



**ASA  
2018**

**Engaging Architectural Science:  
Meeting the Challenges of Higher Density**

# **BOOK OF ABSTRACTS**



52nd International Conference of the  
Architectural Science Association (ANZAScA)  
28 Nov - 1 Dec 2018, Melbourne, Australia

THE ARCHITECTURAL SCIENCE ASSOCIATION AND RMIT UNIVERSITY

**ASA**  
**2018** Engaging Architectural Science:  
Meeting the Challenges of Higher Density

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**WEDNESDAY, 28 NOVEMBER 2018**



# **ARCHITECTURAL SCIENCE: BUILDING SCIENCE AND BUILT ENVIRONMENT QUALITY (I)**

# 1106. Development of a model of adaptive thermal comfort and preference for housing in Australia

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In Australia, the primary mandatory building performance assessment method for new homes indirectly references the ASHRAE 55 Standard adaptive thermal comfort model, which has not been extensively tested or validated for houses in this country. Emerging evidence suggests that while an adaptive model of thermal comfort is likely to be most appropriate for specification and assessment of residential buildings, this particular model does not adequately reflect Australian households' comfort preferences. Responding to the need for a uniquely Australian residential comfort model, a substantial database of observations from thermal comfort field studies in houses has been compiled. The database currently comprises of over 49,000 thermal comfort "votes", contributed by occupants of around 300 houses and apartments. The paper presents a series of investigations of methodological issues, fundamental in the development of a new adaptive model.

**Keywords:** Thermal comfort; adaptive; preferences; residential.

# 1136. A Pilot Study on Users' IEQ Perceptions in a Residential Aged Care Facility in Melbourne

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The aged population in Australia is expanding rapidly. To cater for the Australia's ageing population, there is a significant increase in demand for aged care facilities over the coming decades. The indoor environmental quality (IEQ) affects users' physical health and psychological wellbeing. However, systematic research on the relationship between users' perceptions and IEQ of aged care facilities has yet to be developed. In this pilot study, a residential aged care facility in Melbourne was selected as a case study for investigating the differences between the measured IEQ data and the users' perceived individual comfort. A questionnaire survey was conducted to collect the perceptions of users on IEQ. Environmental sensors which enable web-based data monitoring were deployed. The measured data were then analysed together with the questionnaire survey results for drawing a comparison with the users' perceptions. It was found that the measurements by environmental sensors are realistic and the survey questionnaires are appropriate for the study. For the future surveys, the language barrier needs to be considered for non-English speakers.

**Keywords:** indoor environmental quality; residential aged care facility; thermal comfort; design for ageing.

# 1145. The impact of IEQ factors on people on the autism spectrum

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This study is an exploratory investigation into whether differences in sensory processing impact the way people on the autism spectrum perceive the built environment, focusing on the effects of individual indoor environment quality (IEQ) factors. Adults on the autism spectrum (n=83) and neurotypical control adults (n=134) participated in an anonymous online survey and were asked about their home and workplace environments, experiences of the general built environment, and general sensory sensitivity. Autistic participants, who reported significantly higher sensory processing scores than control participants, consistently reported significantly higher discomfort due to IEQ factors in both their home and workplace, as well as a greater cause for avoidance of buildings in the wider built environment. While the control group indicated that thermal comfort had the greatest effects on them, the Autistic group was more concerned with people, noise and artificial lighting based factors. These results indicate a need for further research into how and why some IEQ factors have a greater effect on people on the autism spectrum to be able to suggest solutions to create a more accessible built environment. Improving IEQ for the most sensitive of the population is likely to improve the built environment for all users.

**Keywords:** Indoor environment quality (IEQ); autism; discomfort, avoidance.

# 1198. Is new housing a health hazard?

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The National Construction Code has been regularly enhanced since 2002 with an effort to reduce greenhouse gas emissions. Many aging, and very young Australians spend most of their time within their homes. Coincidentally, in Australia, asthma is the leading cause of disease in children aged 0 – 14 years, accounting for 17.9% of the total burden in boys and 18.6% in girls. Many researchers have supported a connection between damp housing and sensitivity to dust mites and other childhood respiratory symptoms. Within Australia's temperate and cool temperate climates, the commensurate change in energy efficiency requirements in the national building regulations may have inadvertently created ideal interior environments that promote mould growth. If the built environment is promoting mould growth, leading to sick building syndrome, it is a matter of serious concern that could be resulting from design or technical flaws in the building fabric. This concern, which has been raised by medical scientists, requires the action of architects to provide guidance on methods to passively, or actively, manage air-borne moisture within homes and workplaces. This paper attempts to bridge the gap between architectural and medical science perspectives in this area of study.

**Keywords:** National Construction Code; greenhouse gas emissions; sick building syndrome; childhood respiratory symptoms; condensation; moulds.

# 1194. Impact of facade design on indoor air temperature and thermal comfort in residential buildings

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This study aims to investigate the impact of building façade design on indoor air temperature and thermal comfort in naturally ventilated residential buildings in tropical climate. Firstly, field experiment was carried out in residential buildings in Singapore. In each unit, indoor air temperature, relative humidity and wind speed were measured continuously for one week. The impacts of window-to-wall ratio (WWR) and orientation on the hourly indoor air temperature were analysed. It was observed that the north-facing room could be 3oC hotter than the east-facing room on sunny afternoon in July. Secondly, the thermal comfort inside the measured units were assessed using the Predicted Mean Vote (PMV) model developed for tropical climate. The impact of façade orientation and WWR on indoor thermal comfort was analysed. Thirdly, computer simulation using Energy plus was conducted to investigate the impact of WWR, orientation and length of shading device on indoor air temperature. Based on obtained results, facade design recommendations were provided for better indoor comfort in tropical climate.

