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Sustainability and Health: The nexus of carbon neutral architecture and well-being



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BIM energy retrofitting frameworks: a critical review

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In the light of local carbon targets responding to climate change and global warming, countries need to curtail the energy consumption of their building sectors. Existing building stock represents most projects in that sector and energy retrofitting of existing unsustainable buildings is, hence, essential in achieving the above goal. Yet, energy retrofitting is a multiplex process plagued with inefficiencies, resulting in the low rates of uptake in Australia and globally. Using Building Information Modelling (BIM) can accelerate energy retrofitting and presents numerous advantages if applied properly. Many studies have presented BIM-Energy Retrofitting Frameworks (BIM-ERFs) that successfully adopt BIM for the ER process. However, the BIM-ERFs in these studies appear to be dispersed in nature, with varying BIM implementation level, scope, software(s), interoperability, and analysis methods. This dispersion can be counterproductive for BIM implementation in retrofitting. The authors identified a need for further research that critically examines and evaluates the current BIM-ERF approaches. In response, the paper presented here fills a knowledge-gap by critically reviewing 64 recently published BIM-ERF studies via a systematic literature review. The review reveals that BIM-ERFs are comprised of four main stages including pre-retrofit, design and analysis, construction, and post-retrofit stages. When critically examined, it is found that most of the studies are focused on the design and analysis stage using BIM and energy simulation and fail to sufficiently address the other critical stages. Accordingly, this review presents the future research priorities for studies to adequately address issues in all BIM-ERF stages.

Architectural green infrastructure: Native living wall impacts on building façade microclimates

Andamon, Mary Myla;
Rajagopalan,
Priyadarsini

TBN

MyComfort App: the application of personal thermal comfort models for older people in an online mobile tool

Arakawa Martins,
Larissa; Soebarto,
Veronica; Williamson,
Terence

By analysing datasets at the individual level, personal thermal comfort models help to unmask the differences between individuals in an environment, enabling a better understanding of specific comfort needs and collecting diagnostic information to identify user acceptability problems. This information, in turn, can be applied in the decision-making process involved in optimizing thermal environments to improve comfort satisfaction and energy efficiency. In this context, this paper investigates the application of personal thermal comfort models in a mobile tool and discusses the tool's benefits in aiding the adaptation of older people's environments to increase their comfort. MyComfort App is based on a study of 28 personal comfort models for a subset of older South Australians, who participated in a house environmental monitoring in 2019. The App uses individualized machine learning models to allow the automatic calculation of thermal preference for the older individuals. This online user interface provides personal thermal comfort prediction as well as a catalogue of strategies related to personal actions, technology, building operation and design, which could aid the control and adaptation of older person's environments. Testing the App on one personal thermal

comfort model proved to be successful in allowing the accessible and automatic calculation of thermal preference for the selected participants. Although still not validated by the end users, the App shows potential to aid designers in the decision-making process, as well as guide caregivers to anticipate needs and control of thermal environments independently.

Evaluation of the illuminance and thermal conditions of perforated facade prototypes for the tropical humid climate.

TBN

Arango, Juan
Fernando; Garcia,
Ader; Posada, Juan;
Perez, Manuela;
Villegas, Juan

Integration of Multiple Intelligence Skills in Architectural Design Process in Sri Lanka

Bandara, Buddhika
Viraj; Rupasinghe,
Himalshi Tharanga

Architecture is a subject that requires multiple skills thus necessitating architecture students to be competent as a multi-skilled person. Skills related to technology, spatial visualization, creativity, analytical and logical thinking, verbal and communication are among the vital skills needed. Design studio is the core of architecture learning process where the students put these skills into practice. Use of Multiple Intelligence Theory (MIT) for architectural education has been discussed in international context. However, research on the relationship between multiple intelligence and architectural design process has not been researched in Sri Lankan context. The aim of this research is to identify the level of multiple intelligence integration in architectural design studios in architectural education institutes of Sri Lanka. Separate questionnaires were developed for the architecture students, academic staff and design instructors based on the MIT and the Multiple Intelligence Development Assessment Scale (MIDAS). Application of the eight factors of MIT in different stages of design process by the architecture students was questioned through the survey. Through the analysis of collected data analysis, it was identified that the MIT is not familiar in local context and direct application of multiple intelligence in design process is not utilized by both the students and the academia. However, unknowingly, identified factors of MIT is applied in different levels. Further, when introduced, probable applications were well acknowledged by a majority of respondents highlighting the relevance of integrating MIT to improve overall design skills in architecture students.

Heat in the streets

Biloria, Nimish;
Thomas, Leena;
Pakdel, Pejman

Heat stress from rising temperatures in the workplace is an urgent public health issue. The absence of canopy cover, excessive built-up areas with heat-reflective materials such as glass facades and concrete paving, the absence of shade provided by surrounding buildings, the width of streets, and traffic occupancy often aggravate heat stress in cities. This paper presents the outcomes of a research study to map, analyse, and visualise the lived experience of climate-exposed outdoor workers. The project sought to understand how experience data of heat-exposed urban workers can

be communicated using digital tools and environmental sensors to derive evidence-based suggestions for developing heat-sensitive urban environments. Focusing on bicycle delivery couriers and outdoor council workers, the project draws on quantitative (temperature, humidity, and geo-location) and qualitative data (time worked and psychophysiological responses to heat) from outdoor urban workers. Minnow sensors, Strava (geo-location mapping), analogue intake and exit interviews, Google Street View, and online surveys were deployed for data acquisition, correlation, and prototyping of a real-time updating digital dashboard that served as a visual narrative of summer heat stress experienced by Sydney's essential outdoor workers. The dashboard is instrumental in revealing heat stress hotspots and corresponding opportunities for urban interventions (e.g., heat refuges, shade, landscaping) to mitigate urban heat effects while simultaneously revealing the lived experience data of the participant outdoor workers. A citizen science initiative, the research is instrumental in communicating the impact of the spatial, social, and policy landscape on critical climate emergencies to a broader audience.

Key factors affecting the implementation of integrated project delivery for sustainable construction

Bin Asad, Saad;
Purushothaman,
Mahesh Babu;
Poshdar, Mani

Integrated Project Delivery (IPD) is an approach that integrates people, systems, business structures, and practices into a process that collaboratively utilises the skills and opinions of all project participants to enhance sustainability through waste reduction. IPD aims to minimise waste in construction projects, improving sustainability, health and safety, cost, schedule, and quality and address the trust issues in the construction industry by attempting to promote a positive collaboration based on mutual respect. Though numerous literatures are available on IPD, an in-depth analysis of the barriers to IPD has never been conducted. This study addresses this research gap and aims to present the barriers to IPD in detail. A systematic literature review (SLR) was conducted using four databases and key publishers- Scopus, Emerald, ScienceDirect and International Group for Lean Construction using the keywords "integrated project delivery" and "challenges". Additional searches using synonyms such as "barriers" and "obstacles" were conducted; the keywords yielding the highest results were selected, and every paper was examined to identify either explicit or implicit mention of IPD barriers. The SLR identified 222 barriers to IPD globally. The barriers were grouped into themes and separated as primary codes. The themes include Legal, Financial, Technological, Cultural/Organisational, Collaboration and Communication, and Governmental/Political. The barriers are displayed using VOSViewer to visualise the co-occurrence of factors. The implications of this research will aid researchers and industry practitioners in understanding existing barriers comprehensively and identifying the most frequent barriers to IPD for sustainable construction in the global context.

Whole-of-life carbon comparison of retrofit strategies for Aotearoa New Zealand's existing housing stock

Residential retrofit is essential for Aotearoa New Zealand to achieve carbon neutrality by 2050, given the current detached housing stock exceeds our allocated carbon budget. This paper presents the findings of a research project that examines the life-cycle carbon performance of various retrofit strategies. The aim is to improve the thermal performance of an existing detached house, bringing it closer to Aotearoa's carbon budget. The paper presents a systematic

Blewden, Eloise Martha
Macdiarmid; Petrović,
Emina Kristina

overview of fabric-first approaches to retrofitting. To achieve this, a range of material retrofit packages are developed and tested on a single case study. These strategies are informed by a review of literature and case studies. The evaluation process considers the whole-of-life carbon of each retrofit package. Quantitative analysis, utilizing energy modelling and Life Cycle Assessment, will be employed to assess the case studies' outcomes. Building from existing research, this study advances the understanding of the carbon performance of different material residential retrofits.

