2278-5278

Abstract:

The International Energy Agency targets CO2 net-zero by 2060, aiming to reduce greenhouse gases by 75% through improved energy efficiency. According to the policies, Republic of Korea has enacted laws and strategies such as the 'Framework Act on Carbon Neutrality and Green Growth for Coping with Climate Crisis'. Considering hot and humid summer and high cooling energy use, improving heat exchange efficiency is considered very important. Combining phase change materials (PCM) to heat recovery ventilation systems can significantly improve efficiency. If the outdoor air is hot during summer, the combined module performs initial heat exchange to reduce the heat load on the system During hot summers, the PCM module initially exchanges heat to reduce the system's load, melting through high indoor air temperatures to aid in cooling. Tests showed that without PCM, indoor temperatures ranged from 24 to 37 °C, whereas with module, they ranged from 22 to 34 °C. This resulted in a maximum heat load reduction of 7 °C without PCM and 10 °C with module. Thus, the combined system effectively enhances energy efficiency by lowering the cooling load during hot weather, outperforming existing systems.

Recycling waste banners into eco-friendly insulation for sustainable building materials

Dongchan Jin, Ji Hun Park, Young Uk Kim and Sumin Kim

Building Environment and Materials Lab, Seoul, Republic of Korea
dinosour1024@yonsei.ac.kr, 0009-0009-7958-2616
jhpyuk92@yonsei.ac.kr, ORCID-0000-0001-6753-8890
yuk92@yonsei.ac.kr, ORCID-0000-0002-8969-1703
kimsumin@yonsei.ac.kr, ORCID-0000-0003-2278-5278

Abstract:

Increased carbon emissions from human activities cause environmental pollution and climate anomalies, threatening Earth and humanity. Many countries aim for carbon neutrality. Polyester-based banner materials contribute to pollution when discarded. In Republic of Korea, about 14,000 tonnes of waste banners were generated from 2018 to 2022, with a recycling rate of only 30%. This study develops insulation material for building interiors from shredded and compressed waste banners. The research aims to reduce greenhouse gas emissions and energy consumption for heating and cooling. Discarded plastic-based banners were shredded, processed into fibres, and compressed at 150 °C for 30 minutes to create 100 mm × 100 mm × 20 mm (width × length × height) specimens. Chemical structure analysis and thermal experiments were conducted. Fourier transform infrared spectroscopy compared the chemical structure before and after specimen production. Thermal analysis included measuring thermal conductivity and conducting a hot-box test. The thermal conductivity of the waste banner specimens was 0.04257 W/m·K at 20(±5) °C, notably low compared to previous studies. In the hot-box test using thermal imaging, the internal temperature rose to 26.1 °C, indicating superior performance. This study demonstrates the potential of repurposing waste banners into high-performance insulation materials, offering an environmentally friendly alternative.

Investigating the impact of emissivity of fully glazed facades on the outdoor thermal environment

Elham Sanagar Darbani, Ehsan Sharifi and Veronica Soebarto

University of Adelaide, Adelaide, Australia
Elham.Sanagardarbani@Adelaide.edu.au
Ehsan.Sharifi@Adelaide.edu.au,
Veronica.Soebarto@Adelaide.edu.au

Abstract:

Prior research on fully glazed facades and outdoor microclimates has predominantly concentrated on investigating the reflectance of the glazing. There is limited research on the influence of the emissivity of fully glass facades on outdoor heat conditions. This study seeks to examine the impact of emissivity of the inner and outer layers of double glass on the outdoor microclimate in an urban canyon, using a site at The University of Adelaide campus in South Australia, focusing on hot summer conditions. We employed the ENVI-Met software to model seven different scenarios to analyse the impact of varying the glass emissivity on two parameters: mean radiant temperature and air temperature, to gain a better understanding of how the emissivity of a double-glazing-layer façade affects the outdoor thermal environments. The findings show that decreased emissivity of a glass façade leads to a reduction in both mean radiant temperature and air temperature within open areas. The results also show that the ENVI-Met software's primary focus is on the outer layers of a glass material, specifically considering how emissivity affects the outdoor microclimate while failing to calculate the influence of inner layers of a double glass.

Engaging diverse stakeholders: Integrating wellbeing and sustainability in residential design and construction

Emma Morse[1], Janice Rieger[2], Penny Wild[1], Muge Belek Fialho Teixeira[1], Jill Franz[1]
[1] Queensland University of Technology, Brisbane, Australia
emma.morse@hdr.qut.edu.au, penny.wild@qut.edu.au, muge.teixeira@qut.edu.au, j.franz@qut.edu.au
[2] Griffith University, Brisbane, Australia
j.rieger@griffith.edu.au

Abstract:

In the context of housing shortages and environmental challenges, researchers and practitioners need to consider the impacts of residential building on both wellbeing and sustainability. The relationship between wellbeing and sustainability has been poorly articulated, with wide variation in understanding across fields. This disparity has implications for design and construction outcomes, including to what degree the environment or end-users are considered independently or in relation to each other. Successfully addressing housing targets requires a multidisciplinary approach, which is impeded by this lack of understanding between theory and practice, and across fields. Informed by an ongoing study, this paper takes a multiple perspective approach, using semi-structured interviews with stakeholders in the residential design and construction industry about their professional experience. Participants included architects, builders, and property developers. Using Interpretative Phenomenological Analysis (IPA), interviews were analysed to explore how different participants make sense of wellbeing and sustainability. Early results indicate key differences in practitioner values and concerns informing their priorities. This paper contributes an industry informed view of stakeholder perspectives to enhance understanding and effectiveness in multidisciplinary collaboration. It has relevance for achieving housing targets while addressing wellbeing and sustainability needs and engaging diverse stakeholders.

Sustainable acoustics: Sound absorptive mycelium composites in architecture

Brandon Martinez[1,2], Densil Cabrera[3] and Anastasia Globa[3]
[1] School of Architecture, Design and Planning, The University of Sydney, Sydney, Australia
[2] Renzo Tonin & Associates, Sydney, Australia
brandon.martinez@renzotonin.com.au, ORCID-0009-0006-4735-3817
[3] School of Architecture, Design and Planning, The University of Sydney, Sydney, Australia
densil.cabrera@sydney.edu.au, ORCID-0000-0003-2966-0371
anastasia.globa@sydney.edu.au, ORCID-0000-0002-4749-5675

Abstract:

In the field of architecture, materials employed to enhance acoustic quality often lack sustainable attributes, presenting a significant challenge for environmentally conscious design. The potential of mycelium-based composites for enhancing acoustic properties in construction remains inadequately explored as a sustainable alternative. The aim of this study is to investigate the sound absorptive characteristics of different types of mycelium-based composites grown using the Australian Reishi Mushroom. The base substrates used to grow the samples included a range of biomaterials including coffee grounds, coconut fibres, shredded paper, ironbark sawdust, and fine beechwood chips—with samples having a thickness ranging from 3.2 to 7 cm. Measurements were made using an impedance tube, yielding normal incidence sound absorption coefficient spectra. The study reports the results of acoustic testing, showing absorption coefficient values ranging from 0.8 to 0.9 at frequencies between 500 and 1000 Hz for the best-performing cases.

An investigation of occupant window opening behaviour in residential aged care facilities during winter in Adelaide, Australia

Ali Malekpour, Larissa Arakawa Martins, Terence Williamson, Dino Pisaniello, and Veronica Soebarto
The University of Adelaide, Adelaide, Australia

Abstract:

Australia's population aged 70 or over is expected to grow by 2 million in the next 20 years, increasing demand for residential aged care places. Poor indoor air quality can be particularly harmful to older adults in these facilities due to prolonged exposure to indoor air pollutants. Natural ventilation through windows can improve indoor air quality, but knowledge about occupants' window opening behaviour and preferences as well as the adequacy of ventilation in these facilities is lacking. This study presents the preliminary results of a research project that aims to understand occupants' window opening behaviour in residential aged care facilities in Adelaide, South Australia, with the objective of improving indoor air quality through natural ventilation. A subset of six participants from two facilities has been selected for preliminary analysis based on data from a two-months period during winter. Environmental parameters such as temperature, humidity, CO2, and PM2.5 concentrations, as well as window operation (open and closed status and opening ratio) have been monitored and recorded continuously during this period. Although residents' window-opening behaviours are highly individualized, the results revealed that they are influenced by the time of day, as well as indoor and outdoor temperatures. However, the window opening behaviours are a result of a complex interplay of environmental and non-environmental factors, requiring further investigations across various seasons and weather conditions.