**Keywords:** Thermal comfort; façade design; tropical climate; naturally ventilated building.

# **ARCHITECTURAL SCIENCE, CONSTRUCTION AND TECHNOLOGY (I)**

# 1181. Circular economy construction: lessons from applied experimentation

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The Circular Economy (CE) poses an immense challenge to the construction sector. For the first time in the history of modern construction key stakeholders are required to consider the end-of-life pathway for building components and materials. CE principles essentially necessitate that any material is productive and without the potential to contaminate in all stages of its life-cycles. These conditions disrupt established construction methods that we have relied on to fix materials together and achieve a water-tight building envelope. This paper reports on an ongoing research project that is working to design and deliver CE building solutions. The initial phase of this study has focused on re-designing light timber framed buildings for optimal resource recovery and material reuse. Through design-led research experimentation a range of recoverable structural frames, cladding and wall lining solutions have been built and tested. The experiments have culminated in the identification of a series of key lessons and challenges the industry will face as it attempts to move towards a CE. This paper outlines what problems occur, why, and how they might be resolved through design.

**Keywords:** Digital fabrication. Closed-loop design. Digital-timber. Circular Economy.

# 1183. Creating a smarter building system: Design of a prefabricated envelope system for cross laminated timber

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Cross- Laminated Timber (CLT) is a contemporary engineered panelised wood product and its use in construction globally is growing due to various benefits. The aim of this research is to design, develop and create a prefabricated envelope system for mass timber construction using CLT. The research capitalises on customisable building panels as they can be fabricated off-site. The design of a prefabricated envelope system is seen as the next frontier in productivity gains. The prefabricated system is designed iteratively and developed using parametric based CAD software (Computer Aided Design). CAD software facilitates the creation of a prefabricated envelope system for Mass Timber Construction (MTC) by establishing geometric relationships that respond to the unique nature of any construction site. The prefabricated envelope system is devised of proprietary joints specific to different types of cladding and unique environmental conditions. The exploration process includes fabricating the iterative schemes to test joint and hinge movement at the correct scale. The final designed envelope system can be optimised and fabricated off-site, delivered to the site, and erected quickly without need for scaffolding. The design and process results in an immense reduction of overall construction time and costs.

**Keywords:** Cross-Laminated Timber; prefabrication; construction; optimisation.

# 1196. Prefabrication: New Zealand manufacturers of prefabricated buildings and components 2017

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The New Zealand population is growing fast. In 2017 it was 4,776,500 and has a 90% probability of increasing to 5.30–7.88 million by 2068. This raises the need for more houses that can be built easily, cheaply and fast and be aligned with the contemporary needs of the growing population. This paper focuses on prefabrication as a method of construction that can help the New Zealand housing industry to meet this growing need for more houses. This paper is part of a larger study investigating the use of prefabricated Accessory Dwelling Units (ADUs) as a potential solution to the shortage of housing in New Zealand. This paper reviews 182 manufacturers of prefabricated buildings and components throughout New Zealand to achieve a better understanding of the services they offer, product innovations, and limitations. All data is culled from manufacturers' websites. An initial analysis reveals that prefabrication in New Zealand is currently focussed on components such as trusses and panels and not on whole buildings. The paper ends by considering what needs to happen if existing manufacturers involved in prefabrication have a role to play in meeting New Zealand's housing needs.

**Keywords:** Prefabrication; New Zealand population; housing shortage.

# 1211. Engineered timber for apartment buildings in Melbourne, Australia: A construction cost comparison with traditional concrete systems

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Engineered timber is rapidly growing in popularity in both the Australian construction industry and abroad. While projects utilising the material as their main structural element are often lauded as being faster, safer, and ultimately cheaper than more traditional systems, there is limited scientific literature to support this. This research attempts to bridge this gap by reviewing and comparing construction costs associated with a five-storey case study building in Melbourne, Australia. The paper considers the construction of this building in three distinct scenarios: an engineered timber superstructure, a reinforced concrete superstructure, and a hybrid of both. While featuring different structural materials, each scenario is designed to be comparable in the areas of fire and acoustic rating, structural sizing (e.g. wall thickness), and compliance with the building code. A complete bill of quantities is prepared for each scenario, with the rates of the concrete project benchmarked against rates available in published references to confirm accuracy. Findings show the scenario featuring an engineered timber superstructure to be the fastest and cheapest to build, with potential time-savings of almost 50%, and cost savings of up to 10% compared to a complete reinforced concrete structure. This demonstrates that the use of engineered timber in this context is cost and time competitive against traditional concrete systems. Further research is needed to establish if this holds true in other contexts.

**Keywords:** Engineered timber; mid-rise construction; pre-fabrication; cost benefits.

# 1245. Embracing natural timber features of plantation hardwood: Material-aware digital workflows in product design and development

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The adoption of digital workflows within the architecture and construction industries is wide spread. Advanced digital methods including parametric and associative tools, integrated and iterative optimisation and file-to-factory automated fabrication workflows are now common in architectural and design offices internationally. These tools offer unique, fast and flexible opportunities for designers to conceptualise, rationalise, communicate and fabricate a wide range of complex designs that were previously deemed too complex to produce. While there are many contemporary examples of digital workflows used in the development of architectural solutions, there are limited examples where these tools have been used to deliver architectural products with low-value materials for the built environment. There is a current market-pull for the use of timber products in Australia and a resource-push to utilise emerging low-value Australian plantation hardwood timber. This emerging resource is deemed low-value by the excessive amount of natural feature that prevent its use in structural and appearance grade products. This research demonstrates the development of unique timber architectural lining products utilising digital workflows to rapidly generate unique product design outcomes with low-value materials that can be manufactured according to user defined parameters.