**Weaving as Lo-TEK
architectural
solutions; a transition
towards perishable
architecture**

Brown, Jessica Rose
Creighton; Petrovic,
Emina Kristina

In the realm of built environment disciplines, focus often gravitates towards high-tech solutions to address architectural challenges. Consequently, softer approaches can remain underexplored. Local traditional ecological knowledge (Lo-TEK) is an approach looking to indigenous peoples and climate-resilient infrastructures to develop unique techniques and methods. Focused on the pressing issue of rental housing quality in Aotearoa New Zealand, this study examines the potential of Māori weaving techniques as Lo-TEK interventions to address subpar living conditions. The research delves into the cultural significance of weaving, emphasising its potential to be applied architecturally. Māori weaving practices and techniques were evaluated, with acknowledgements to the tikanga (Māori customs and values) surrounding the practice. From there, two preliminary studies involving weaved interventions were conducted, utilising Māori weaving techniques. An analysis of these initial studies was conducted using thermal imaging and occupant observations looking into the effectiveness of different weaving techniques in improving temperature control and comfort. Findings indicate promising improvements, establishing a foundation for further research. Discussion highlights the need for larger scale testing to confirm preliminary findings and observations. The paper also acknowledges the departure from traditional harakeke (Māori flax)-based weaving in favour of more readily accessible waste materials, emphasising the potential for future research in collaborating with local iwi (Māori tribe) to explore harakeke-based interventions. This study contributes to development of culturally sensitive and environmentally conscious architectural solutions which are also sustainable, highlighting Lo-TEK's potential to reshape the built environment. As research continues, these findings could pave the way for more.

**Environmental
impacts of digital
platforms for building
design: A case study
exploration using
scenario-based EEIO
analysis**

Bunster, Victor; Weis,
Edan; Maxwell, Duncan
W.

This study uses two building design platforms to investigate the environmental impact of an increase in the Australian construction industry's adoption of digital technologies. Environmentally Extended Input-Output (EEIO) analysis is used to trace the upstream and downstream environmental impacts of industries represented in the Australian national accounts' Input-Output Tables. Two intervention strategies are used to simulate tool adoption affecting two industry groups, i.e., an increase in the demand for Software Publishing and a decrease in Architectural, Engineering and Technical Services. Disaggregation of industry sectors was done using primary data and information from the Australian Bureau of Statistics, Labour Markets Insights, the Housing Industry Association and the National Skills Commission, among others. Iterative Proportional Fitting and Structural Path Analysis were used to rebalance the Input-Output Tables and trace the flow of environmental impacts, including proxy second-order effects. The results suggest a potential emissions

reduction of 6.3 MtCO₂-e associated with embodied environmental impacts throughout the Australian economy under the explored scenario range. Within this range, the results show a maximum theoretical reduction of 0.0013% and 0.0026% for the case study tools. Under assumptions of wide-scale adoption and optimal efficiency gains, commercial objectives can be guided to capitalise on these results' potential magnitude and direction. The methodological limitations of this study and their implications on the results are discussed in detail, including uncertainty levels, data gaps, and ignored variables. Regardless of these issues, the study provides insights into the potential environmental benefits of transitioning to extensive digitalisation of building design services.

Techniques for documenting urban assemblages

TBN

Connolly, Peter John

Indoor environmental quality and occupants' satisfaction in high-rise mixed-use buildings: Preliminary results from a case study

Croffi, Juliana;
Soebarto, Veronica;
Kroll, David; Barrie,
Helen

Indoor environmental quality (IEQ) can impact occupant's health, productivity, and wellbeing, as evidenced in various building performance studies with an occupant-centric approach. Quantifying the impact of each of the IEQ parameters – thermal comfort, visual comfort, acoustic comfort and air quality – on occupants' satisfaction with the indoor environment (IE) is a key step to move towards a human-centric building performance evaluation, and consequently, to improve building design and their performance in fostering IE satisfaction, enhancing occupants' wellbeing. This study conducted a post-occupancy evaluation (POE) at U City, a high-rise mixed-use building in Adelaide, South Australia. The POE investigated the correlation between IEQ and occupants' satisfaction with the indoor environment, collecting data from apartment residents and office workers. The data collection included surveys, monitoring of indoor environmental parameters with data loggers, observations of public space use in the building and focus groups. This paper presents the preliminary results on how each of the IEQ parameters affected the overall satisfaction with the IE as part of a broader framework to evaluate building performance in fostering wellbeing. The preliminary statistical analysis showed significant correlations between IEQ parameters and IE satisfaction for both residents and workers. Indoor temperatures, noise issues or sound quality and air quality were found to be the most significant factors that affected IE satisfaction. The outcome of this investigation will inform the elaboration of a metric that will be embedded in a building design evaluation tool based on computational 3D model analysis.

The unintended consequences of novated design construct procurement and the impact on the education of graduate architects in Victoria

In the practice of the building industry, Novated Design and Construct (NDC) contracts have gained widespread usage and are well-established in the Victorian market across many building classifications. This study draws insights from a comprehensive approach that includes interviews, desktop research, transcript analysis, and key takeaways from ongoing research. A notable concern arises from the bespoke nature of NDC Contracts, which demands a nuanced understanding of their contents and associated risks. This prompts a critical examination of the architecture profession's foundation, debunking the notion of the lone genius

Day, Kirsten M;
Raisbeck, Peter; Vaz-
Serra, Paulo;
Greenham, Phillip;
Bates, Donald

designer. Instead, the evolving role casts architects as both designers and coordinators of documentation, carrying shared liability. This paradigm shift necessitates an expanded education framework, beyond the current confines, warranting the development of a structured 'apprenticeship' model. Over the past three decades, the construction industry has undergone profound transformations, resulting in heightened complexity to construct the built environment. To comprehend this complexity, the prevailing siloed discussions and contract author-centric approaches must be disrupted. It is imperative that education, both initial and ongoing, equips professionals with the requisite skills to thrive in an evolving remodelling. This research underscores the urgency for adaptive education, ensuring that architects are adept at navigating intricate contracts and industry dynamics, thus promoting sustainable architectural practices and an improved built environment.

**Integrated planning
as a 'smart' solution
for improved
sustainability of
construction
logistics: A transport
perspective**

Dhawan, Kamal;
Tookey, John;
GhaffarianHoseini, Ali;
Poshdar, Mani

The trans-disciplinary nature and extent of the construction supply chain make it prone to inefficiencies at its component domain/segment boundaries. Project-centric delivery accentuates these. Logistics, a significant element of the construction supply chain, forms part of complex systems with multiple stakeholders and a wide range of concurrent on-/off-site in-action activities, processes, and systems. Transport is the largest logistics component, with most other processes (except warehousing) being business processes and not 'real' ones. The low-value/high-volume nature of construction materials leads to substantial transport requirement, even for small projects, with costs up to half the logistics costs or a fifth of construction costs. Transport is naturally fragmented, with a component intrinsic to every business, and asset ownership and deployment typically external to it. Incremental inefficiencies, driven by siloed planning between involved stakeholders, aggregate into visibility at the macro level. Adverse sustainability impacts are the obvious consequence. Transport optimisation results from re-configuring activities, re-combining resources, and re-positioning actors, which demand integrated strategic and/or operational planning. This paper undertakes data-driven analysis of an integrated business model as a 'smart' solution for improved transport efficiency in a specific New Zealand construction supply chain segment. Quantification and validation of sustainability benefits is undertaken using domestic/international parameters.

**A Test-cell for
Building Conditioning
Experimentation**

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Mark B.; Matthews,
Jane; Martek, Igor;
Zheng, Wang

Over the years, empirical experimentation has been proven to be a favourable method for understanding the performance of various building systems. A literature review provided information on past experimental setups. This paper introduces the design of a test room (the TEST CELL) emulating a realistic high-rise perimeter office for experimentation with instrumental measurement. An example for testing is a new hydronic radiant panel system developed for perimeter zones in office buildings. The Test Cell is contained within a workshop adjacent to a north-facing corrugated steel sliding door. The Test Cell has a double-glazed (6mm, 12.5mm cavity, 6mm) 7.5m² window facing solar North. At present, the room can be passively heated to temperatures above 40°C, even at medium outdoor ambient. The Test Cell provides for different conditioning systems and various glazing and shading systems to be tested. A weather station accompanies the location, and the Test Cell contains numerous

instrumentations for determining interior performance on comfort as well as its required energy inputs. The most recent testing involves hydronic conditioning systems and a polyvalent heat pump that provides for the conditioning of the room. The room is divided into four zones: two on the ceiling and two on the floor. Conditioning is provided through a solar-driven air-to-water heat pump. The instrumentation, data reporting, and graphical templates for this experimental Test Cell are reported in this paper. Several initial testing results and a proposed method of analysis and energy simulation verification are addressed.