Input for building energy modelling: Automatic 3D geometry model processing from UAV images

Mengfan Jin[1,2] and Marco Cimillo[1]
[1] Xi'an Jiaotong-Liverpool University, Suzhou, China
mengfan.jin19@xjtlu.edu.cn, 0009-0a002-8272-1735,
marco.cimillo@xjtlu.edu.cn, ORCID-0000-0002-6260-4470
[2] University of Liverpool, Liverpool, United Kingdom
m.jin2@ liverpool.ac.uk , 0009-0002-8272-1735

Abstract:

Urban Building Energy Modelling is crucial for analysing current performance, forecasting future scenarios, and optimising retrofit interventions. However, large-scale energy modelling is limited due to inconsistent data and labour-intensive workflows. To address these challenges, this study proposes a workflow for developing 3D geometric models of existing buildings using only photos captured by Unmanned Aerial Vehicles (UAVs), automating the process while ensuring precision at low cost. Photogrammetric technology processes the images to generate point clouds, Digital Surface Models (DSM), and Digital Terrain Models (DTM). ArcGIS Pro serves as the platform for building footprint generation and the parametrised 3D model. This interdisciplinary workflow is user-friendly and automated, enabling its use by building energy experts without advanced 3D modelling expertise in computer vision. A pilot study in a 1990s residential community proves the workflow's effectiveness compared to traditional modelling methods. This approach fills a critical gap in the rapid generation of 3D models for energy simulations, offering a reliable and scalable solution for urban energy assessments and retrofitting strategies.

A novel approach to investigate the impact of building features on occupant heating behaviours: A case study of dwellings of low socio-economic older people in South Australia

Shadi Jamialahmadi, Larissa Arakawa Martins, Terence Williamson and Veronica Soebarto

The University of Adelaide
shadi.jamialahmadi@adelaide.edu.au

Abstract:

Building features can affect heating and cooling use and related adaptive behaviours in people's living environments. This study aims to explore the impact of building features on older people's heating behaviours using an advanced predictive modelling technique. The proposed model is based on collected data of environmental parameters, building and occupant features, and occupant survey responses, from 25 dwellings in South Australia. The building features analysed include the dwellings' conditioned area, window orientation, envelope thermal properties, floor-to-ceiling height, and window-to-wall ratio. By using collected data as inputs, a CatBoost model was developed to predict heating status (on or off), as an indication of the occupants' winter thermal behaviour. The analysis indicates that the type of internal and external blinds, zone area, floor-to-ceiling height, main window orientation, window-to-wall ratio, existence of a recent renovation, month of the year, and hour of the day are the features that affect heating behavioural patterns. Additionally, energy cost concerns also have an impact on how often the occupants use heating. As the model reflects actual occupants' experiences, it is expected that the outcome can help designers and housing providers develop building designs that respond more accurately to the occupants' needs.

The thermal qualities of the living environments of older South Australians: An examination of two cohorts

Larissa Arakawa Martins[1], Terence Williamson[1], Dino Pisaniello[2], Renuka Visvanathan[3] and Veronica Soebarto[1]
[1] School of Architecture and Civil Engineering, The University of Adelaide, Australia
larissa.arakawamartins@adelaide.edu.au, terence.williamson@adelaide.edu.au, veronica.soebarto@adelaide.edu.au
[2] School of Public Health, The University of Adelaide, Australia
dino.pisaniello@adelaide.edu.au
[3] Adelaide Geriatrics Training and Research with Aged Care Centre
The University of Adelaide, Australia
renuka.visvanathan@adelaide.edu.au

Abstract:

Improving the thermal quality of people's homes can contribute to healthier environments as well as help minimize reliance on heating and cooling and potentially minimize energy poverty and economic vulnerability. Studies focusing on the thermal environment of older people's houses and its impacts, however, remain under-researched, especially in the Australian context. Furthermore, studies that investigate the thermal quality of the living environment of older people with lower socioeconomic status are also rare in the literature. This paper aims to better understand the thermal qualities of the living environment of older South Australians through the examination of the data collected from two 9-month indoor environmental monitoring studies: one based on 57 houses and 71 participants of higher socioeconomic status, living in relatively higher advantaged areas; and one comprising a cohort of 42 houses and 53 participants with low socioeconomic status, living in relatively disadvantaged areas. Statistical analysis showed, among other correlations, differences exist in thermal preferences and adaptive behaviours between the cohorts. House and participants' details were also found to be different between the two cohorts, which could affect overall thermal quality of environments. The study findings will be used to develop tailored design guidelines for the cohorts, to support healthier, thermally comfortable, energy efficient and resilient living environments for all.

Multicriteria framework for land use planning in watershed areas: Case of Matina river watershed, Davao City, Philippines

Marlon Suelto[1], Isidoro Malaque III[1] and Dennis Alonzo[2]
[1,]University of the Philippines Mindanao, Davao City, Philippines
mcsuelto1 up.edu.ph, 0009-0001-6700-612X
irmalaqueiii@up.edu.ph, ORCID-0000-0002-8757-5047
[2] University of New South Wales, Sydney, Australia
d.alonzo@unsw.edu.au, ORCID-0000-0001-8900-497X

Abstract:

The occurrences of landslide hazards risking the built environment were often neglected in the planning and design process. Eventually, failure to mitigate with proper interventions leads to unsuitable spatial qualities with inevitable high risk of natural and man-made landslide risks. This is evident in the case of Matina River Watershed in Davao City, Philippines, where urban developments within the watershed area are observed at risk of landslides. To enhance the quality of life, this paper aims to synthesize natural hazard maps by applying multiple criteria and analyzing data maps to produce a single landslide susceptibility map using the Analytical Hierarchy Process (AHP) and QGIS. Susceptibilities to landslides were modeled, and results present varying landslide susceptibilities that are mitigable within the watershed study area. The model showed that hazards are prevalent on the eastern border of the watershed traversed by a fault system with weak lithological units. Consequently, the western flanks of the watershed are the least susceptible to landslides, which are suitable for urban development. While vulnerabilities to landslide risks and disasters cannot easily be quantified, this paper concludes with a call for multicriteria analysis towards enhanced quality of life by the resilient built environment.

Bio-hygrothermal performance of clay masonry veneer wall systems in Southeast Australian residential buildings: A comparison from 6 star to 7 star with aeh 0.250, 0.375

Liqun Guan, Mark Dewsbury and Louise Wallis

University of Tasmania, Launceston, Australia
Liqun.guan@utas.edu.au, Mark.Dewsbury@utas.edu.au, Louise.Wallis@utas.edu.au

Abstract:

Abstract: Energy-efficient buildings are celebrated for their ability to reduce energy consumption. However, research has shown that these buildings can also foster indoor mould growth, which poses a risk to occupant health. This study investigates whether new homes built to 6 Star and 7 Star standards in the temperate and cool climates of southeastern mainland Australia are more prone to moisture accumulation and mould growth. We conducted robust hygrothermal and bio-hygrothermal transient simulations on low-rise timber-framed residential Clay Masonry Veneer external wall systems across eleven NatHERS climate zones with air exchange rates of 0.250 and 0.375. The objective was to identify risks and improve wall construction practices to achieve a mould index no greater than 3.0. This paper focusses on the results of the clay masonry veneer external wall system. Results indicated that 100% of AEH 0.250 scenarios had unacceptable mould index values for both 6- and 7-Star assemblages. Performance varied significantly with air change rate and climate type. Under AEH 0.375 scenarios of 7-Star, 18% of the mould index results were <3.0. These findings underscore the need for design and construction practices that exceed current code requirements. The study emphasizes the importance of co-developing energy efficiency and hygrothermal regulations, advocating for climate-sensitive approaches to mitigate condensation and mould risks, given the unique Australian climates, wall types, and occupant usage patterns. This research highlights the necessity for improved regulations and climate-specific strategies for various climates and ventilation scenarios.