**Keywords:** digital workflows; plantation hardwood; natural timber features.

# **ARCHITECTURAL SCIENCE: BUILDING AND ENERGY (I)**

# 1128. Impact of building envelope design on Auckland public library energy consumption

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This study investigated impact of building envelope design on energy consumption of Auckland public libraries under local climatic conditions. Energy consumption data and library building envelope design data of the 30 libraries (55% of local library buildings) are used for this study. The study investigated and identified relationships between daily mean energy consumptions per unit volume of library building indoor space (kWh/m<sup>3</sup>/day) and library building design data such as ratio of building surface to volume. Building design data related to building envelopes were calculated according to building plans of the sample public library buildings. This study converted monthly energy consumption data into annual, winter, heating-months and summer daily mean energy consumptions per unit volume of library building indoor space (kWh/m<sup>3</sup>/day). This study focuses on impact strength of building envelope design on library annual, winter, heating-months and summer mean energy consumptions and identifies quantitative relationships between the building design data and the energy consumption data, which can be used to proximately estimate the amount of saving energy consumption associated with the change of a design datum for the future library building development. This study also identified some design issues related to energy efficiency of local library building design.

**Keywords:** Building energy, building envelope, building thermal design, library building design.

# 1176. Beyond the 'premium-for-height' framework for designing structural systems for tall buildings: considering embodied environmental flows

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During the 1960s, the Bangladeshi-American structural engineer and architect Fazlur Rahman Khan proposed a design framework for the structural systems of tall buildings titled 'premium-for-height.' Khan argued that the challenge of a structural engineer is to design structural systems that minimise the 'premium-for-height' of tall buildings as defined by the increase in material per gross floor area with increasing building height. This framework has had a profound influence and is commonly cited in the literature. However, in meeting the challenges of climate change and higher density, minimising the initial embodied environmental flows of tall buildings, such as greenhouse gases, must also become a priority in design frameworks. This paper discusses the limitations of the 'premium-for-height' framework and the importance of considering initial embodied environmental flows of tall buildings during their structural design. Finite element modelling and advanced structural analysis are proposed to assess the structural performance of tall buildings. The Path Exchange (PXC) hybrid life cycle inventory analysis method is proposed to analyse the initial embodied environmental flows of structural systems. This research forms the basis of a revised framework for the design of structural systems in tall buildings.

**Keywords:** tall buildings; structural systems; premium for height; embodied environmental flows.

# 1213. A methodology towards achieving Net zero energy performance for high-rise residential buildings in Australia

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Achieving Net zero energy (NZE) standards for high-rise residential buildings is a significant challenge. One of the challenges is the absence of detailed design guidelines for selecting systems, technologies and strategies necessary to achieve the goal. For this reason, design practitioners are not empowered to participate in the creation and the proliferation of Net zero energy high-rise residential buildings. This paper aims to address this challenge by proposing a framework for the creation of a reference guide that will enable the design of Net zero energy high-rise residential buildings in Australia. Referencing the National Carbon offset standards for buildings framework for definition and the cost-optimal framework of the European Union EPBD Directive 2010/31, the methodology addresses key issues of: reference building selection, energy performance assessment and enhancement approaches, building performance simulation strategies and cost-optimal analysis based on the net present value approach. The methodology is applied to a case study high-rise residential building in Melbourne for testing and fine-tuning, with the aim of applying to similar high-rise residential buildings in four additional NatHERS-based climate zones in Australia. The findings will contribute to the development of a design reference guide for achieving Net zero energy performance in high-rise residential buildings in Australia.

**Keywords:** Net zero energy, high-rise residential buildings, building performance simulation, Cost-optimal framework.

# 1271. Electricity demand reduction in Sydney and Darwin with local climate mitigation

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Urban overheating in synergy with global climate change will be enhanced by the increasing population density and increased land use in Australian Capital Cities, boosting the total and peak electricity demand. Here we assess the relation between ambient conditions and electricity demand in Sydney and Darwin and the impact of local climate mitigation strategies including greenery, cool materials, water and their combined use at precinct scale. By means of a genetic algorithm, we produced two site-specific surrogate models, for New South Wales and Darwin CBD, to compute the electricity demand as a function of air temperature, humidity and incoming solar radiation. For Western Sydney, the total electricity savings computed under the different mitigation scenarios range between 0.52 and 0.91 TWh for the summer of 2016/2017, namely 4.5 % of the total, with the most relevant saving concerning the peak demand, equal to 9 % with cool materials and water sprinkling. In Darwin, the computed peak electricity demand is of 2 % with respect to the unmitigated condition. Greater savings could be achieved acting on the demand linked to hot and humid conditions.

**Keywords:** Urban Heat Island; Cooling; Energy; Building.

# 1273. 5x4 Hayes Lane Project: learning from a grand design

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The 5x4 Hayes Lane Project was built in response to some of the current housing issues being exacerbated by a rapidly expanding global and urban population. One of its main aims was to minimise operational GHG emissions without compromising liveability or lifestyle. It appeared on Grand Designs Australia in 2015 as an exemplar of environmentally sensitive design. The design intent was to eliminate fossil fuel-based energy through omission of gas to site, a high performance envelope, geothermal heat pump, energy efficient appliances, a roof and wall mounted grid-connected solar power system, and the purchase of 100% renewable energy from the grid. With the building having now been occupied for three years, this paper presents the results of an operational performance evaluation to understand whether the project's minimisation of GHG emissions goal has been realised. Operational energy-related GHG emissions were calculated based on energy use and generation data collected from energy bills and on-site meters. The study found that the 5x4 Hayes Lane Project would have resulted in net operational GHG emissions of 13.8 kg CO<sub>2</sub> e per day without the purchase of renewable energy from the grid. While this is lower than average Melbourne households, there is still room for improvement. The findings of this study provide an opportunity to re-evaluate current building design and performance and set more ambitious, but achievable energy use and GHG emissions targets for future housing. The 5x4 Hayes Lane Project demonstrates a different approach for addressing some of the challenges that come with a need for higher density housing. It shows how infill housing can be used to capitalise on under-utilised land with high amenity and liveability while at the same time achieving improved environmental performance. However, it also shows that a substantial reduction in operational GHG emissions is not necessarily easy and ongoing monitoring and improvements are often needed to achieve optimal performance.