Child-friendly smart homes: an outline of possible challenges

Ehteshami, Azin;
Lozanovska, Mirjana;
Tucker, Richard

Children's daily lives mainly occur in their homes. As technologies in residential environments constantly evolve, concerns about children's physical and digital safety are emerging. While the current literature highlights the influence by digital technologies and how smart home technologies might improve children's lives, there is a lack of critical appraisal of the relative pros and cons identified in the literature for children living in homes with smart home technologies. This paper asks what challenges are raised in the literature around using smart technologies in homes with children and what key knowledge gaps need addressing by future research. In this study, we conducted a scoping review to analyse and synthesise diverse research on the challenges of creating smart homes suitable for children. We followed a systematic process to gather a comprehensive scope of research relevant to the research question. As our prime aim was to identify knowledge gaps as a precursor to further research, we did not evaluate the data quality or findings. Key areas of research that need addressing to create child-friendly smart homes were identified through this analysis, including Safety Measures, Cognitive and Developmental Considerations, and Privacy and Data Protection. These findings aim to guide future research towards enhancing the development of safe and interactive smart home environments for children.

Experimental Building/Experimental Building?

Francis, Kerry Stuart;
Treep, Lucy

In 1968, students in their final year at Auckland University School of Architecture designed and built a studio for their year group into a space between two existing villas in adjacent Wynyard Street that were also occupied by the architecture programme. The studio has come to be known as the Experimental Building. To date there have been two pieces of formal documentation of the project; A 1968 Building Report by student William (Bill) Benfield, who was part of the design and construction team, and a 1980 Study Paper by contemporaneous staff member Ian George. The paper begins by outlining the motivations and provocations of the time and then turns attention to the construction process and the spatial and tectonic qualities of the Experimental Building. By examining this project through the lens of these documents it will attempt to identify what can be learnt and what was experimental about this project.

Sustainability and Health: The nexus of carbon-neutral architecture and well-being

Within the imperative surrounding contemporary concepts for environmental and social sustainability and the affordable housing crisis, an opportunity exists to explore low-cost, low-skill labour use as a transferable housing solution to support vulnerable communities. In this scenario, recognising the intricate nature of the domestic construction industry is critical: involving the interweaving balance between material culture, the social networks of construction and the

Gardiner, Blair;
Colabella, Sofia

boundaries between architecture, structure, materials, and building in a digitally enabled domestic construction industry. Amongst the challenges this scenario poses is to broaden education modes, using technological enablement and aligning them to communicate architectural science in its application to political economy, societal equity and the environment. This paper explores ways to use a digitally designed and fabricated unit to embed youth training through participation in the assembly process and as future training ambassadors as the project develops. It enquires how digital tools engender new pathways for collaboration between designers and makers and incorporate end-users needs, facilitating the permeation of capacity-building access via a construction material (timber) that has traditionally circumvented formal-driven social structures.

Leveraging digital technologies for façade renovations

Globa, Anastasia;
Sangiorgio, Alberto;
Bogdanova, Alex;
Brambilla, Arianna

Digital tools have significantly influenced the design and construction of new objects and buildings, offering a broad range of specialties, including computational modelling for analysis, design, and optimization, as well as advanced manufacturing processes. These emerging digital technologies are gradually transforming the field and revolutionizing the way we approach design and construction. While their benefits for new building designs are well-documented, their application for retrofitting existing buildings remains relatively unexplored. This research aims to investigate the potential benefits of employing digital workflows for the analysis, reconfiguration, and optimization of existing facades. Building upon the case study of the 'F10 – New Law Building' at the University of Sydney, the design team, in collaboration with the Sydney Law School and Sydney Infrastructure leveraged multiple digital technologies to analyse the existing facade, evaluate various design options, and identify the most effective solutions. The process involved a quantitative and qualitative analysis and leveraged the use of shoebox analysis utilizing parametric models, multivariable optimization considering factors such as daylight, radiation, glare, and view factor, an online questionnaire to gather valuable feedback from building users and establish performance priorities, a user-centric design approach employing virtual reality to assess the visual impact of potential design solutions and their potential impact on occupants' well-being. This paper presents the proposed research methodology and implementation of the holistic data-driven design approach and meaningful engagement with simulation data and its communication to a wide range of key stakeholders using VR technologies.

Hygrothermal and Bio-hygrothermal Risks of Architecture: moisture accumulation, indoor mould growth, and energy efficiency

Guan, Liqun{Antonia};
Dewsbury, Mark;
Wallis, Louise

TBN

A new look at smart ventilation for the tropical public buildings at the post-pandemic era

TBN

Gumbaketi, Benedict

An Investigation of the Effective Reuse of Heritage Buildings to Achieve Resilience in New Zealand Small Towns: A Literature Review

Inal Kaynar, Cansu; Isaacs, Nigel; Brown, Andre; Noy, Ilan

Small to medium-sized towns in Aotearoa New Zealand (NZ) have a substantial number of heritage buildings built before the 1931 Hawkes Bay earthquake, mostly earthquake-prone. The seismic vulnerability, along with the rising industrialization of agriculture that prompted a migration to larger urban centres, has led to the abandonment of numerous historic structures in small towns worldwide. In turn, these affect the town's seismic and social resilience, which can create a negative spiral of town vitality. Strategic and thoughtful adaptive reuse is an important tool. It has the potential to contribute to UNESCO's Sustainable Development Goals (SDG) like SDG 8, Decent Work and Economic Growth, SDG 11, Sustainable Cities and Communities, and SDG 12, Responsible Consumption and Production. The literature review in this paper examines adaptive reuse through the lens of UNESCO's SDGs to understand its challenges and benefits within NZ's small-town context, focusing on Whanganui as a case study. The literature review revealed four themes concerning adaptive reuse in NZ and the SDG: Causes of Obsolescence; Seismic Risk; Environmental Sustainability; and Heritage Conservation. Reusing and retrofitting, rather than demolishing, obsolete buildings can contribute to the solution of the housing problem while lowering NZ's carbon footprint in line with the legislated goal of becoming net zero by 2050.

Investigating the effect of the building envelope and weather conditions on the transport and distribution of pollutants within residential buildings

Jha, Atul Anand; Chani, Prabhjot Singh; Sharma, Anoop Kumar

Air pollution is an acute problem for numerous prominent cities in the global south. This paper explores the case of India's capital - Delhi. The temporal variations in ambient air pollution levels are studied for the city based on data from the years 2018-2022. The ambient pollution levels are within acceptable levels for less than 20% of days in the year. The pollution levels peak in winter, where ambient concentrations of the most prominent pollutant, PM10, exceed 600 $\mu\text{g}/\text{m}^3$ for continuous stretches of a few hours regularly. A typical residence is modelled in this context to understand the impact of outdoor pollution on indoor Air Quality. Infiltration is estimated based on a 2021 study of residential apartments in Ahmedabad (India), where blower door tests were conducted in 20 apartments. The infiltration data in air changes per hour (ACH) was translated into the effective leakage area of the envelopes. The derived leakage area estimates are used for modelling with CONTAM, a multizone airflow network simulation software. Modelling the transportation of PM10 particles reveals that higher wind speeds and higher envelope leakage rates lead to faster transmission of pollutants indoors. It took 15 hours for the indoor pollutant level to match the outdoors in the room to the windward side in the modelled residence when the leakage area was 4 cm^2/m^2 under steady-state environmental conditions. It can be concluded that active removal of indoor pollutants is essential for maintaining acceptable indoor air quality levels.

Tipping point for condensation water drainage on surfaces and interfaces of insulated wall assemblies – experimental method to define water content limits for hygrothermal simulation models.