An approach for comparing the embodied greenhouse gas emissions of HVAC systems for large volume buildings

Robert H. Crawford[1], Praddeep Gobinath[1] and Ken Thomson[2]
[1] The University of Melbourne, Parkville, Australia
rhcr, p.gobinath@unimelb.edu.au
[2] Fusion Modulair, West End, Australia
ken.thomson@fusionmodulair.com

Abstract:

The thermal comfort and indoor air quality requirements of buildings are met by means of heating, ventilation and air conditioning (HVAC) systems. Operating these systems contributes to a large proportion of the operational energy and greenhouse gas (GHG) emissions of buildings. As these systems require dedicated distribution and delivery systems (i.e., ducts and pipes) in addition to the HVAC equipment, the embodied GHG emissions of these systems can also be significant over the life of a building. Quantifying the embodied GHG emissions of HVAC systems is arduous and requires the quantification of the individual components and materials that make up these systems. There is a need for a streamlined approach to assess and compare the life cycle GHG emissions of HVAC systems based on detailed system characteristics to inform HVAC system choices. While standards such as TM65 provide guidance, an in-depth system-specific approach is lacking. This paper outlines the development of an approach for quantifying and comparing the embodied GHG emissions of HVAC systems, with a focus on large volume buildings. The approach is demonstrated by comparing the embodied GHG emissions of a ductless HVAC system to alternative systems such as air-cooled and water-cooled chilled water systems as well as rooftop packaged units. The approach estimates the heating and cooling loads to specify and size the components of the systems to be compared. Information about the sizing and quantities of the selected components are then used to calculate the embodied GHG emissions, using a hybrid life cycle inventory (LCI) approach. The study shows how a more in-depth analysis of the embodied GHG emissions of HVAC systems may better inform HVAC system design and specification aimed at reducing embodied GHG emissions.

A Psarran analysis: Architectural narratives in Taylor Swifts' artistic landscape

Siti Balkish Roslan

Xi'an Jiaotong-Liverpool University
Department of Architecture, Suzhou, China
sitibalkish.roslan@xjtlu.edu.cn

Abstract:

This study explores the nuanced relationship between architecture and narrative in Taylor Swift's artistic development, utilizing Sophia Psarra's theoretical perspective as a critical lens. It focuses on Swift's "Lover" music video and the song "The Last Great American Dynasty," illustrating how architectural elements actively engage in the narrative process of her works. Psarra's framework, which interprets architecture as a conduit for cultural and emotional narratives, is central to understanding Swift's strategic use of spatial elements as storytelling devices. These architectural features not only enrich her music and art but also layer it with cultural significance and emotional depth, thereby enhancing the narrative experience. Through a comprehensive visual and lyrical analysis, this paper highlights the dynamic interaction between architectural spaces and narrative in Swift's music. Applying Psarra's insights reveals the evolution of Swift's narrative techniques through architectural motifs, reflecting shifts in time and emotional narratives within her storytelling. This research contributes to the broader discourse on the role of architecture in artistic expression, emphasizing how spatial environments amplify narrative storytelling. By adopting Psarra's theoretical framework, the study offers insights into the intricate relationship between music, art, architecture, and cultural symbolism, affirming the vital influence of architectural narratives in contemporary artistic expression.

Addressing interdependencies between urban ecology and Urban Industrial Buildings (UIBs) in the context of climate change: A literature review

Marjan Rafiei, Paola Boarin and Alessandro Premier

Waipapa Taumata Rau University of Auckland, Auckland, New Zealand
marjan.rafiei@auckland.ac.nz, 0009-0006-5460-731X,
p.boarin@auckland.ac.nz, ORCID-0000-0003-3252-5699
alessandro.premier@auckland.ac.nz, ORCID-0000-0002-2565-9923

Abstract:

Urban industry zones are key drivers of economic activity but also major contributors to environmental degradation. Addressing the environmental impacts of Urban Industrial Buildings (UIBs), along with their vulnerabilities to climate change, is crucial for mitigating climate change effects on urban ecosystems while enhancing the resilience of these buildings. Regenerative sustainability offers a new approach to this challenge, aiming to reduce harm, restore and regenerate urban industry zones and buildings, turning them into catalysts for ecological and community well-being. This paper investigates the implementation of regenerative sustainability principles in UIBs by exploring their interdependencies with urban ecology. This paper uses a qualitative method, including a narrative literature review and analysis of internationally built regenerative UIBs to examine current approaches to achieving regenerative sustainability outcomes. Findings highlight that current research on Urban Industrial Buildings (UIBs) prioritizes pollution control and technical resilience, overlooking scalable regenerative approaches. International case studies like Copen Hill and LIKO-Vo reveal the potential of green infrastructure but show economic and adaptability challenges, underscoring the need for flexible, cost-effective regenerative frameworks .

The reliability and comparability of environmental product declarations in Australia

Robert H. Crawford and Monique Schmidt
The University of Melbourne, Parkville, Australia
rhcr@unimelb.edu.au, monique.schmidt@unimelb.edu.au

Abstract:

The need for organisations to enhance transparency and disclose the environmental impacts of their goods and services is growing. One approach for disclosing this information is through Environmental Product Declarations (EPDs). EPDs are typically produced by life cycle assessment consultants on behalf of product manufacturers, disclosing a range of environmental performance data associated with the manufacture of a product. Currently, there are over 130,000 EPDs published in nearly 50 countries. In Australasia, the EPD database contains close to 300 EPDs, covering over 4,000 products. Previous studies from other regions show major limitations with the reliability and comparability of EPDs, which can make comparison between products problematic. No such study has been conducted for Australasian EPDs, which is needed to ascertain whether this is also a major issue for this region. This study analysed 254 EPDs from the Australasian EPD database across all product categories, covering 2,667 declared products. Several factors affecting the reliability and comparability of EPDs were identified. Most EPDs rely on generic data rather than primary data, reducing their reliability. Additionally, all EPDs excluded capital goods and very few EPDs included impacts associated with the use stage of products. Most EPDs lack transparency regarding data inputs, data quality, and data sources, leading to an 'Adequate or Worse' rating for quality. A consistent, detailed template for compiling EPDs would help improve consistency, comparability, and transparency, and improve their usefulness for decision-makers.

Why don't we see more examples in Australia of sustainability retrofits initiated by apartment owners?

Denise Ryan

University of Melbourne, Melbourne, Australia
Denise.Ryan@student.unimelb.edu.au

Abstract:

Technical solutions to improve the sustainability and liveability of existing apartment blocks have been available for decades. Despite the potential benefits for residents, the clear imperative for retrofit to limit the climate impact of buildings and the significant number of apartment buildings in Australian cities, few examples exist of owners successfully undertaking ambitious sustainability retrofit projects of their multi-title buildings. There are a range of factors preventing strata committees achieving the same kinds of results from building retrofits as single-client projects such as those seen in public housing. These include the complexity of reaching agreement amongst owners, lack of knowledge and experience of committees and strata managers about sustainability options, insurance and finance constraints and government policies that exclude strata from subsidies available for other housing types. Additionally, guidance on the retrofit process is usually focused on commercial buildings, or if available for residential buildings it is targeted to a single owner. By summarising the issues associated with an apartment building retrofit, this research provides an insight for architects and other experts engaging in this work about the realities of apartment living and the complexity of managing common title property.

Good medium: Better maximum

Guy Marriage and Megan Scholtz
Victoria University, Wellington, New Zealand
guy.marriage@vuw.ac.nz, ORCID-0000-0002-9794-5451
megan.scholtz@vuw.ac.nz

Abstract:

The political and architectural landscapes in Aotearoa New Zealand have both had drastic revisions over the last decade. Once being a country with high home ownership and almost exclusively single storey housing on quarter-acre sections, New Zealand now has rapidly dropping home ownership rates, rapidly rising house prices and drastically shrinking section sizes. While the quarter-acre was once perceived as a harmonious solution, the Covid pandemic and subsequent significant unplanned immigration has significantly changed the long-term housing situation. The major cities are now all heading along a pathway of extensively densified housing solutions. This research examines the recent political changes at local and central government level that have permitted these changes to occur and illustrates the resulting changes that have occurred so far. The research methodology used is archival based, interpretive-historical research, utilising modern media sources as an information base. This paper investigates the drivers behind the ensuing residential medium density housing changes. The most important contribution this paper makes is to set out the background for an upcoming series of papers regarding affordability, housing sustainability and their link with political instability. Politicians claim that increasing density will put the country on the road to a sustainable, affordable future, asking the question, at what density level should NZ set its maximum?

Floating and stilt houses in Agusan Marsh, Philippines: Vernacular architecture and water urbanism in the 21st century

Isidoro R. Malaque III[1] and Rachel Mae P. Sitcharon[2]
[1] University of the Philippines Mindanao, Davao City, Philippines
irmalaqueiii@up.edu.ph, ORCID-0000-0002-8757-5047
[2] Provincial Government of Agusan del Sur, Prosperidad, Agusan del Sur, Philippines
rpsitcharon@gmail.com, 0009-0007-5785-2211

Abstract:

To further study vernacular and indigenous architecture as man-made environment complementing the dynamism of marsh ecosystem in the context of 21st century influences, this case study investigated the houses in La Flora, Talacogon, Agusan del Sur, Philippines. Other than the typologies of floating houses, stilt houses and houses combining stilt and floating technologies were also found in La Flora. In this area, floating houses are situated along the main Agusan river and in the tributary Mayat river. These houses can float all throughout the year, but during dry season, some are sitting on land near river banks. Stilt houses that is the most common type were constructed with stilt heights in accordance to the various water levels during annual flood recurrences. The third type are houses that will function as stilt houses during dry season but will float with the bamboo floaters inserted below the main floor during flooding. Shown in the use of building materials and design variations, the 21st century influences are reflected. Finally, with this century's issues and concerns on climate change adaptation and disaster risk reduction management, this study is hoped to inspire new insights towards sustainable development strategies for cities and other regions.