**Keywords:** Infill housing; greenhouse gas emissions; energy; life cycle.

# 1182. How big should my battery be?

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Solar photovoltaic systems have been planned using rules of thumb and theoretical models, often in Excel spreadsheets, to size and explore the system required. These programs implement models based upon first principles and consider seasonal changes, location and orientation. Several are beginning to model battery storage. These methods depend on average data and ignore possible extreme behaviour. In this paper, we report on using grid energy data from a smart meter and harvested solar energy data collected from an existing domestic solar PV system. We use this data to explore the effects of varying solar system size and of adding a battery of various sizes. We examine the relationship between available solar energy, solar PV system size, grid data, house load and battery size using this data.

**Keywords:** Energy; estimation; PV system size; battery size.



# **ARCHITECTURAL SCIENCE: ARCHITECTURE, DESIGN AND ENVIRONMENT (I)**

# 1129. Towards an assessment framework for the environmental performance of alternative, multi-residential housing models

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Reducing the environmental impacts of building whilst improving urban liveability has become a key challenge for the Australian multi-residential sector, as recent projects have been criticised for their poor environmental performance and internal amenity. Alternative models for multi-residential development – such as the Nightingale Model – are a recent response to this challenge. Employing an ‘architecture of reductionism’, the Nightingale Model seeks to deliver superior environmental and occupant outcomes. However, given the infancy of the model, an assessment of its performance is yet to be conducted. Assessments of building performance are critical to developing new and emerging approaches, yet existing evaluation methodologies are plagued by limitations. The most notable limitation is the lack of holistic frameworks that concurrently consider life-cycle ecological impacts and occupant wellbeing. The absence of such frameworks limits the ability to identify interrelationships between areas of performance and may possibly promote problem shifting. To develop an approach that can address this key limitation – and subsequently assess innovative housing models targeting a holistic approach to building performance – the paper concludes with a series of recommendations for approaching the creation of an integrated framework of assessment, which will quantify impacts to ecological and human systems in parallel.

**Keywords:** Performance assessment; multi-residential; alternative housing models; Nightingale.

# 1186. Designing for relationships: housing and communities that improve the quality of life of the high-needs elderly

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Globally population profiles are ageing and the proportion of elderly people with high-care needs is projected to increase at an even higher rate. Subsequently, there is an increasing demand for housing that can support independence and provide a high Quality of Life (QoL). Relationships are one of the significant contributors to QoL for the high-needs elderly. However, a loss of social connection and isolation is a growing social concern in the ageing-society. Housing design can have a significant influence on occupant relationships. Through a qualitative investigation of the experiences and spatial use of 30 high-needs elderly people, the research finds themes for relationships, which included; living with a spouse, having guests in the home, relationships with other residents and staff, and connections with the wider community and nature. In the design of dwellings, there should be attention to flexibility for providing sufficient space for social activities, and design for views and sound to provide control-of and connection-to visitors/neighbours and nature. Walkability and appropriate deployment of communal space should be sought in the design of the complex. These considerations contribute to comfortable and meaningful relationships for the high-needs elderly, thereby enhancing their QoL.

**Keywords:** Design of housing and communities; relationships; high-needs elderly; quality of life.

# 1157. Space syntax analysis of low-income housing in progressive urban settlements: case of Davao City, Philippines

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The incremental construction of low-income housing, in progressive urban settlements in Davao City, Philippines, was observed being directly related to the improvement on the degree of security of tenure. Housing as material expression of the status of its inhabitants, there is a need to further explore on the spatial configuration of low-income housing classified in five contiguous categories from formal to informal housing types. Space syntax analysis is used by architects to examine spatial configuration of houses as reflection of social and environmental outcomes of human movement and social interaction. Thus, the aim of this paper is to use space syntax analysis technique to explore spatial morphology of low-income housing cases from a simple shack in informal settlement to becoming more formal housing types; illustrate interior spatial pattern; and, interpret interior spatial configuration. Space syntax analysis of houses in progressive urban settlements is compared with a housing unit in a planned and completed socialised housing subdivision. This paper maintains a claim that housing, in low-income settlement in developing country, is socially constructed as demonstrated by the valuable contribution of the people, who shape, and whose behaviour is shaped by, the built environment.

**Keywords:** Space syntax analysis; low-income housing; progressive urban settlements; Davao City.

# 1121. The exploration of higher density, family-friendly design considerations for dwellings in Auckland

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The population growth and increased demand for housing in Auckland are causing a rise in the construction of housing infrastructure. This has contributed to Auckland's sprawl and unaffordable housing market. One solution to sprawl is building in higher densities within the city centre. For higher density developments to effectively address sprawl and act as an affordable housing solution, they must accommodate a greater range of potential occupants. This research aims to provide recommendations and considerations when designing higher density housing for the overlooked, family-type occupants. The family friendly design evaluation can be broken down into three scales of urban, building and unit considerations, and are derived from a combination of international guidance documents, case studies and post occupancy studies.