Kuenzel, Hartwig
Michael; Tanaka, Eri;
Zirkelbach, Daniel
Maria

If condensation occurs on non-hygroscopic surfaces of insulated wall constructions, droplet runoff may happen if the amount of condensate exceeds certain limits. Depending on the situation this phenomenon may help to dry the wall, but it may also result in material degradation by water accumulating at the bottom where drainage is not intended. The limits for interstitial condensation amounts on non-hygroscopic materials calculated by the dew-point method in European standards differ with values up to 500 g/m². However, it is questionable whether these limits are based on rigorous experiments and whether they are suitable to evaluate hygrothermal simulation results. Therefore, a laboratory test method has been developed to determine the amount of condensate required for water to run off from vertical surfaces or interfaces of insulated assemblies. For this test 14 fibrous insulation materials (9 x mineral wool, 3 x wood fibre, 2 x cellulose) and 4 types of condensation planes (hydrophilic, hydrophobic, smooth, or rough surface) were examined. The results proved to be much lower than in the above-mentioned standards. Mostly, they ranged between 100 and 200 g/m². Furthermore, by correlating the acceptable amount of condensate with the hygrothermal properties of the insulation materials, a simple formula was derived to estimate the material specific limit value, using its moisture equilibrium at 80 % RH. Finally, by comparing the test results with hygrothermal simulation results, it can be concluded that the water content in the critical one-centimetre-thick layer of the assembly, referred to in DIN4108-3 (2018), is appropriate to assess the probability of condensate runoff.

The building-health nexus in water damaged buildings

Law, Tim; Stamkos,
Jeremy

In 2018 a parliamentary inquiry was conducted by the Commonwealth of Australia into biotoxin illness (Chronic Inflammatory Response Syndrome, or CIRS) from water damaged buildings (WDBs). CIRS manifests across multiple organs and symptoms and is diagnosed. Due to the complex patient profile and uncertainties in establishing microbial contamination thresholds, CIRS has not been recognised and is little heard outside of integrative medical practitioners. The Inquiry recommended that further medical research should be supported. In 2022, the National Health and Medical Research Council (NHMRC) funded a targeted call for research to an interdisciplinary team led by Macquarie University. Though this research is underway, it already expands the discussion on healthy buildings from its well known allelopathic, pathogenic and toxicological effects to now accommodate CIRS. The paper is situated at the confluence of the two emerging field of condensation research and CIRS, explaining why the architectural scientist plays a pivotal role in delivering buildings that will not be prejudicial to the health of CIRS patients.

Experimental investigation of vibration performance of cross-laminated timber floor constructed from fibre-managed *Eucalyptus nitens* with various surface treatments

Cross-laminated timber (CLT) floors made from fibre-managed plantation *Eucalyptus nitens* (*E. nitens*) have raised a lot of research interests recently due to their sustainability and higher value than producing woodchips. However, their serviceability performance is not yet fully understood. Investigating vibration behaviour of timber floors is necessary because the inappropriate control of structural vibration would finally lead to human discomfort. In this study, seven CLT samples were analysed, consisting of six *E. nitens* CLT panels with different structural grades (modulus of elasticity) in each layer, and one spruce CLT with constant structural grade used as a control sample. The vibration performance of all CLT panels were

Liang, Yingwei; Taoum, Assaad; Kotlarewski, Nathan; Chan, Andrew

investigated under different scenarios including the utilisation of residential carpet, hardwood overlay and a soundproofing material. A ball-dropping method was used as an excitation for the vibration test, and an accelerometer was used to collect the acceleration-time data. Calculations of natural frequency and damping ratio were performed by MATLAB. The results have demonstrated the reliable serviceability performance of *E. nitens* CLT via comparing the vibration properties of spruce CLT. The variations in structural grade within different layers of CLT, as well as the inclusion of carpet, timber overlay and soundproofing material have demonstrated different vibration performance of CLT panels.

Enhancing thermal performance: self-shading steel facades to reduce heat gain in hot to warm climates

Lionar, Ricardo; Kroll, David; Soebarto, Veronica; Sharifi, Ehsan; Aburas, Marina

Energy consumption for heating and cooling the space is affected by the building envelope design and detail including the roof, windows, walls, and other components. A potential optimization strategy for reducing energy demand is through self-shading. This paper focuses on the implementation of self-shading at the building components level and the impact of reducing heat gain in the facade. The pattern and shape of self-shading strategies to decrease the amount of heat absorbed by building envelopes will be investigated through a simulation and physical setup. To validate the simulation result, a test box is developed to isolate the self-shading façade from unwanted heat gain. Data loggers are used to gather the temperature data. The results from the simulation were initially analysed to make a comparison between profiles. The results show that the self-shading provides a reduction in both external surface and indoor temperatures, which is affected by the tilting angle and shape of the folded steel façade cladding. Additionally, the percentage of the sunlit area serves as a reliable predictor of external surface temperatures. However, this study also identifies limitations in the current simulation method, emphasizing the need for a validation process in self-shading studies.

Let's Play Together. The Role of Positive, Creative & Collective Practices towards Building Adaptation.

Lovesmith, George; Rasbash, Zoe

Throughout 2022-23 Watershed (cultural cinema & creative technology centre) have been working with George Lovesmith, an architect & socially engaged artist on plans to adapt their building for the Climate Emergency. Watershed leads within its communities with a proud activist agenda and has set ambitious Zero Carbon 2030 commitments. Housed in a heritage structure where building operations form most of its carbon emissions, the challenge is immense. Integral to this endeavor are creative methods for coming together as an alliance of building users, staff, creatives, activists & visitors, demonstrating the value of creative practices (e.g. events, games, storytelling, play, metaphor, gratification, imagination, collective learning, reciprocating, entertaining...) This is bringing people into partnership to address the challenge, establishing shared understandings of building retrofit principles. This isn't a purely technical challenge – Indeed the endeavor is intentionally re-framed as transdisciplinary, and inherently creative, because the way things are currently getting done internationally isn't working and has insufficient urgency. & because as an arts organization, addressing climate emergency isn't only about technical solutions, it's about collective expression and welcoming people on board. The practice and research have hinged around: -a recognition that design proposals are more successful if clients/users/others are invited to invest expertise, understandings, creativities and desires in the processes- testing the educational value of communing – mutually

engaging those same clients/users/others in design processes & - a belief in the net gain to society of increased critical design appreciation and a wider-spread ability to contribute to improvements of our built environment.

A study for implementing and assessing acoustic design in architectural design curriculum

Mack, Michael;
Colabella, Sofia

There are few studies on pedagogical approaches to acoustic design in architecture degrees, particularly those addressing how acoustics is taught within design studios and how students apply acoustic design principles. This paper presents a preliminary analysis of the current approaches to acoustic design within architectural design coursework in top-tier universities. It also showcases a unique architecture design studio framework incorporating acoustic performance, developed for, and tested in The University of Melbourne context. Delivering this design studio on acoustic design led to the development of a methodology to categorise and compare student design outcomes.

Architectural green infrastructure: Native living wall impacts on building façade microclimates

MacKinnon, Maggie;
Pedersen Zari, Maibritt;
Brown, Daniel K.

Living walls can improve building envelope performance and contribute to human well-being; however, their value to native biodiversity is often not considered in their design or the study of their performance. Native biodiversity is essential for ecosystem health and the provision of ecosystem services that support human well-being and foster climate adaptation. This research aims to quantify and assess the biodiversity and cooling effects of native living walls on building façades in Wellington, Aotearoa New Zealand. Light and temperature data were collected from two types of felt-pocket living walls over six months. The living walls provided up to 89% more shade than bare walls. Temperature impacts were most notable during the hottest part of the day, with the living walls recording substrate air temperatures that were 0.8 – 1.3°C (5-8%) cooler than bare walls. The living walls with smaller, denser plant pockets supported more native plant biodiversity and had higher leaf coverages and cooling effects than those with larger pockets. This research demonstrates a potential alignment between biodiversity and thermal performance outcomes for living walls, which could help inform the design of living walls that optimise cooling effects while providing diverse plant communities for local, native biodiversity in warming cities.