Examining sound insulation properties of bamboo-based composite material: A literature review

Mia Tedjosaputro[1], Solomon Evangel[1], Farkhondeh Vahdati[1] and Kiarash Amiri[2]
[1] Xi'an Jiaotong – Liverpool University, Suzhou, P.R. China
Mia.Tedjosaputro@xjtlu.edu.cn, ORCID-0000-0003-1328-3671,
0009-0003-2644-1330,ORCID-0000-0003-1355-0063
[2] Malek Ashtar University of Technology, Tehran, Iran, 0009-0007-1095-9193

Abstract:

This review examines the sound insulation properties of bamboo-based composites by analysing recent research findings. The main aim is to evaluate how effectively these materials reduce sound transmission and enhance acoustic comfort in building applications. While bamboo is widely used in construction, its acoustic properties are less explored than its structural and thermal attributes. This review paper focuses on composite bamboo panels, such as bamboo particle boards, laminated bamboo, and cross-laminated bamboo. The literature review includes studies from Science Direct, Scopus, and Web of Science published between 2014 and 2024. Comparisons with alternative sustainable materials are also included to enhance the review's contribution. The findings reveal that the acoustic performance of bamboo composites varies due to the natural properties of bamboo and the lack of standardized testing methods. Cross-laminated bamboo panels generally demonstrate superior insulation capabilities, attributed to their unique layering configuration, among the three types of composite bamboo panels. Key factors influencing performance, such as material composition, thickness, and layering technique, are critically analysed to provide insights for future research and applications. Additionally, this review proposes specific empirical research methods to address gaps in the current literature, such as standardized testing procedures for sound insulation evaluation.

Harmony, Vāstu architecture and contemporary living

Aparna Datey[1] and Anna Bonshek[2]
[1] Queensland University of Technology, Brisbane, Australia
aparna.datey@qut.edu.au,
[2] Maharishi Vedic Research Institute, Gold Coast, Australia
anna@maharishivedicreserach.org

Abstract:

The traditional Indian sciences, recorded in Vāstu Shāstra, are a holistic approach to design, construction, and training of architects. With a set of principles and guidelines rooted in Vedic knowledge and environmental criteria, it produces congenial settings for living and working, including increased creativity and workforce development, and enhanced harmony, stability, defence and well-being. The ancient system of architecture and city planning has influenced architecture and city planning globally. In Vāstu science the built structure is a symbol of the physical body and a microcosm of universal energy, defining a correlation between the individual and the cosmic, emphasising coherence with environmental criteria, both at the gross level dealing with climate, comfort, and sustainability, and at the subtle level with harmony and prosperity. Continuously practiced over the centuries by Sthāpatis (master architects) in India, and more recently since the 1990s, under the guidance of Maharishi Mahesh Yogi and leading Sthāpatis, there has been a holistic revival of Vāstu science notably active in the USA, Europe, Asia, and Australia. This paper discusses main principles and case studies, and recent research on Vāstu and its impacts through presenting case studies. It aims to increase awareness of this universally applicable system to validate its relevance for a broader audience.

Distant landscapes: Finding harmony in the work of Roberto Burle Marx

Susan J. Wake and Cesar Wagner
Unitec Institute of Technology, Auckland, New Zealand
swake@unitec.ac.nz, ORCID-0000-0002-1837-7581,
cwagner@unitec.ac.nz, ORCID-0000-0001-7212-916X

Abstract:

Roberto Burle Marx was a renowned Brazilian artist, gardener and landscape architect who perhaps came to greatest acclaim through painting with plants using modernist curves and mass planting of varied plant form, colour, and texture. His strong designs read like a 2D landscape tapestry when viewed from above and his fascination with landscapes and Brazilian native plants fuelled his many plant-hunting expeditions. Burle Marx (BM) promoted the use of native flora and was a passionate conservationist who worked with famous Brazilian architects to sculpt 3D gardens composed of careful arrangements of volumes and shapes that surrounded and complemented their modernist buildings. This paper proposes that he was influenced by the anthropophagic movement that emerged in early 1920s São Paulo, which represented consumption or 'cannibalisation' of existing cultures, ideas, and beliefs and their subsequent transformation into something that reflected Latin American civilisation and its sense of identity. A rich fusion that is uniquely Brazilian resulted - embracing European, indigenous, and black African heritage. The movement influenced art, music, religion, design, and architecture. We present the case that BM infused his garden-making with an anthropophagic approach which influenced his conservation and use of native Brazilian plants. Further, we argue that this has created more harmonious outcomes and is part of the enduring regard for BM both within Brazil and internationally.

Sleep in intensive care units: the impact of light interventions

Iza K. Linders[1], Veronica Garcia-Hansen[1], Francisca Rodriguez[1] and Oystein Tronstad[2]
[1] School of Architecture and Built Environment, Faculty of Engineering,
Queensland University of Technology, Brisbane, Australia
izakaren.linders@hdr.qut.edu.au, 0009-0002-3896-6452
v.garciahansen@qut.edu.au, ORCID-0000-0001-5934-5554
f3.rodriguez@qut.edu.au, ORCID-0000-0001-9177-1991
[2] Critical Care Research Group, The Prince Charles Hospital, Brisbane, Australia
oystein.tronstad@health.qld.gov.au, ORCID-0000-0001-7751-3267

Abstract:

The lighting in intensive care units (ICU) is commonly suboptimal, with low levels of natural light, excessive artificial lighting at night, and insufficient support for circadian rhythm synchronisation. Consequently, critically ill patients encounter disrupted sleep and circadian dysrhythmia, which hampers recovery and contributes to various health complications during and after admission. Given the demonstrated link between sleep deprivation and adverse patient outcomes, as well as prolonged hospital stays and increased hospitalisation costs, prioritising effective interventions to optimise sleep in ICUs is crucial. Recent research endeavours have shifted towards exploring dynamic light interventions as a potential direction for addressing these issues; however, significant gaps in the literature still exist. This paper aims to bridge the present knowledge and research agendas between academic/lighting researchers and clinical researchers and highlight gaps in the literature regarding ICU lighting and its impact on sleep. Based on a comprehensive analysis of current research, this narrative synthesis identifies key areas for future investigation into effective ICU lighting strategies.

Considering embodied environmental flows in the building design process

Fabian Prideaux[1], Robert H. Crawford[1], André Stephan[1] and Karen Allacker[2]
[1] The University of Melbourne, Melbourne, Australia
fprideaux@unimelb.edu.au, ORCID-0000-0002-4959-3615
rhcr@unimelb.edu.au, ORCID-0000-0002-0189-3221
Andre.Stephan@unimelb.edu.au, ORCID-0000-0001-9538-3830
[2] KU Leuven, Leuven, Belgium
karen.allacker@kuleuven.be

Abstract:

The building sector requires extensive transformative changes to rapidly reduce the embodied environmental effects associated with buildings. Building designers are pivotal actors in this transformation, as decisions made during the design process can significantly influence environmental outcomes. Currently, decision-making is predominately guided by rules of thumb, professional experience, or ad hoc assessments, rather than being informed by best practice techniques such as life cycle assessment (LCA). When LCA is employed, it is typically outsourced to experts late in the design process, rather than being used to incrementally inform design decisions. The building design process is inherently complex and poorly documented, making it difficult to theorise how this integration could be achieved. This research introduces a process mapping technique to investigate how embodied environmental assessments may be integrated into design workflows. Participatory workshops are conducted with design practitioners, based on a residential case study project in Australia. The finalised process map illustrates the complexities of the design process, highlighting immediate challenges faced by practitioners, including tight timeframes, limited engagement in early stages, and challenges integrating and interpreting results from LCA tools. Findings explore how process mapping can be used to successfully document complex design workflows, providing much needed insight for researchers.