**Keywords:** Urban Sprawl; Higher density; family friendly.

# 1180. Occupant Satisfaction and Comfort in Green Buildings: A Longitudinal Occupant Survey in a Green Building in the Subtropical Climate in Australia

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Understanding occupant expectation and feedback is an important part of building performance evaluation. This paper explores occupant satisfaction change during a 10-year period in a green building located in the subtropical zone. Occupant satisfaction at two timestamps, three and ten years after project completion, were compared. It was observed that occupant satisfaction regarding indoor air quality (IAQ), noise and overall building comfort remained unchanged during the 10-year post-occupancy period. This finding suggests that perceived IAQ, noise, and overall satisfaction with buildings may not be biased by point-in-time of surveys, the year weather or sample characteristics. However, satisfaction scores regarding the two parameters of lighting and thermal comfort are likely to be subject to change over time. The change in satisfaction scores in relation to thermal comfort and lighting might be explained in various ways. The change of climate and sky conditions, and different sample characteristics were the two assumptions considered worthy of further investigations. The study found some evidence of a possible correlation between year weather and occupant satisfaction responses. The study also showed that green buildings with natural ventilation may be more susceptible to climate change impacts.

**Keywords:** Building performance; green buildings; occupant satisfaction; thermal comfort.

# **ARCHITECTURAL SCIENCE: DESIGN EDUCATION AND RESEARCH (I)**

# 1163. Using eye-tracking to study designers' cognitive behaviour when designing with CAAD

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This paper presents a case study exploring the eye-movement of two architecture master students while using a CAAD tool. The students completed an architectural design task using CAAD software in a 60 minute design session. The "Think aloud" method was used to collect cognitive data while their eye movements were captured using eye-tracking equipment. The session was segmented and coded for visual location. Results of this exploratory study indicate differences when using a CAAD tool when designing compared to visual scanning of existing objects. These results, if generalizable, imply that CAAD software development should focus on space making as well as on object boundaries.

**Keywords:** Eye-tracking; CAAD; Protocol analysis; Design cognition.

# 1224. Intensive Design Building Studio: A Collaboration with Industry

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The purpose of this paper is to explore a case study project between a timber supplier, industry body and an architecture school. The project, an installation stand, became a test to access how resilient junior architectural students can uptake digital fabrication technologies. The brief was simple, design a product that visitors could touch, create conversation around and showcase materials in an innovative light. The students had no prior experience and found it difficult to understand what the fabrication technology represented but over time they learnt to self-reflect and take on constructive criticism. Laser cut models enabled the students to experiment and reflect on their design decisions, through making. The students discovered that the iterative design process and testing have a direct correlation to the outcome quality. If one step is missed or overlooked – particularly with communication, detailing and planning - the consequence will be added time and frustration. Students successfully obtained the necessary skills surprisingly faster than previous years, the students used conventional design processes alongside modern fabrication skills. The success was that the product produced was received very well and displayed at numerous architectural events. As a result of including industry it creates better relationships that foster innovation and creativity.

**Keywords:** Design Build, Prototyping, Pedagogy.

# 1244. Online delivery of architecture and building design studios: a case study of Central Queensland University

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Online delivery offers students flexibility to choose when, where, and with what pace they wish to learn. This mode of delivery, however, presents challenges specifically for design studio units, which depend largely on students' creative processes and facilitating social interactions with their teachers and fellow students. In practice, design is a collaborative process that engages a range of stakeholders from different disciplines, backgrounds, experiences, expertise, motivations, and interests and integrates their contributions through effective communication. This paper examines challenges, opportunities, and factors that influence students' experiences of online delivery of architecture and building design studio units. It was developed as part of the project funded by Centre for Learning and Teaching at Central Queensland University (CQU) that explores best practices in online delivery of design studios. We present a thematic analysis of students' comments from CQU Unit Evaluation Surveys of two units of Bachelor of Building Design that had emphasis on creative design tasks from 2012 to 2017. Students provided feedback on aspects of the units that they were most satisfied with as well as areas that need to be improved in future offerings of the units. The five main themes that were identified from students' comments had to do with: (1) assessment processes and practices; (2) teacher support and teaching strategies; (3) interactions, communication, and collaboration; (4) unit content and knowledge building; and (5) educational technologies and Computer Aided Design (CAD) software. The paper concludes with a set of pedagogical considerations for online delivery of design studio units.

**Keywords:** Design Studio; architecture; building design; online delivery.

# 1246. SETTING UP THE UPSETTER: a vertical studio for architecture

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Contemporary education systems tend to subdivide learning groups into horizontal slices of similar age or similar levels of experience or skill. Architectural education programmes in most western countries generally follow this pattern and work in a horizontally stratified manner. Similarly, architecture and design practices tend to ossify in patterns around specialisations in work processes. To maintain all the qualities required of creative practice there is a need to shake up these patterns, to destabilize the obvious in order to constantly reinvigorate practice. As design educators and practitioners, we have long recognised a need for what we have called upsetter projects. In 2017 a Vertical Studio experiment involving final year BAS and first year MARCP students was initiated to try and shake things up and generate a stronger peer learning/peer assessment culture. The first half of the paper describes and analyses that original Vertical Studio and discusses the insights gained. The second half makes use of a matrix derived from that analysis and proposes two upsetter projects each using a different method of generation. The paper concludes that there is potential for further use of these methods in the development of upsetter projects designed to enrich both pedagogy and practice.