Urban voids in the CBD of Davao City: Their potential towards sustainable infill development and inner urban regeneration

Magno, Karl Wendell
C; Malaque III, Isidoro
R

TBN

Building resilience to climate change and mental wellbeing through eco-centric urban design

Climate change threatens more than just our physical livelihoods. In developed areas, urban heat island effects, flooding and coastal inundation - amongst other impacts of climate change – also trigger a psychological response. Recent terms such as *eco-anxiety*, *ecological grief*, and *nature deficit disorder*, have emerged associating the connection between climate change and mental wellbeing. Despite

Manoharan, Morgan
Sajeev

this, the dominant modes of urban design are not fit for purpose regarding our response to climate change and mental wellbeing and will only exacerbate the impacts of these issues moving forward. Ecocentrism, provides an alternative approach to problem solving. In comparison with the dominant models currently used which reflect anthropocentric thought, ecocentrism recognises the intrinsic link between the health of the ecosystem; and the health of people, who, are part of the ecosystem. This eco-centric thinking was applied to an existing neighbourhood sub-catchment in Māngere – Auckland, New Zealand and showed that when design decisions are driven by ecocentrism, it brings forth possibilities for our built environment that will better address the environmental and social challenges we face.

Why standards and perceptions are discouraging sustainable access of low-density timber for flooring?

Millaniyage, Kuluni
Piumika; Kotlarewski,
Nathan; Wallis, Louise;
Taoum, Assaad

The anecdotal circumstances observed in the timber flooring industry make the introduction of new timber resources and products to the consumers challenging. This study explores the challenges of introducing new timber resources and products to the consumers when standards reflect resources that are informed/based on the availability of high-density, mature timbers. Extensive research exists to determine the timber properties specified in standards as important for flooring applications. However, the lack of consensus in methodologies and boundary conditions employed to differentiate end-user performance requirements restrict the comparison of these studies and standards. This is further complicated by end consumers selecting traditionally accepted species with divergent properties; species used in flooring defies the standards and are informed by aesthetics and cultural attachment. This paper evaluates the commonly used standard tests used for timber flooring and compares them with the feedback received from interviews conducted with several Australian timber industry stakeholders, architects/interior designers, and experts in the field, with the view of designing and developing new flooring products from plantation hardwood timber – a resource that is constrained by the standards that are widely used yet is growing in popularity because of its natural aesthetics and performance as a flooring alternative.

Towards a circular economy: a review of the current challenges and potential for recycling construction waste materials in New Zealand

Mohamed, Gehad
Ragab; Brown, Andre;
Isaacs, Nigel

Construction and demolition waste has many negative environmental and economic impacts. In order to achieve the New Zealand governmental vision of carbon neutrality by 2050, the transition toward circular economy principles could play a crucial role in mitigating construction waste environmental effects. However, barriers hinder the reuse and recycling of such waste. This paper provides a structured overview of the different challenges. The analysis includes an evaluation of different construction materials' nature and their potential to be reused or recycled. This is set against the environmental impact of those waste materials and how different research projects have aimed to overcome the barriers limiting better use and reuse. The paper reviews how successful projects have taken advantage of the latest research to improve resource circularity. The findings presented reflect on the legislative, cultural, financial, infrastructure, logistical, and technical barriers. The examples reviewed showed how different construction materials' characteristics affect their potential to be recycled or reused. Generally speaking, composite materials are the hardest to be recycled, whereas assembled materials are more suitable to be reused or recycled. The potential use of material passports is also discussed. A detailed map

of the obstacles and the possible solutions to maximize the benefits of those potential resources is an outcome of the research presented in the paper. The intention is to support the construction industry stakeholders by evaluating the current situation, thus paving the way toward adopting a viable circular economy approach and 'Closing the Loop' through increased construction waste recycling.

Dynamic Embodied carbon BIM based Calculation tool: a User Experience Analysis Study

Mohamed, Rana
Ayman; Alwan, Zaid;
Salem, Mohamed;
McIntyre, Lesley

The integration of sustainability assessments, such as life cycle assessment (LCA), with digital construction workflow has become increasingly important in the architectural, engineering, and construction (AEC) sector due to global and governmental pressures to construct sustainable and low carbon buildings. Building information modelling (BIM) has revolutionised the AEC sector and has shown potential for integrating LCA into its platforms. However, there is still a need for testing and accessing early design and dynamic tools. To address this gap, the paper proposes a dynamic BIM based embodied carbon assessment tool and conducts a validation usability study to determine its ease of use and acceptability. The study employed mix between quantitative and qualitative method using online workshops with architects and sustainability assessors in UK to illustrate the use of the tool and collect feedback from participants through survey and semi structured interview. The results of the usability testing reveal the need to enhance the calculation model, visualisation and optimisation options, and develop a more advanced user interface for the tool. These results serve as a basis for future development to be addressed by researchers and practitioners to increase adoption of the new integrated approach. Overall, the paper highlights the significance of integrating sustainability assessments into digital construction workflow and the potential of BIM-based tools to achieve this goal.

Hempcrete housing: a preliminary evaluation of the relationship between housing typology and demand on agricultural land

Murray, Michael;
Petrovic, Emina
Kristina

At a time when awareness of the need to accelerate the uptake of low carbon construction practices is at an all-time high, it is critical to reflect on the rich histories of such already existing materials. Industrial hemp is a plant with a troubled history, but one with the potential to alleviate the troubled future that the world faces, staring down the barrel of climate change. Hempcrete is an example of a low-carbon material which has struggled to permeate into mainstream construction. Through visualizing the impacts that an accelerated uptake of hempcrete for medium-density housing may have on agricultural land use, it is possible to envision what a future of hemp-based construction looks like in Aotearoa New Zealand. These insights are further contextualised by comparisons to the agricultural land use of different diet types, acknowledging the concerns for food safety that rise with discussions of transition to a bio-based economy. The case study undertaken demonstrates that the quantity of adjoining housing units directly influences the volume of hempcrete required for construction, when adjusted for the number of units provided or people housed. Furthermore, the data implies that the required agricultural land, adjusted per occupant, is equivalent to that required to sustain one person on a plant-based diet for one year.

Impacts of the Covid-19 Pandemic on Building Consents and Construction

TBN

Sector Activities in New Zealand

Nwadike,
Amarachukwu
Nnadozie; Aigwi, Itohan
Esther

Compliance strategies towards achieving net zero transition within the built environment

Nwadike,
Amarachukwu
Nnadozie; Aigwi, Itohan
Esther

The urgent need for a net zero transition of carbon emissions to safeguard the built environment from the devastating impacts of climate change has become a primary concern for the global community. To this end, various countries have developed different rules, regulations, and guidelines to achieve the United Nation's net zero emissions target based on the 2015 Paris Agreement. This study seeks to explore strategies for achieving compliance in the quest for a net zero emissions transition. An integrative literature review technique was adopted for this study to gain insights into relevant compliance strategies for transitioning to net zero carbon emissions within the built environment to achieve this goal. The results revealed that the different climate change response policies on greenhouse gas (GHG) emissions across the globe are time-based, with each country establishing transition strategies to regulate emissions while promoting alternative clean energy. However, the low compliance rate, cost, risks, and uncertainties surrounding these transition strategies have resulted in unintended resistance, despite the urgency and benefits of achieving net zero emissions. This study developed a compliance strategy that utilizes the PESTLE analysis factors to enhance adherence to net-zero transition regulations. The strategy monitors, evaluates, enforces, and encourages net-zero transition targets. Hence, it is imperative to adopt a collaborative approach that is more transparent and inclusive to facilitate the willingness to comply with the net zero transition regulations. These findings would guide relevant stakeholders and decision-makers with an improved compliance strategy towards net zero carbon emissions transition plans.

Building tomorrow's buildings today – Assessing the climate resilience of a high- performing apartment building in Melbourne

Petruzzi, Roberto;
Jensen, Christopher A.

It is well established that unabated greenhouse gas emissions will lead to warming of globe of at least 1.5°C during the 21st century, and the resulting changes in atmosphere, ocean, cryosphere and biosphere that already have, and continue to occur, will alter perceived and measured indoor environment comfort levels. Despite the collective knowledge of building design mitigation strategies for climate change, relatively little is known about the future resilience of current high-performance apartments based on expected temperature rises and during extreme weather events. At present, we are still learning how to design for these future scenarios. This knowledge gap places building owners, operators and occupants at risk, and designers responsible for the thermal performance and resilience of buildings without a defined, evidence-based and common methodology. This research uses a calibrated computer simulation to predict future achievement of international comfort standards based on data collected from a recently built 8-star NatHERS apartment in Melbourne, Australia. These results show that a shift from a predominantly heating to a predominantly cooling scenario is likely for high-performance apartments that are designed for today's climate. These findings are significant for assisting designers to understand

the need to balance the thermal performance of apartments in Melbourne both now and in the future.