Sustaining the future by using university campuses as material and greenhouse gas emissions banks

André Stephan, James Helal, Robert H. Crawford, and Katie Skillington
The University of Melbourne, Melbourne, Australia
Andre.Stephan@unimelb.edu.au, ORCID-0000-0001-9538-3830
James.Helal@unimelb.edu.au, ORCID-0000000282111454
rhcr@unimelb.edu.au, ORCID-0000-0002-0189-3221
Katie.Skillington@unimelb.edu.au, ORCID-0000-0002-1769-4462

Abstract:

We need to change the way we conceptualise, plan, design, construct, operate, maintain, and discard buildings if we are to address the significant environmental effects of the built environment. As such, understanding material stocks and flows in existing built stocks as well as their associated embodied greenhouse gas emissions is a critical step. University campuses can play an important role in this regard by acting as living labs and providing data and information for teaching and learning, research and campus management. This paper explores how an atlas of materials and greenhouse gas emissions can be developed for a university campus, using the Parkville campus of the University of Melbourne as a mock-up example. Results show that such atlases can be developed with existing data and could provide significant scope for teaching and learning activities across multiple disciplines, research, notably in terms of validating current models to estimate material quantities and campus management, to understand the embodied greenhouse gas emissions cost of demolition and better circulate materials. Future research includes developing such an atlas, ideally for multiple campuses and universities, and scaling this effort to entire cities. Equipped with such knowledge and tools, actors of the built environment will be able to make significant reductions to the environmental effects of buildings, helping humanity reach a safe operating space, within planetary boundaries.

Embodied greenhouse gas emissions of the Fusion Modulair VPAC system

Robert H. Crawford[1], Kristian Gjoka[1] and Ken Thomson[2]
[1] The University of Melbourne, Parkville, Australia
rhcr, k.gjoka@unimelb.edu.au
[2] Fusion Modulair, West End, Australia
ken.thomson@fusionmodulair.com

Abstract:

Heating, ventilation, and air conditioning systems for large volume spaces, such as retail, wholesale, temperature-controlled storage, or large sporting venues are typically characterised by long, inefficient duct runs, fixed angle air distribution, uneven air coverage, hot and cold spots, and draughts or air stagnation. The Modulair system developed by Fusion contains a roof-mounted VPAC (Vertical Package Air Conditioner) module with a motorised swirl diffuser. The system provides draught-free, variable discharge direction (VDD) air distribution for large volume spaces. While it has been shown to reduce operational energy demand compared to traditional HVAC systems, by reducing system components and installation time, there has been no assessment of the embodied greenhouse gas (GHG) emissions of the system. This study assesses the embodied GHG emissions of the Modulair system over a period of 50 years to gain an understanding of the significance of its embodied GHG emissions and areas for potential reduction. Embodied GHG emissions were quantified using manufacturer-specific data, product-specific Environmental Product Declarations, and hybrid embodied GHG emissions coefficients. The product stage GHG emissions were found to account for the highest proportion of embodied GHG emissions, with metal materials accounting for up to 87% of these. Replacement of filters accounts for the largest share of use stage GHG emissions. This study provides insight into the embodied GHG emissions of the Modulair system and provides useful data for comparing its performance to alternative HVAC systems, helping to inform HVAC selection that lowers a building's whole of life GHG emissions.

Understanding the Differences in LCA Tools for Building Environmental Impact Assessment: A Comparative Analysis of New Zealand House Case Study

Huixin Peng, Emina Kristina Petrović

Victoria University of Wellington, Wellington, New Zealand
penghuix@myvuw.ac.nz, ORCID-0009-0001-4738-7957
emina.petrovic@myvuw.ac.nz, ORCID-0000-0003-3446-093X

Abstract:

At the time when carbon assessments are entering built environment professions, Life Cycle Assessment (LCA) has emerged as an important method for evaluating environmental impacts throughout a building's lifecycle. Despite its potential, LCA faces significant challenges, including but not limited to variations in goal and scope definitions, discrepancies in databases and assessment methodologies, and inconsistencies in regional data integration and so on. These challenges can lead to considerable uncertainties in LCA outcomes, limiting its broader application. In response, this study critically evaluates and compares three LCA tools by applying them to a case study of a typical New Zealand single-detached house. The research first conducts a literature review to identify key challenges in LCA tools development and implementation. Subsequently, the study applies selected LCA tools to assess the carbon emissions of the chosen building. The results are analysed to understand the differences and the factors driving these variations. The study aims to contribute to the standardisation and improvement of LCA practices and offer recommendations for achieving more accurate and consistent assessments.

A theoretical framework for development of virtual environments to aid contextual architecture

Raziyeh Teimouri, Soroush Masoumzadeh Sayyar, Rongrong Yu, and Ning Gu
UniSA Creative, University of South Australia, Adelaide, Australia
Raziyeh.teimouri@mymail.unisa.edu.au, soroush.masoumzadeh@mymail.unisa.edu.au
Rongrong.Yu@unisa.edu.au, Ning.Gu@unisa.edu.au

Abstract:

The main goal of this study is putting forward a theoretical conceptual framework that aims to better support the integration of virtual reality tools into the contextual architectural design process. This paper seeks to develop a framework to enhance the creation of various virtual environments in accordance with different levels of virtual environment fidelity, in a way that facilitates and empowers contextual architectural tasks. Via a literature review focus and also with consideration toward different spectrums of abstraction in architectural virtual reality modelling, we have developed a spectrum of different approaches which can be utilised for virtual environment development at varying levels of fidelity. Those approaches can support contextual architecture in diverse ways to accommodate the aims and scales of the projects.

Multimodal Perception-Driven Safety Analysis for Urban Street

Xuan Zhang[1,2], Shuyang Li[2,3], Yining Zhang[1], Tianning Yao[5], Haoying Han[1,4], Liang Sun[5], Rudi Stouffs[3]

[1] Zhejiang University, Hangzhou, China
zhang_xuan@zju.edu.cn, zhangyining@zju.edu.cn

[2] Singapore-ETH Centre, Singapore, Singapore
shuyang.li@sec.ethz.ch

[3] National University of Singapore, Singapore, Singapore
shuyangli@u.nus.edu, stouffs@nus.edu.sg

[4] City University of Macau, Macau, China
hanhaoying@gmail.com

[5] China University of Mining and Technology, Xuzhou, China
tianning_yao@cumt.edu.cn, sunliang@cumt.edu.cn

Abstract:

The evaluation of urban streets provides valuable insights and design references for decision-makers and stakeholders. While previous studies have focused on human perceptions of street view images primarily using questionnaires, the underlying mechanisms of design elements and perceived safety behind these evaluations remain insufficiently understood. In this study, we utilize eye-tracking data, facial expressions, verbal descriptions, and scoring questionnaires to gain a deeper understanding of how people perceive safety for different types of urban streets. We explore the relationships between these multimodal data and human perceptions, both individually and collectively. This multimodal analysis framework allows for a more transparent investigation of how urban street features influence human perceptions, moving away from the ambiguous "black box" approach. Additionally, this research offers an interpretable evaluation of urban streets in Shanghai, helping decision-makers gain a more comprehensive understanding of public needs and fostering the optimization and renewal of urban streets.

Verticality, density and porosity equilibrium for yielding desirable microclimatic conditions

Ruffina Thilakaratne[1], Jason Tse[2]
[1]Hong Kong Chu Hai College, Tuen Mun, Hong Kong
[2]Buro Happold Burohappold International (Hong Kong) Ltd
ruffinaat@chuhai.edu.hk, Jason.Tse@BuroHappold.com[2]

Abstract:

High density cities face critical challenges when the global population reaches 9.7 billion by 2050 demanding twice the building stock and related amenities. High-rise high-density has become the norm for cities with limited land resources. Hong Kong reports the lowest open space per capita among other Asian metropolitan cities and residential towers above 200m with nano flats as small as 11sqm is a fast-growing trend. Lack of urban porosity, low wind velocities, lack of urban greenery, Urban Heat Island (UHI) effect and poor air quality have led to public health concerns. Due to limited land area, creating urban porosity on the ground plane is challenging. This paper investigates development typologies to increase urban porosity along the vertical plane and facilitate desirable microclimate conditions for users to enjoy elevated landscapes. Six typologies were tested for their wind performance, shadow analysis, daylight levels and solar radiation / UTCI. This study examines the impact of different building typologies on wind flow and thermal comfort within a residential development in Hong Kong. Results show that Option 4, which incorporates tower voids and elevated podium gaps, achieved the highest wind performance with an average speed of 2.38 m/s, significantly improving ground-level ventilation due to downdraught effects. In contrast, Option 1 exhibited poor wind performance due to its solid massing. While shading improved the microclimate, elevated daylight exposure and excessive hardscape led to heat stress, underscoring the need for additional shading and greenery to enhance comfort.