**Keywords:** Design studio; pedagogy; practice; invigoration.

# 1220. Women in Fabrication: A platform for inclusive and diverse design

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In New Zealand, over half of our architectural graduates are female but this number significantly drops within professional practice. The fact remains that industry is a male citadel whether in the realm of design or manufacture. This paper explores a new generation of women building their own coalitions and strategies that promise to bring about change within the architecture and the construction discipline with the formation of a collaborative group: Women in Fabrication. The purpose of forming a female fabrication group was to support learning through the process of making, creating a project-based platform that created leadership opportunities and better accessibility to fabrication and mentorship. Students were given the challenge of designing and building a pre-fabricated exhibit at a prominent Building Expo in New Zealand. With a timeline of six weeks, students had to learn CAD/CAM technology and apply what they learnt to a real-life design making situation- providing a platform for learning and sharing ideas. Digital design processes allowed for the project to be morphed, tweaked and customized with new interchangeable parts to suit the different prescribed audiences and function. This educational model aims to provide everything from leadership opportunities and understanding fabrication to networking with industry suppliers, whilst also providing senior female role models to young designers at architecture institutions.

**Keywords:** Fabrication; design-build; women; collaboration.

# 1279. Lessons in Density: approaches to teaching housing design for higher densities

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In cities affected by high growth rates the public debates generated by intensification policies are vigorous, dividing opinion along established political lines: higher densities are generally acceptable to the left, and suburban densities are defended on the right. Auckland, New Zealand is not an exception. In architecture, such opinions and the divisions between them can become the source of argument, sometimes exhilarating, in the generally pragmatic routine of housing design. Students in Architecture Schools, many themselves the products of the suburbs also have political opinions, some tending to individualist conservative positions, others open to concepts of social community as a function of housing. Media debates inform and influence our work in design teaching. One side of the debate advocates for the continuation of low density suburbs, regarded as our rightful inheritance, our true culture of housing, and the most secure route to high and stable property values. Thirty years after Thatcher's infamous statement, "social engineering" continues to be debated, even as architects in practice acknowledge that some manifestation of community is a probable consequence of higher densities. Recognising higher density housing as an issue in urban design and in professional practice, our Design Studios include at least one "housing" project in each of the second and third year project lists. These project briefs define housing design as the development of generic models and typologies for the unknown client. Two Elective courses in the Unitec School Programme expand on history, construction detail, sustainability parameters, and prime exemplars of the genre. This Paper describes the Electives and identifies issues that emerge most frequently from the Studio process and from studies conducted in the Electives: density, as the "first variable" in housing, used as a design tool (how to measure it, and how to define its effects); the qualitative issues of privacy and identity; and the readiness of most students to engage with ethical responsibilities relating to user anonymity (concepts of duty). Its conclusions suggest that students of this generation are capable of understanding and using the technical rules of housing design and also to competently express ideas dealing with social dimensions at levels of considerable subtlety.

**Keywords:**



# **ARCHITECTURAL SCIENCE: CITIES AND ENVIRONMENTS (I)**

# 1142. Rehabilitating Healthcare: Healthcare landscapes a catalyst for health, well-being and social equity

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With increasing prevalence of mental illness and domestic violence incidents, there is an ever-growing need for supplying supportive and rehabilitative social and health services. In its current state, the healthcare infrastructure, transitional services, and communities are isolated from one another, creating physical and mental barriers for rehabilitation. Therapeutic landscape research suggests outdoor spaces can facilitate rehabilitative healing, community support, and self-empowerment. This form of preventative and rehabilitative health may bridge the gap between treatment at the institutional level, and day-to-day living, to better support the well-being of vulnerable people. The under-utilised interface between the residential landscape and Kenepuru Community Hospital in Porirua, New Zealand, is used as a case study for testing how therapeutic landscapes may enable hospital infrastructure, residential housing and transitional landscapes to coexist with mutually beneficial relationships. Results suggest that suitable urban integration of these services through therapeutic landscapes will promote well-being for future inhabitants and for the wider community, thus mediating healthcare stigmas.

**Keywords:** Healthcare; Urban integration; Well-being; Vulnerable people.

# 1268. Wayfinding in major waterfront points of interest in Queensland Australia – A case study in Surfers Paradise

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This paper presents a study exploring wayfinding in major waterfront points of interest in Queensland, Australia. Waterfronts are often highly significant spaces, contributing to the tourism industry as urban tourist attractions and providing quality leisure spaces for residents. Wayfinding is a critical issue for tourists walking or driving through urban waterfronts, and may affect a visitor's spatial experience. Yet the syntactical properties of waterfronts in Australian cities have never been analyzed systematically, nor have space syntax methods been employed for improving waterfront precinct design. To solve this problem, the Surfers Paradise central waterfront area in Queensland was selected as a case study. Employing space syntax, three measurements for both pedestrians and vehicles were extracted to capture the spatial characteristics of the case study area. Results identify key locations, that are important for visitors' decision-making during wayfinding processes, both when walking and driving. This paper demonstrates a method for capturing the social and spatial properties of waterfronts in Australia and provides possible new insights into the properties of these important tourism attractions.

**Keywords:** Australian waterfronts, wayfinding, space syntax, Surfers Paradise.

# 1118. Review of Campus Sustainability Rating Systems for Indian Campuses

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Sustainable campus development is becoming universal with an increase in the number of campuses demonstrating leadership on pursuing sustainability. Even though there are various international campus sustainability rating and ranking systems but they are not completely utilized in India. The purpose of this study is to analyse and compare eight of these rating systems and prepare a comprehensive list of sustainability parameters and their indicators. Further, check the presence of these Indicators in Indian Institute of Technology Roorkee (IITR), India campus to lay the foundation of the problems faced by the Indian institutions while rating their campuses. Also, an attempt to rate the IITR campus has been made to identify the obstacles faced by Indian institutions for rating their campuses. Parameters of sustainable development are approximately same in all the campus sustainability rating /ranking systems. Indian institutions lack a measuring and monitoring system due to which they are unable to rate their campuses, leading to a situation where the institutions are unaware of the extent of sustainable development achieved on their campuses. This obstructs the comprehensive sustainable development of the campuses. This paper identifies a need to study sustainable campus development for higher education campuses in India.