Optimizing thermal comfort and indoor air quality in school classrooms

Ramanan, Nithesh;
Rajagopalan,
Priyadarsini

Recent studies from Victoria provided some baseline ventilation data for schools and noted that ventilation in many of the classrooms are below recommended minimum values. The Covid-19 pandemic has brought about an increased focus on indoor air quality in schools as a result of which many schools in Victoria have been engaging in fit out works to improve the air quality by various means such as introducing portable filters, leaving windows and doors open and bringing in outdoor air mechanically through air inlets. However, introducing outdoor air without pre-conditioning can cause thermal discomfort to the occupants in the classroom. This paper examined the effect of providing fresh air through air inlets to school classrooms using computational fluid dynamins (CFD) simulations. A number of variations were tested by changing the location of the cassette units and the location and number of inlets and outlets. The results showed that though the existing equipment is suited for extreme summer conditions, they are undersized for extreme winter. There was only 4.1% increase in the efficiency with the change in the arrangement in terms of the location of the cassette units and the location and the number of openings for outside air and return air. The use of Direct Outside Air System (DOAS) or a heat recovery system is recommended to address these issues. The findings will assist in developing standards regarding the installation of outside air systems for improving thermal comfort for children in school classrooms while ensuring good ventilation and indoor air quality.

Affect theory, digital heritage and circular economy; the fate of Dennys Lascelles Wool store in Geelong

Rashid, Md Mizanur;
Khoo, Chin Koi;
Masoomikhameneh,
Donya

This paper explores the connection between affect, digital heritage, and the circular economy through Dennys Lascelles Wool Store in Geelong. Despite the demolition of its bow truss structure, the site prompts vital preservation questions amid urban change. Affect, encompassing emotional and sensory experiences tied to a place, plays a pivotal role in preserving cultural legacies. In the digital era, virtual platforms enhance the accessibility of heritage, facilitating the collection, preservation, and sharing of intangible aspects. Critics have long noted that the Authoritative Heritage Discourse (AHD) primarily focuses on physical preservation and overlooks intangible elements and emotional connections to a site. This paper addresses these concerns by exploring how digital heritage can enhance preservation, documentation, and public involvement in a circular city context. By integrating affective heritage and digital tools with circular economy principles, sustainable practices in heritage preservation can be enhanced. While the bow truss building can only be digitally preserved, the remaining complex can be recycled and repurposed. The synergy of affective heritage and the circular economy, using digital tools, benefits the local economy and environment. This paper underscores the importance of acknowledging the emotional and historical value of industrial and cultural heritage, advocating for appropriate digital tools for preservation and engagement, and endorsing sustainable practices for the potential adaptive reuse of historic sites in the digital age. It highlights the necessity of reimagining preservation strategies for enduring accessibility to cultural heritage.

Cooling potential of C3 and CAM species of vegetative roofs for improving building thermal performance and surroundings urban environments

Rojas, Aldo; Vera, Sergio; Pianella, Andrea

Urban growth presents challenges such as increased greenhouse gas emissions, the urban heat island (UHI) effect, and poor resilience to counter heat waves. Vegetative roofs can offer high cooling potential due to plants' transpiration, substrate moisture evaporation, and shading. Therefore, vegetative roofs can reduce building operational energy consumption and related CO₂ emissions, mitigate the UHI and make cities more resilient against global warming by lowering the surrounding air temperature of the urban environment. This paper aims to quantify the cooling potential of vegetative roofs in Melbourne (Australia) and Santiago (Chile). Six C3 and CAM species used in vegetative roofs are assessed using a New Linear Model (NLM) for the stomatal resistance (r_s) and a heat and mass transfer green roof model implemented in Matlab and validated in several climates. *Selliera radicans* (C3) outperforms the other species in terms of cooling potential; leaf area index (LAI) is the main plant characteristic that influences the substrate surface temperature due to the shading effect; r_s and LAI have a significant impact on the foliage temperature and evapotranspiration control. This research allows designers and urban planners to comprehend the importance of choosing suitable vegetative roof species to maximize their cooling potential.

Building a healthy, zero-carbon ecovillage: innovative homes meeting a high-performance building standard

Shiel, John James

The Council of Australian Governments (COAG) have set a trajectory towards net zero carbon buildings by 2050. This paper describes the design, materials and construction technologies of low carbon homes of members of a low environmental footprint ecovillage. Fifty homes in Stage 1 of Narara Ecovillage Co-operative (NEV) in NSW, have met a flexible, high-performance building standard, which required homes to have 1) a 2017 NatHERS rating of at least 7 stars, 2) solar power to meet their annual energy needs, and 3) sufficient reward points for items such as resource efficiency, good indoor environmental quality and low embodied carbon. The methods used included surveys of members and case studies comparing innovative buildings including an earthship home; a kit home with reverse-timber-veneer walls; an earthquake-resistant super-adobe walled art studio; homes with straw panel and strawbale walls; and those with CO₂-absorbing hempcrete wall infill. The paper describes the lessons learnt in Stage 1 that have improved the Stage 2 building standards, and considers the carbon life cycle for five homes. NEV has created a healthy, high-performance residential precinct with affordable, low embodied carbon homes, some built on difficult sites. This study provides a glimpse into the future of housing to 1) lower its impact on the electricity grid, 2) mitigate home operational and embodied carbon emissions for the climate emergency, 3) adapt homes for heatwaves, and 4) provide home energy storage as bi-directional charging becomes available for electric vehicles and they are charged from renewable energy.

Live data-driven digital twin approach for assessing social and environmental building performances in high-rise mixed-use developments: a conceptual framework and

As the demand for socially responsible practices in the built environment industry increases, incorporating social considerations within building performance evaluation becomes essential. Current building performance evaluation approaches predominantly emphasise environmental performance, lacking a comprehensive understanding of the interplay between social and environmental performances. This paper proposes and explores a conceptual framework for developing a digital twin-enabled approach that facilitates a holistic assessment of building performance, focusing on the interplay between social and environmental performances. The

evaluation of the operational platforms for its implementation

Shtykov, Adii; Gu, Ning; Barrie, Helen; Soebarto, Veronica; Faulkner, Debbie; Kroll, David

presented framework provides a foundation for developing a digital twin-enabled tool that captures various social and environmental performances of a building through live data collection. The paper discusses the underlying technology, data availability, and methods for data collection and incorporation. To demonstrate the applicability of the conceptual framework, an assessment of digital twin operational platforms was conducted. This research addresses challenges in modern building performance evaluation, such as limited scope and focus, insufficient data collection and analysis, and lack of longitudinal studies. This approach integrates performance metrics from various social and environmental assessment methods to contribute towards a more holistic and dynamic understanding of building performance, emphasising the importance of integrating social performance in building performance evaluation and fostering more sustainable, occupant-centric built environments.

Building with Nature: The Case of Floating Houses in Agusan Marsh, Philippines

Sitcharon, Rachel Mae Perono; Malaque III, Isidoro Ramacula

Interest on vernacular and indigenous architecture is gaining more ground in search for socio-ecological approach to planning and design since urbanisation and climate change necessitates reframing the production of architecture as material expression of human-environment relation. Thus, this case study investigated the floating houses of Agusan Marsh in Sabang Gibong, Talacogon, Agusan del Sur, Philippines, home to the Manobo ethnolinguistic group. It documented the architecture, methods of construction, and factors that shape the dwellings and settlement of the community. Through direct observation and immersion, focus group discussions, and structured and key informant interviews, results revealed that there are four typologies of floating houses in the area referred in local dialect as *hapa*, *hanger*, *hapa-hanger*, and *dos andanas*. Further observation revealed that these typologies and settlement pattern are influenced by and in response to environmental conditions specific to Agusan Marsh, local materials available, and financial capacity of households. This indigenous practice reflective in the vernacular architecture maximizes environmental conditions as opportunities to produce man-made environment that complements the dynamism of marsh ecosystem. Thus, this study demonstrates the agency of the people in shaping the built and natural environment, which plays important role towards sustainability of the marsh landscape and its people.