Barriers and Opportunities in Online Delivery of Architecture and Building Design Studios: Australian Educators' Perspectives

Neda Abbasi, Ergun Gide and Peter Lawrence
Central Queensland University, Australia
n.abbasi@cqu.edu.au
e.gide1@cqu.edu.au
p.lawrence1@cqu.edu.au

Abstract:

Online delivery of design studios, which rely heavily on creativity, communication, and interaction, is challenging. The authors' earlier study of Central Queensland University students' comments in Unit Evaluation Surveys of two Bachelor of Building Design units between 2012 and 2017 revealed factors that influence students' experiences of online design studios. One of the five themes identified was "teacher support and teaching strategies." This paper presents the study that further examined design educators' role in online delivery of design studios. A survey was developed and administered in 2018 with open-ended questions about educators' views on online design studios and their experiences with this mode of delivery. The 17 design educators from Australian higher education institutions who completed the survey shared their views on key attributes of the design studio as a physical space, teaching strategies to develop design skills, and whether a design studio unit can be delivered completely online. Among the barriers in online design studio delivery identified from a thematic analysis of the educators' comments were communication issues, limited peer interactions, and difficulty in providing effective feedback on students' creative design work. Based on these findings, several recommendations are made to enhance delivery of existing online design studios.

Designing climate-responsive built and living environments: perceptions of barriers and facilitators among design practitioners

Sareh Moosavi, Anna Hürlimann, Georgia Warren-Myers, Judy Bush and Alan March

Faculty of Architecture, Building and Planning, University of Melbourne, Parkville, Australia
sareh.moosavi, hurac, g.warrenmyers, judy.bush, alanpm@unimelb.edu.au

Abstract:

The paradox of climate change is that it is both a human-designed problem, and likely humanity's greatest design challenge. Architects, landscape architects, and urban designers are among the key actors responsible for designing and shaping the built and living environments. Despite an increasing climate change awareness among Australian design practitioners, actions taken across different scales and practices are not sufficiently transformative to adequately address the problem of climate change. Understanding more about the barriers faced by design professionals could help to identify opportunities for action and facilitate more effective responses. This study takes an empirical approach to identify key barriers and facilitators for climate actions among Australian architects, landscape architects and urban designers. We interviewed 67 design practitioners from across these three disciplines. The results demonstrate that perceived lack of agency and influence is a common barrier when it comes to convincing clients, politicians and the general public. The synthesis of data revealed several common facilitators, including transforming design processes to be more circular, interdisciplinary and long-term focused, reforming current built environment policies, greater interdisciplinary collaboration and involvement in projects from early stages of strategic planning, and individual and collective climate advocacy that goes beyond single projects, disciplines or interests.

The Effect of Indoor Temperature and Task Complexity on the Cognitive Performance of Office Workers

Sadia Israt Anam and Fan Zhang

Griffith University, Gold Coast, Australia
sadia.anam@griffithuni.edu.au, fan.zhang@griffith.edu.au
ORCID-0000-0002-8331-9484, ORCID-0000-0002-3031-8218

Abstract:

This study investigates the impact of indoor temperatures and task complexity on the cognitive performance of office workers. Controlled laboratory experiments were conducted with temperatures set at 22°C, 25°C, 28°C, and 31°C in a climate chamber. Sixteen participants completed a series of cognitive performance tests with two different levels of complexity to evaluate their memory and math processing, executive function, strategy and planning, reasoning, decision-making, and motor skills. The results revealed that temperature variations within the tested range had minimal effects on cognitive performance, supporting the extended-U hypothesis. Task complexity was a more significant predictor of cognitive performance than indoor temperature under these conditions, despite the minor cognitive performance differences between easy and difficult levels. The interaction between temperature and task difficulty was non-significant across tasks, which suggests that while task complexity strongly influences cognitive performance, temperature did not significantly alter this relationship. This study uncovers how different task types with varying complexity levels affect the relationship between thermal environments and productivity, providing a foundation for more tailored environmental recommendations for optimizing cognitive performance in office settings.

Unveiling the design faults of green roofs as novel urban green spaces for enhanced thermal comfort: Lessons from Melbourne

Andrea Pianella, Pui Kwan Cheung, Christopher A. Jensen and Stephen J. Livesley
The University of Melbourne, Parkville VIC, Australia
andrea.pianella@unimelb.edu.au, cheung.p@unimelb.edu.au
cjensen@unimelb.edu.au, sjlive@unimelb.edu.au

Abstract:

Urban green spaces can enhance human thermal comfort in densely populated cities but creating them at ground level is challenging due to limited land availability. Green roofs offer a promising alternative, and this study examines their effectiveness in providing thermal comfort in summer by focusing on the Sky Park green roof in Melbourne's CBD. Over a month in the summer of 2022, microclimate data from the Sky Park green roof were compared to a nearby paved plaza control site. Surprisingly, the results showed minimal differences in temperature between the two sites, indicating limited thermal comfort benefit from the green roof. The Universal Thermal Climate Index revealed that during opening hours from 8:00 to 18:00, the Sky Park experienced temperatures >32°C (strong heat stress) for 27.8% of recorded hours, compared to 22.3% at the control site. The reduced thermal comfort was attributed to a) the Plexiglas barrier around the Sky Park that hindered ventilation and b) reflective surfaces of nearby buildings that increased radiant heat. The study underscores the impact of adequate site ventilation and surrounding infrastructure on the thermal comfort of urban green spaces on hot summer days and the importance of integrated urban planning to create thermally comfortable environments.

From rooftops to ecosystems: Understanding the life cycle embodied GHG emissions of green roofs in Melbourne

Andrea Pianella, Megan Loffler and Robert H. Crawford
The University of Melbourne, Parkville VIC, Australia
andrea.pianella@unimelb.edu.au, m.loffler@unimelb.edu.au, rhcr@unimelb.edu.au

Abstract:

Green roofs are becoming increasingly popular in urban areas worldwide, including Australia, due to their benefits, such as reducing stormwater runoff, improving energy efficiency, and enhancing biodiversity. However, the environmental impact of constructing and maintaining green roofs, particularly their life cycle greenhouse gas (GHG) emissions, remains underexplored. This study uses a hybrid life cycle assessment (LCA) and the EPiC database to analyze the embodied GHG emissions of green roofs in Melbourne, Australia and compare with overseas studies. Conventional roofs in Melbourne showed average annual life cycle GHG emissions of 2.54 kgCO2-eq per m² for concrete and 1.63 kgCO2-eq per m² for timber roofs, aligning with international data. In contrast, extensive green roofs with 120 mm substrate emitted 3.84 kgCO2-eq per m² annually, and intensive green roofs with 450 mm substrate emitted 9.19 kgCO2-eq per m². While green roofs exhibit higher embodied GHG emissions, their insulation properties reduce the need for bulk insulation materials. This research underscores the need for optimizing materials and construction practices in green roof assemblies to lower their overall environmental impact. Despite their higher emissions, green roofs remain a promising sustainable solution, but further research is required to explore their operational energy savings over a building's lifetime.

Viral architecture or the unintentional architecture criticism of social media

Ines Consuela Essen
Xi'an Jiaotong-Liverpool University, Suzhou, China
ines.essen@xjtlu.edu.cn

Abstract:

In the digital landscape of social media, a phenomenon has emerged that challenges traditional architectural discourse – the unintentional architecture criticism fostered by photography, algorithms, and influencer culture. This paper delves into the concept of "viral architecture," exploring how platforms like Instagram have become inadvertent spaces for architectural critique and celebration. Photography, long revered as a medium for capturing and disseminating architectural narratives, has taken on a new dimension in the social media realm. Through carefully curated visuals, users engage in an implicit form of architectural criticism, highlighting or critiquing various aspects of the built environment. This discourse is amplified by algorithms that govern content distribution, favouring visually striking and engaging posts related to architecture. The rise of influencer culture has played a pivotal role in shaping this unintentional architectural criticism. Influencers, with their substantial followings and cultural capital, wield the power to shape public perception and discourse around architecture. Their meticulously crafted posts, often showcasing specific architectural elements or spaces, can propel certain structures into viral fame, simultaneously celebrating or criticizing their design. This paper examines the dichotomy between "Instagram architecture" – structures designed with social media share ability in mind – and the representation of traditional architecture on these platforms. It explores the implications of this phenomenon, shedding light on how social media has democratized architectural criticism, blurring the lines between professional and public discourse. By analysing the interplay of photography, algorithms, and influencer culture, this study unravels the unintentional yet profound impact of social media on architectural criticism. It prompts a critical examination of the role of digital spaces in shaping perceptions of the built environment and raises thought-provoking questions about the future of architectural discourse in an increasingly digitized world.