**Keywords:** Sustainable development; Campus Sustainability Rating systems; Sustainability parameters and indicators; Indian campuses.

# 1208. Towards an Energy Modelling Framework for Australian Cities

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Accountable for more than 70% of the worldwide CO<sub>2</sub> emissions (World Energy Outlook International Energy Agency 2008) and constantly growing, urban metropolises are the key actors of climate change. A rapid transition of urban areas towards energy efficiency is highly required, in particular for the building stock, which represents the main urban energy consumer. In this context, city municipalities, energy suppliers, housing companies and private owners must be mobilized and bonded around a common low-carbon urban energy strategy.

GIS simulation offers a first step into the development of this long-term strategy. It has long been applied to demographics, social and economic indicators, housing density, property costs, infrastructure, transport and water consumption. In regard to building energy modelling, it has the potential to move from a basic overview calculation down to a precise diagnosis of consumption; its causes, function, location, and time of use. Furthermore, it can allow for prediction of operational energy and carbon emission savings through identifying retrofitting upgrades and refurbishment priorities.

This study demonstrates the potential and implications of an energy modelling framework for Australian cities. A case study of a city's CBD region that encompasses 665 buildings is modelled in 2D and 3D, comparing residential, commercial and industrial development energy prediction. Several strategies are proposed and investigated towards developing a better understanding and mapping of the energy use at a regional scale, suggesting retrofitting potential, energy targets and infrastructure capabilities.

**Keywords:** energy prediction; GIS modelling; city energy.

# 1215. Street greenery; a vital planning integration to overcome carbon dioxide concentration and pedestrian discomfort in urban streetscapes

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With the rapid urbanization, population growth and advancement of technologies, human impact on temperature rise is becoming a severe issue. Unprecedented burning of fossil fuels and deforestation escalate carbon dioxide concentration (CO<sub>2</sub>) and global warming causing many environmental impacts. Road traffic is identified as a major contributor to CO<sub>2</sub> concentration. Integration of street greenery is recognized as the best strategy in addressing this scenario. However, in Sri Lankan context the importance of street greenery is less considered when implementing infrastructure development plans. And the true potentials of street greenery is not adequately researched to implement street greenery as a vital planning strategy. Thus, the research aims at investigating the benefit of street greenery to overcome CO<sub>2</sub> concentration and pedestrian discomfort at street level in local context to highlight the importance of integrating street greenery as a vital urban planning strategy. The paper presents findings of the research conducted in the city of Kandy. Three main street sections of Kandy city were observed, investigated and measured. A clear variation in temperature and CO<sub>2</sub> concentration was identified in Kandy city streets with greenery and less greenery. Pedestrian preference for streets with greenery too was highlighted through the results.

**Keywords:** Global warming; traffic; carbon dioxide emission; street greenery.

# 1212. Urban planning policy practice and climate change adaptation science for sea-level rise impacts upon cultural heritage places in Sorrento, Mornington Peninsula

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Climate change, and in particular sea level rise, erosion, storm surges and inundation, poses significant risk to coastal settlements. With such a high proportion of the Australian and Victorian populations inhabiting low lying coastal areas, it is integral that the coastal edge is managed effectively by conducting up to date climate change studies and risk assessments, as well as implementing strategic adaption responses and plans. Using a qualitative research methodology, this paper examines the role and responsiveness of urban planning policy in seeking to address coastal climate change impacts including sea level rise upon the cultural heritage of Sorrento township on the Mornington Peninsula. Possessing numerous European and Boon Wurrung Indigenous cultural heritage sites that are located along the coastal foreshore that are highly vulnerable to the potential impact of sea level rise, Mornington Peninsula Shire is yet to adopt a climate change adaption plan. Using the coastal towns of Port Fairy and Queenscliff as comparative case studies to assess their level of preparedness, noting their successfully adoption of climate change adaption plans, applied planning recommendations are offered for the Shire to better inform their pending Climate Change Adaption Plan including relevant cultural heritage management strategies.

**Keywords:** Climate change; climate change adaption plan; cultural heritage place; Sorrento.

# 1250. Stepping back: a look at managed retreat in NZ

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In 1990 the Intergovernmental Panel on Climate Change proposed the adaptation strategies of Protect, Accommodate and Retreat, and these were adopted and incorporated into New Zealand's national policy. This paper investigates the practice of managed retreat in New Zealand, with the aim to understand how the strategy has been implemented in the coastal environment. Some local councils have faced vociferous opposition from those who are affected by the implementation of 'managed retreat' as a preferred coastal hazard management strategy. Coastal property is highly valued, and this financial and social investment in the coastal edge is increasingly being threatened by climate related change. Managed retreat both threatens and aspires to protect the significant role the coast plays in New Zealand's social identity. The challenges of implementing, even openly discussing these 'retreat' strategies in an urban residential context in NZ are yet to be fully realised. The resistance to managed retreat appears to be economic, barely veiled as socio-cultural concerns. Should not socio-ecological resilience take precedence?

**Keywords:** Managed retreat; climate change; coastal policy; local government.

# **ARCHITECTURAL SCIENCE, CONSTRUCTION AND TECHNOLOGY (II)**

# 1254. Construction project manager skills: a systematic literature review

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The construction industry is one of the most important economic activities in the world, and research in this field has identified a positive relationship between project management skills and the success of construction projects. This research project systematically reviewed more than 380 documents in 14 academic journals from the construction and project management fields, searching for construction managers' skills and competencies, and identifying key skills in educative terms for graduates. The final selection of articles was reviewed in detail and categorised into three themes: education, project manager competencies, and employment. Additionally, a database with 306 competencies, gathered from the reviewed studies, was quantitatively analysed, grouping them into overarching categories. One of the main findings from this systematic literature review is the importance (in quantitative terms) of a project manager's personal attributes and leadership skills. This systematic literature review explores the current dichotomy that exists within the literature between research about key managerial competencies, and the lack of them within the industry and formal education institutions. Future research will explore how to bridge the gap between academic programs and industry needs.