Investigating strategies to be future-climate ready: A case of dwelling for low-income older people

Soebarto, Veronica; Le, Ha Than

Recent studies have discovered that many people in Australia live in cold homes but also in homes that become extremely hot in summer. The dwellings can only become comfortable with heating and cooling; however, not all occupants use air-conditioning due to cost implications, worsened in recent years due to increasing energy prices. Extremely cold or hot indoor environment and a total reliance on air-conditioning indicate poor design that should be urgently addressed not just in new but also existing homes as poor thermal environment is linked to poor health/wellbeing outcomes. Addressing this problem becomes more critical in older people's housing, because as people age, they become more vulnerable to poor indoor environment. The warming climates further highlight the need to address this issue. This paper presents a preliminary study of investigating the current thermal performance of an existing dwelling of an older occupant using building monitoring and simulation where the model was calibrated to measured data. The calibrated model was

used to predict the dwelling's performance in 2030 and 2050. To improve resilience of this dwelling in future climates, strategies were investigated, including those of low cost as well as more substantial changes such as installing double glazing and changing the floor construction. The results indicate that passive design strategies already known for years, such as thermal mass, shading and reducing leakage, will increase the chance of the dwellings to be comfortable without heavy reliance on heating/cooling even in future climates, but these are often absent in current housing developments.

Improving resilience of housing for low socio-economic older people: Let's first look at the frailty level!

Soebarto, Veronica;
Williamson, Terence;
Visvanathan, Renuka;
Pisaniello,
Dino; Arakawa Martins,
Larissa

This research aims to gather information about existing house conditions of low socio-economic older people in South Australia including of those from culturally and linguistically diverse groups, in order to advance knowledge about resilient and affordable older people's housing. The first stage includes focus group discussions, which so far have involved more than 40 older people and were conducted in English, Mandarin and Cantonese. The second stage involves collecting relevant data of 50 older occupants who participate in indoor environmental monitoring and occupant surveys, through interviews as well as frailty level assessments using validated tools. Environmental data loggers have been installed to record indoor and outdoor dry bulb temperatures, indoor globe temperatures, relative humidity, air velocity as well as indoor and outdoor CO2 concentration, every 15 minutes. Thermal image camera and blower door tests are used to detect sources of air leakage and calculate infiltration rates in selected homes. In the third stage, data collected will be analysed to develop improvement and new design strategies to improve wellbeing and reduce operational costs. This paper reports the preliminary results from the indoor environmental monitoring and occupant surveys. The results so far show significant differences between older participants identified to be frail and severely frail and those who are identified to be non-frail and vulnerable in terms of their thermal sensation, preference and satisfaction as well as the strategies they take to be comfortable. Lessons learned from these shall be considered in developing the relevant housing improvement strategies for the future

Modeling of timber moisture content in the supply chain

Tanton, David;
Dewsbury, Mark;
Kotlarewski, Nathan;
Wallis, Louise; Ettelaei,
Azin; Kuenzel, Hartwig;
Bludau, Christian

For the last three decades Architects and Engineers have used one and two dimensional hygrothermal simulation tools to better understand the flow of heat and moisture through building envelopes. These tools have provided significant guidance regarding risks of moisture accumulation and mould growth. Many of the algorithms used in these tools have been established around the physical properties of solid wood products. Recent research has identified significant concerns from the design and construction professions regarding the moisture content of kiln dried solid wood products at construction sites. Changes in timber moisture content are inevitable as it progresses from end of production, through to storage, transportation and installation. Using WUFI® 2D modelling, this research utilises recorded under-wrap temperature and humidity data to investigate the likely change in timber moisture content that occurs due to the use of impermeable membranes for timber packaging. Packaging used for timber is typically impermeable and comes in a variety of colours and translucency. Previous research has proven that timber protected from the elements by impermeable plastic wrap can experience significant moisture content change from 11% to >30%, dependent on climate and storage practices. Such changes in

moisture content are likely to promote mould growth and early stages of decay, rendering the timber unsatisfactory for building applications. This research seeks to prove that digital modelling can be used to reliably predict changes in timber moisture content prior to dispatch and improve management practices including the wrap membrane (thickness, colour and translucency) to mitigate supply claims and material loss.

Modelling of conventional timber drying using alternative methods

TBN

Tanton, David;
Dewsbury, Mark;
Kunzel, Hartwig;
Bludau, Christian;
Nolan, Gregory

Rethinking architectural typologies in times of change – Integrating food production with high-rise residential development for resilience

Teo, Mark Shan Chian

Despite importing more than 90% of its food to meet its local needs, Singapore is ranked the fourth most food secured country in the world, according to the 2017 edition of the Global Food Security Index. Singapore achieves this by adopting a successful food security strategy that is heavily dependent on the global food supply chain and diversification of sources. Yet, considering the recent coronavirus pandemic and the growing threats from the impacts of climate change, a new strategy is needed. Such complex problems will require a design-led approach, leveraging on methods such as foresight, scenario planning and transition design. This paper examines the resiliency of Singapore's food security and explores, through a scenario planning study, the possible roadmap for Singapore to enhance its food security through integrated architectural typologies. Approximately 80% of Singapore's population live in public housing. This presents a unique opportunity as the government has control over a large building stock. How might the Singapore government increase production of leafy green vegetables through Plant Factories with Artificial Lighting (PFAL) integrated with public housing. In a land-scarce country like Singapore, this presents an unique opportunity for agriculture to be practiced in a highly urbanised setting without using additional land.

Future of work: positioning home offices in the work landscape

Thilakarathne
Mudiyansele,
Sachithra Kumari
Thilakarathne; Petrovic,
Emina Kristina; Vale,
Brenda

The COVID-19 (coronavirus disease) pandemic shook the world by storm and affected human living in various ways and at multiple levels, politically, socially, and economically. The changes emerging from workplaces of new working habits could be considered one of the most significant transformations. Although working from home has become the new norm globally, more knowledge is needed about the impact of working from home. There is a significant amount of literature on the effects of working from home on productivity and health/well-being. In contrast, the physical and environmental implications of remote work require further research. This paper begins by examining the historical context of working from home and its current position in the modern work landscape. It then sets out a proposed study to investigate the physical aspects of home working, such as space design, adaptation and user experience of home workspaces, in order to understand whether fully or partly working

from home has benefits in both personal and environmental terms, focusing on Wellington, New Zealand, as the context. This study will be exploratory and inductive. Ultimately, the proposed study aims to develop guidelines for optimising home office workspaces and environments.

Architectural Design Andragogy: Insights from Online Learning

Thilakaratne, Ruffina;
Schnabel, Marc

Architecture education traditionally based on a distinctive andragogy, that revolve around design studios with a strong emphasis on hands-on technologies and face-to-face discussions. However, the COVID-19 pandemic necessitated a rapid shift to online learning, fundamentally reshaping the conventional studio format. This paper presents a rigorous study that scrutinizes the effectiveness of online design learning in terms of learning outcomes, challenges, users' feedback and future adaptations. More than ninety undergraduate and postgraduate students who experienced face-to-face and online learning participated in an online survey. The educators participated in interviews. The findings emphasize advantages of online learning, particularly in pre-design phases such as site analysis, research, program development and validation. Nonetheless, students expressed notable limitations in developing design ideas through discussions with tutors and peers, leading to slower progress and dwindling commitment, ultimately fostering demoralization. Educators also encountered challenges in assessing students' reactions, emotions, learning progress. Notably, junior students exhibited reduced motivation and commitment within the online studio environment. To foster authentic learning experiences, the paper concludes with recommendations for post-COVID architecture design education, focusing on infrastructure improvements, integration of hybrid modes, and students' engagement and well-being, while preserving the quality and effectiveness of learning. Overall, our research underscores the pivotal role of traditional design studios in fostering creativity and collaboration among architecture students. While online learning offers certain advantages, particularly in pre-design phases, the irreplaceable value of face-to-face interactions remains evident, emphasizing the need for a balanced and hybrid approach in the post-pandemic architectural education landscape.

Regulation for comfort: an investigation of policy and practice in Australian homes

Thomas, Leena
Elizabeth; Thomas, P
C; Venkatesan, Aysh;
Powles, Rebecca

On average, 40% of the energy consumed in residential buildings in Australia is expended towards space conditioning to ensure comfort and well-being of occupants. While national regulations have focused on the thermal efficiency of the building fabric, that is assessed in relation to predicted energy based on heating and cooling setpoints, less attention is paid to the actual practices and outcomes for occupants in these buildings. This study reflects on the regulatory landscape of systems such as NATHERS in Australia to investigate how thermal comfort is perceived and mandated in residential settings. It compares actual occupant practices drawn from a two-year monitoring study of 40 homes in western Sydney (by the authors), against some assumptions built into the regulatory systems. Findings indicate that rating assumptions - such as bedrooms are only occupied at night, and unrealistically low thermostat settings in winter - are out of touch with observed and prevailing practices. Computer-based modelling is used to the impact of alternate occupancy settings on predicted energy, comfort and building fabric performance. This study reveals an underestimation of energy use which compromises the thermal performance and specifications of the building envelope

by the equivalent of a one star under NATHERS. These findings call for changes in the regulatory settings whereby bedrooms must be assessed with a night time heating set point of 18°C instead of 15°C and should also be tested for comfort during the daytime, and that the necessary improvements to the building fabric to account for these changes are mandated.