A policy and roadmap review for building sector decarbonisation – insights from Australia and New Zealand

Dilshi Dharmarathna, Peter Graham and Victor Bunster

Monash University, Melbourne, Australia
Dilshi.Dharmarathna@monash.edu, Peter.Graham@monash.edu, Victor.Bunster@monash.edu

Abstract:

The building and construction industry contributes to 37% of global annual greenhouse gas (GHG) emissions. In comparison to year 2020, global building operations related carbon emissions showed an increment of 5%. In 2015, the Paris Agreement was put in action, with global leaders pledging to limit global temperature increase below 1.5°C. To achieve these set targets, countries have established Nationally Determined Contributions (NDCs), Net Zero Carbon (NZC) targets, pathways and roadmaps towards building sector decarbonisation. However, while some countries are in the forefront, making significant progress, the others are lagging. Australia's Climate Change Act aims to reduce net GHG emissions to 43% below 2005 levels by year 2023, and to zero by 2050. New Zealand has committed to NZC emissions by 2050, through the Climate Change Response Amendment Act in 2019. Formulation of successful building sector decarbonization targets and pathways are context dependent due to varying climatic, economic, cultural and regulatory aspects. This study evaluates, compares and summarizes the decarbonization targets, roadmaps, policies, practices and initiatives in Australia and New Zealand. It presents an understanding of the building sector decarbonization status of Australia and New Zealand, while providing implications for research, practice and society towards achieving building sector decarbonization.

Evaluation of ventilation options for an urban childcare centre

Sanuj Bandara[1] and Mary Myla Andamon[2]
[1] SEED Engineers, St Lucia, Queensland, Australia
sanuj@seedengineers.com
[2] RMIT University, Melbourne, Victoria, Australia
mary.andamon@rmit.edu.au, ORCID-0000-0003-2979-277X

Abstract:

Thermal environments and ventilation are key considerations in the design of schools and childcare centres with children particularly sensitive and especially vulnerable to environmental contaminant exposures. Studies show that school environments generally exhibit issues of overheating, poor indoor air quality and inadequate outdoor air ventilation, attributed primarily to ineffective ventilation and air conditioning systems. This paper is a proof-of-concept evaluation of three (3) ventilation options – natural ventilation, mixed mode and mechanical ventilation for a proposed childcare centre using building simulations and assessed the effects on thermal comfort, indoor air quality and energy consumption. Simulation results indicate all three ventilation strategies achieved acceptable thermal comfort and mechanical ventilation as most effective with a median PMV of -1.0 in summer. Natural ventilation was shown to be superior in maintaining indoor air quality, with maximum CO2 concentration levels ranging 640-678 ppm. Even though mixed mode ventilation achieved optimal energy performance with the lowest cooling energy consumption, it required refinements to improve indoor air quality and thermal comfort performance. The findings will inform the development of guidelines on ventilation and air conditioning strategies in childcare centre designs for improved thermal comfort, optimal indoor air quality and energy efficiency.

Assessing the cooling effect of novel photonic meta-concrete on buildings with and without thermal insulation

Nick Adams, Delphine Ramon, Roxanne Stroobants and Karen Allacker
Faculty of Engineering Science, Department of Architecture,
KU Leuven, Kasteelpark Arenberg 1, box 2431, 3001, Louvain, Belgium
nick.adams@kuleuven.be, ORCID-0000-0003-4693-0070

Abstract:

With 70% of the population in urban areas by 2050, the urban heat island effect will intensify, raising city temperatures and cooling demands. This study evaluates the cooling effect of a novel photonic meta-concrete, integrated in roof finishing, through EnergyPlus simulations for both non-insulated and insulated buildings. The analysis focuses on indoor and outdoor temperatures as well as net energy demands for heating and cooling. Using weather data from Madrid and Brussels, the simulations reveal that including photonic meta-concrete significantly reduces outdoor roof surface temperatures for both cities, with a smaller effect for Brussels due to a lower ambient temperature and radiation intensity. Indoor temperature reductions are also notable, with decreases of 9.4°C in summer for Madrid. However, the effectiveness of photonic meta-concrete reduces when thermal insulation is present, showing indoor temperature reductions of less than 1°C. The energy savings hence show that implementing the photonic meta-concrete on an uninsulated roof leads to bigger energy savings for cooling compared to an insulated roof. However the energy penalty due to the winter thermal losses on both locations is substantial and leads to an increase in greenhouse gas emissions when the cooling material is applied in climates with a substantial heating demand.

Designing in Different Realities: How Virtual Environment Fidelity Influences Design Thinking—Insights from Pilot Studies

Soroush Masoumzadeh[1], Rongrong Yu[1], Ning Gu[1], Ina Bornkessel-Schlesewsky[1], Jimmy Cao[1] and Fan Zhang[2]
[1] University of South Australia, Adelaide, Australia
soroush.masoumzadeh@mymail.unisa.edu.au, rongrong.yu@unisa.edu.au,
ning.gu@unisa.edu.au, Ina.Bornkessel-Schlesewsky@unisa.edu.au, jimmy.cao@unisa.edu.au
[2] Griffith University, Gold coast, Australia
Fan.zhang@griffith.edu.au

Abstract:

Though Virtual Reality (VR) is increasingly integrated into architectural design, there are nuances that require further exploration before it can be fully embraced in practice. This study explores how different levels of fidelity (LoF) in VR environments influence design thinking, focusing on the timing and frequency of Function (F), Behaviour (Be, Bs), Structure (S), and Context (C) codes using protocol analysis. Expert designers engaged in architectural concept design tasks within both High-Fidelity and Low-Fidelity Environments (HFEs and LFEs). Findings suggest that LFE displays a higher density of transitions early in the design process, indicating rapid idea exploration; potentially linked to creativity. In contrast, HFE shows a steadier rate, overtaking LFE later in transition density, suggesting deeper engagement. Analyses also suggest that HFE tasks encourage early contextual integration, whereas LFE tasks allow flexibility in engaging with context. These results highlight VR environment fidelity's impact on design processes, with LFEs supporting broader conceptual exploration and HFEs enhancing contextual integration. If the findings of this paper are generalisable, they could contribute to the development of Virtual Environments (VE) that foster and enhance the design process.

Harmony in the House: Qajar Architecture through a comparative case study of six houses

Azin Ehteshami
Deakin University, Geelong, VIC, Australia
a.ehteshami@deakin.edu.au

Abstract:

This study delves into the architectural styles of Qajar houses in Esfahan, Iran, a city known for its remarkable collection of these historic homes. The research aims to uncover how these houses represent a harmonious blend of architectural design, environmental adaptability, and cultural significance. By examining and analysing six specific case studies, the research seeks to reveal the underlying design principles and influences that have shaped these houses, considering cultural, historical, and geographical factors. The study utilises both fieldwork and desk research, involving the collection of drawings, photographs, historical texts, and other relevant resources. The analysis of the architectural styles will be organised into four distinct categories to provide a comprehensive understanding of their features and development.

Decoding Office Satisfaction: What Drives Positive and Negative Experiences for Occupants

Maryam Khoshbakht[1], Eziaku Rasheed[2] and George Baird[3]
[1] Griffith University, Brisbane, Australia
m.kh@griffithuni.edu.au
[2] Massey University, Auckland, New Zealand
e.o.rasheed@massey.ac.nz
[3] Victoria University of Wellington, Wellington, New Zealand
george.baird@vuw.ac.nz

Abstract:

Insights from office building users can drive improvements in existing structures and influence the design of future ones. This study analysed post-occupancy feedback from 68 office buildings to identify key factors affecting occupant satisfaction and dissatisfaction. It was found that operational elements, including furniture, building image, and meeting occupant needs, were more highly rated, with satisfaction scores of 74%, 73%, and 70%, respectively. In comparison, environmental factors like lighting scored lower, with a satisfaction rating of 68%. The study also highlighted that dissatisfaction was primarily associated with inadequate storage, noise, and discomfort due to high summer temperatures, with scores of 33%, 33%, and 32%, respectively. Notably, buildings with fewer reported complaints often showed lower satisfaction across various factors, indicating a possible correlation between the lack of complaints and overall satisfaction. Furthermore, clusters with documented complaints, especially those with larger work groups, reported the lowest satisfaction levels regarding noise. This suggests a link between building-related complaints and heightened dissatisfaction with noise, raising concerns about noise sources and the effectiveness of existing control measures.