**Keeping it simple:
Public messaging and
climatic design
guidance for the built
environment**

Volz, Kirsty; Healy,
Emma

A variety of resources, toolkits, guides, and frameworks have recently emerged to manage built environment outcomes in response to climate change however methodologies for assessing the social and economic value of design guidelines have not been established. This is because the procurement of guidelines by local and state governments has, to date, been relatively reactive, reflective of rapid social change and climate events. Assessing the impact and successful implementation of guidelines is challenging because of a lack of data and benchmarks. This paper emerges from a larger research project that aims to firstly collate various design guidance documents published by local and state governments in Australia and then to establish a method to analyse the social, environmental and economic value of design-led policy for the built environment. Utilising a content analysis method, this paper focuses on climatic and climate resilience design guidelines produced by local government authorities in Southeast Queensland and the Queensland State Government to establish a preliminary framework for assessing different communication methods employed.

**Stop the chop: A
humane response to
city tree loss**

Wake, Susan J.;
Havell, Robert

This paper outlines the rationale and methods used to collect feelings from the School of Architecture community about recent tree losses on the Unitec Te Pūkenga campus, due to land sales for housing. The aim was to use this data to inform a research by design process to propose a memorial to be constructed on-site, as an appropriate reminder of the lost trees and to educate about the importance of trees in our environment. Data took the form of emails shared by staff soon after a significant tree removal and anonymous comments by students that were written on posters created by the authors and put up around the School of Architecture building. In agreement with other authors, social factors such as strength of place attachment is important in considering views on contentious issues such as tree removals – which are equally revered and reviled in the landscape, despite their established benefits of shading, cooling, water absorption etc. Themes were drawn out of the data and connected to the design via Bowring's taxonomy of possible memorial treatments. 'Healing and Repair' was chosen as the best approach matching the themes and a site on the campus was chosen to create a memorial, using research by design methodology. The paper presents sketch plans and perspectives for a design based on Akira Miyawaki's mini forests. It concludes that considering both social and physical aspects of trees encourages a more humane response to city tree loss and may lead to greater environmental stewardship and social resilience. In this case it not only provides a 'living memorial' that addresses climate change, it acknowledges trees as beacons of legibility within the landscape, symbols of meaning, improvers of the environment and significant contributors towards the zero-carbon nexus of lifestyle and well-being.

A solar PV-driven heat pump for conditioning a test room

Wang, Zheng; Luther, Mark B.; Do, Hung Q.; Matthews, Jane; Liu, Chunlu

Growing concern over residential carbon emissions has highlighted the necessity to electrify and decarbonize building conditioning by moving away from reliance on natural gas and towards renewable generation. Therefore, this paper experimentally investigates the energy and comfort performance of conditioning a test room using hydronic radiant ceilings connected with an off-grid solar photovoltaic (PV)-driven heat pump. The heat pump is connected to two water tanks that provide heating and cooling energy for radiant ceilings. PV generation, battery state of charge, direct current (DC) loads and heat pump power consumption are measured with a Victron Remote Monitoring application and an AcuDC power meter, respectively. Due to seasonal constraints, only the heating test was performed. The average hot tank temperature and the conditioned performance of the test room are measured at one-minute intervals using a CR10X Campbell Scientific data logger and a comfort cart, respectively. The results demonstrated that the heat pump heated the hot water from 18.8 to 60 °C in less than two hours. During this period, the battery state of charge dropped slightly from 100% to 91% as the PV was simultaneously charging the battery. The room yielded substantially stratified temperature results and moved progressively towards comfort, as the predicted percentage dissatisfied (PPD) approached 0.1, and the predicted mean vote (PMV) approached -1 to 0. This paper demonstrates the feasibility of using hydronic radiant ceilings together with off-grid PV-driven heat pumps for space heating. Future research will investigate the energy and comfort performance of this system for space cooling.

Testing of new feedback methods for architects on school design – methodology and preliminary results

Whittem, Vanessa; Nakai-Kidd, Akari; Sadick, Abdul-Manan; Roetzel, Astrid

Architects and designers need feedback from completed buildings to improve the sustainability of future designs. Besides quantitative measures like energy performance, embodied energy, and water use, sustainability also includes assessment of qualitative aspects such as occupant wellbeing, psychological and physical comfort and social and community connection. For this research, school buildings were selected as a test typology due to the large body of pre-existing qualitative research, multi-disciplinary research community, worldwide application and long-term effects on people. A prior literature review determined gaps in the comprehensiveness of available feedback methods for schools. A prior survey of Australian architects ascertained aspects upon which they desire feedback and showed that existing feedback methods omit aspects architects believe are necessary to improve future designs. This paper presents methodology and preliminary results of new feedback methods designed to provide comprehensive, designer-friendly, and easy-to-analyse feedback. These methods included on-line surveys for older children, teachers, administrators and parents, a drawing-voice activity for younger children, and other visual response methods for all grades. They are compared to more traditional methods including instrument recording of classroom indoor environment indicators, walk-around interviews with staff and a traditional style post-occupancy evaluation survey of staff. The overall results of this study will illuminate the strengths and limitations of more traditional feedback methods and offer insight into alternate feedback methods that gather design-related experiential information.

Socialized Housing Adequacy from the Lens of Potential Housing Intenders: The Case of Davao City, Philippines

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The growing Philippine housing backlog has resulted in increasing socialized housing developments, the country's primary mode of housing delivery. While it aims to address the Filipino's dream of home ownership, it is necessary to consider what the potential users think of the current housing provision. This study asked 401 individuals regarding their perception of the current socialized housing and determined their willingness to live in such developments. Principal Component Analysis was used to group the 53 housing variables into components. Confirmatory Factor Analysis was utilized to determine if the variables manifest a specific construct and Multiple Linear Regression Analysis helped determine which factors significantly explain the perception. Additionally, the qualitative perception was noted and grouped into themes to further explain the results of the perception index. About 63% of respondents expressed interest in moving to a socialized housing development while 37% do not intend to live in a socialized housing development. Overall, the housing intenders perceive the current housing provision as "satisfactory" while the non-intenders rated it as "neither satisfactory nor unsatisfactory". The quality of the dwelling unit, social environment, acquisition and financing, were found to be significant factors in the respondents' perceptions. Despite being a practical housing choice, many respondents expressed that the current socialized housing provision is small, low in quality, and unaffordable. With a rise in row-house socialized housing developments, prioritizing the potential residents' voices is crucial. The study underscores embedding aspirants' preferences to ensure new projects match their needs, enhancing contentment, sustainability, and suitability.

Impact of indoor environmental quality satisfaction on guests' rating of Australian tourist accommodation

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Numerous studies have shown that indoor environmental quality (IEQ) plays a significant role in occupant satisfaction in office buildings, yet insufficient research has been done on how IEQ factors affect customer ratings of hotels and serviced apartments. This study analyzed 543,213 guest reviews from 1,397 Australian hotels and serviced apartments with 2-5 stars on Booking.com using web-mining, natural language processing, and the Three-Factor Theory of customer satisfaction. The sentiment polarities for nine IEQ factors were calculated to estimate the IEQ satisfaction. The Three-Factor Theory and mixed effects models were applied to model the asymmetric effects of IEQ factors on guests' rating scores. All IEQ factors except for exterior view were considered Basic Factors of customer satisfaction, meaning that customers expect satisfactory performance of these factors. Exterior view served as an Excitement Factor in accommodations with 3 stars and lower, a Performance Factor in those with 4 stars, and a Basic Factor in 5-star guest homes. When IEQ performance was deemed satisfactory, the most influential factors in determining overall satisfaction were exterior view, cleanliness and maintenance, and acoustics. When IEQ performance was unsatisfactory, the most influential IEQ factors were cleanliness and maintenance, indoor air quality, and acoustics.