Leveraging AI and AR to Revitalise Suzhou's Canals: Enhancing Sustainable Cultural Heritage Awareness via Participatory Workshops

MinJoo Baek

Xi'an Jiaotong-Liverpool University, Suzhou, China
Minjoo.baek@xjtlu.edu.cn, ORCID-0000-0002-7652-2302

Abstract:

This research aims to reutilise Suzhou's historic water canals while promoting sustainable community engagement through innovative methods. By integrating heritage studies and design, the study explores the relationship between cultural heritage and community well-being. It focuses on revitalising the waterways, rediscovering regional cultures, and enhancing community well-being through the canals' cultural and historical significance. The research emphasises the reuse of historical water infrastructure to improve waterfront activity, social engagement, and placemaking. Central to the study are participatory workshops, such as the "Flow with Me" series, which involve community members in crafts and storytelling, culminating in public art exhibitions. These workshops leverage advanced digital technologies, including AI and AR, to create interactive and immersive experiences. AR technology in exhibitions offers dynamic presentations, while AI-generated visuals and digital storytelling make heritage accessible to a broader audience. The findings highlight the positive impact of heritage-based interventions on community well-being, emphasising the role of art, design, and digital technologies in fostering community and belonging. The study advocates for a comprehensive approach to heritage preservation involving residents, academics, students, and experts, demonstrating the potential of community-centred initiatives in enhancing social sustainability.

An evaluation of methods to determine the water vapour diffusion resistivity properties of solid-wood plantation timber commonly used in construction

Zahraa Al-Shammaa[1], Mark Dewsbury[1], Louise. Wallis[1] and Hartwig Künzel[2]
[1] University of Tasmania, Launceston, Australia
zahraa.al-shammaa utas.edu.au, ORCID-0009-0000-9911-7425
mark.dewsbury utas.edu.au, ORCID-0000-0002-3607-3637
louise.wallis@utas.edu.au, ORCID-0000-0001-6611-8376
[2] Fraunhofer Institute for Building Physics IBP, Germany
hartwig.kuenzel@ibp.fraunhofer.de, ORCID-0000-0001-8305-0262

Abstract:

Understanding the water vapour diffusion resistivity properties of elements used in the external envelope of buildings is a key input for transient hygrothermal analysis of energy efficient buildings. For the last three decades, solid-wood and engineered wood products have been increasingly used in the external envelope of Australian buildings. Previous hygrothermal research has identified that water vapour diffusion resistivity properties for Australian grown timber was not available from international databases and may not be known. Solid wood elements adsorb moisture, and under the right conditions support mould growth, leading to mould spores and structural decay. This research focuses on evaluating the water vapour diffusion resistivity of Australian plantation grown softwood and hardwood. The timber materials will include solid wood, solid wood with glue and engineered solid wood elements. This paper includes an assessment of laboratory based and 'in-building' evaluation methods. The review identified the need to adopt relative humidity dependent wet- and dry-cup laboratory test methods to ascertain the water vapour diffusion resistivity properties for Australian solid wood and engineered wood products.

Decarbonization of PV homes through services system electrification

Zheng Wang, Mark B. Luther, Peter Horan, Jane Matthews and Chunlu Liu

Deakin University, Geelong, Australia
wangzheng@deakin.edu.au ,ORCID-0000-0002-8468-59371
mark.luther@deakin.edu.au , ORCID-0000-0002-9677-76362
peter.horan@deakin.edu.au , ORCID- 0000-0002-0514-8501
jane.matthews@deakin.edu.au, ORCID-0000-0003-3367-9278
chunlu.liu@deakin.edu.au , ORCID-0000-0003-1144-4355

Abstract:

The increasing interest in achieving residential decarbonization has highlighted the necessity of reducing home fossil fuel consumption. Therefore, this paper explores the impact of electrifying services systems, including space heating, space cooling and domestic hot water systems, on the reduction of the natural gas and grid electricity consumption of photovoltaic (PV) homes as well as the increase of PV energy utilization. A typical Australian house equipped with a 10-kW solar PV system in Geelong, Victoria, is used as a case study. The conventional fossil fuel-based system and the electrified services system are modelled using Transient System Simulation (TRNSYS) software, and the simulated PV generation, space heating, and DHW load are validated using actual measured results. Findings show that the electrified system offsets all the natural gas demand of 6915 kWh required by the conventional services system, and the services system electrification increases the PV self-consumption and self-sufficiency from 17.5% and 23.6% to 37.7% and 74.6%, respectively. Moreover, the electrified building services system reduced annual carbon emissions by 67%, from 2913 kg to 948 kg. This study demonstrates the capability of achieving a decarbonized residential future through residential services system electrification.

A discrete choice experiment approach towards students' preferences of the lighting and acoustic condition in a virtual classroom

Cynthia Hou and Haifeng Lan
Department of Building Environment and Energy Engineering, The Hong Kong Polytechnic University, Hong Kong, China
Cynthia.hou@polyu.edu.hk, Haifeng.lan@connect.polyu.hk

Abstract:

This study employed a virtual reality-based discrete choice experiment to investigate university students' preferences for lighting and acoustic conditions in virtual classrooms. Fifty-four students participated, evaluating 15 choice sets with varying lighting and acoustic conditions. The results revealed nuanced preferences, with females showing similar preferences to males for lighting and acoustics, but higher expectations for VR environments. Age differences were significant, with participants aged 25-45 being more engaged. Optimal conditions were identified as bright ambient lighting (500-1000 lux), neutral lighting colour temperatures (4000-4700K), moderate background noise (25-45 dBA), and minimal intrusive noise (10-25 dBA). Nine interaction effects between lighting and noise levels were found to influence the user experience. This research demonstrates the efficacy of VR in simulating real-world environments and provides valuable insights for architects, engineers, and educators to create more user-centric and effective educational environments, both physical and virtual. The findings have practical implications for integrating virtual reality in future educational settings.

Multimodal machine learning model for thermal comfort prediction using infrared facial thermal images and tabular data

Haifeng Lan[1], Cynthia Hou[1] and Yuzhi Su[2]

[1]Department of Building Environment and Energy Engineering, The Hong Kong Polytechnic University, Hong Kong, China
Haifeng.lan@connect.polyu.hk, Cynthia.hou@polyu.edu.hk

[2] School of Computer Science and Network Engineering, GuangZhou University, Guangzhou, China
yuanzhisu@e.gzhu.edu.cn

Abstract:

Developing accurate thermal comfort prediction models is essential for occupant-centric control (OCC) systems to optimize indoor environments. Conventional machine learning models, which rely solely on tabular data, face limitations in prediction accuracy and practical use. This study proposes a framework for building a multimodal model that incorporates both tabular and image data to address these shortcomings. To start, the study collected 610 paired data records, which included environmental data, individual attributes, thermal sensation votes (TSV), and occupants' facial thermal images. Separate single-modal models were trained on these two types of data to identify the best-performing model for each. Then, a self-attention mechanism was then introduced to combine the two models into a comprehensive multimodal prediction model. The hybrid ANN+Inception-V3 model significantly improved the prediction accuracy to 82.41%, effectively capturing the interaction effects between the two data types. This methodology offers valuable insights for future research, contributing to personalized and energy-efficient indoor thermal environment management.

Through the Forest of Extraneous Things: Exploring Cognitive Load Theory and Architectural Design Studio Andragogy

Daniel Gibbs

School of Architecture and Built Environment,
Deakin University, Geelong, Australia
daniel.g@deakin.edu.au, ORCID-0009-0006-0057-4495

Abstract:

Consisting of largely unstructured, open-ended design explorations as well as in-depth, in-class discussions and feedback, the architectural design studio model forms the fundamental basis of architectural design education at a tertiary level. Typically, architectural design studios are structured around an architectural design studio brief, which provides information regarding the general theme of the studio, location of the project, suggested tasks and precedent studies to be explored etc. Informed by the brief, the process of creative exploration and discovery in architectural design studios often imposes significant cognitive load. However, the quest to develop effective forms of architectural design studio andragogy remains relatively uninformed by an understanding of human cognition and Cognitive Load Theory. Through a discussion of Cognitive Load Theory and its potential application in architectural design studio andragogy, this paper presents an informed position of how Cognitive Load Theory might benefit students involved in creative exploration and discovery. It ponders that for students otherwise lost in The Forest of Extraneous Things, too often the case in architectural design studios, effective and transformative instructional design processes, informed by Cognitive Load Theory, could have significant potential in positively affecting the future development of architectural design studio andragogy.

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