**Keywords:** Construction, Competencies, Management, Project, Education, Skills.

# 1115. Life cycle analysis of cross laminated timber in buildings: a review

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Greenhouse gas (GHG) emissions have increased for the last three consecutive years in Australia, and this directly threatens our ability to meet our 2030 GHG emission reduction target under the Paris Agreement. Despite progress in reducing building-related GHG emissions, little focus has been placed on the indirect GHG emissions associated with building material manufacture, and construction. Cross laminated timber (CLT) is an alternative construction material that has been subject to numerous comparison studies, including many life cycle assessments (LCA). The aim of this paper is to provide a review of the recent literature on the environmental performance of CLT construction for Medium Density Residential (MDR) buildings and to identify knowledge gaps that require further research. Studies reviewed were sourced from web-based research engine, direct searches on global wood promotion websites, and the review was limited to peer reviewed publications. This review provides a useful basis for informing the exploration of important gaps in the current knowledge of how CLT buildings perform from an environmental perspective. This will ensure a comprehensive understanding of the environmental benefits of CLT construction and inform decision-making relating to structural material selection for optimising the life cycle GHG emissions performance of buildings.

**Keywords:** Cross laminated timber; life cycle assessment; greenhouse gas emissions; construction.

# 1204. Parametric skinning of complex-graphs: an airborne textile structure test-case

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The research project presented in this paper aims to extend the repertoire of architectural design and construction. To achieve this purpose, research-through-design methods are used to match a commonly desired target geometry with a realistic and efficient materialisation strategy. The proposed approach has been tested through construction of practical prototypes that eventuated in a full-scale structure that performed well in a variety of outdoor conditions. The outcome of this work is a workflow for semi-automated skinning of complex graphs such as trusses or space frames. The project tests this workflow through an application to a topologically complex L-system. The L-system graph is parametrically skinned with a continuous, adjustable envelope. The outcomes of this skinning are materialised in fabric to produce a twelve-metre-long, wind-supported, airborne inflatable structure. This workflow is a novel extension of existing approaches to skinning and fabrication of structures based on complex graphs because it allows a hitherto unavailable, fabrication-ready geometric definition of joints between cylindrical and conical tubes of varying diameters. It is significant as a reusable approach to the geometric construction of such joints in a variety of materials and across multiple scales. Furthermore, it is interesting as an innovative prototype of possible wind-supported architectural structures.

**Keywords:** parametric modelling; space frames; textile structures.

# 1151. Unconventional approach to housing design and construction practice in Indonesia and its challenges

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Globally urban housing is moving toward a vertical high-density typology. Addressing the high-density issue in Bandung City, the local government aims to improve the sprawling unplanned-settlement by redesign the area and provide medium to high-rise development in place of sprawled landed housing. A case study of Walk-up apartment project in Tamansari, Bandung is discussed in this paper to elaborate further about unconventional approach to housing design and subsequently in the construction practise. The project was designed by Akanoma studio, adopts an innovative design approach. Design concept was developed based on the understanding of site context and general issues in Bandung, among of them are urban water issue, site topography, and waterfront area within the site. One of the design strategy is to design the building as a stilt structure to maximize absorption area while minimizing site intervention. The design was implemented through a design and built method which is not common in Indonesia's construction practise. During the construction process, issues and challenges are arising. This paper employed deep interview with the stakeholders involved and literature study. This paper aims to study the implementation process of Rumah Deret Tamansari and its challenges.

**Keywords:** walk-up apartment, Bandung, design and built, construction project.

# 1225. The DigiShed: a small structure designed, fabricated and assembled with three emergent digital technologies

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Since 2010 the University of Tasmania, Architecture & Design has fabricated structures using a custom sheet-based digital fabrication construction system. This paper highlights how present and emergent digital technologies have been applied to the design, fabrication and assembly of a small experimental structure known as the DigiShed. The DigiShed has been designed to optimise the characteristics of wood-based sheet products processed with CNC-driven digital fabrication. An analytic comparison is made with an equivalent lightweight timber framed structure. Augmented Reality has been used to communicate each component's physical location within the structure and the overall assembly sequence. The assembled DigiShed has subsequently been used as a canvas for students to investigate design parameters for a cladding system using Incremental Sheet Forming (ISF), a process where a robot arm deforms a flat metal sheet into a three-dimensional form. The paper speculates how the results of the research might be applied to larger and more complex structures.

**Keywords:** digital fabrication; monocoque construction; incremental sheet forming; augmented reality.

# 1197. Learning from the past to build tomorrow: an overview of previous prefabrication schemes

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The world population growth can potentially lead to a shortage of appropriate houses in many countries. It can also increase the cost of land, which will directly affect the price of houses. Given the advantages of prefabrication, this method has the potential to provide numbers of high-quality houses in a short time. However, despite many historic attempts to produce prefabricated houses, there have been many failures. This paper presents a review of previous house prefabrication schemes to better understand the factors involved in their failure. Prefabrication schemes in five different time periods have been reviewed. The review looks at the construction-related needs in each period, the way the method of prefabrication responded to those needs, and any weaknesses of the method. The review ends by suggesting the most important factor for the potential of prefabrication is the current negative perceptions of stakeholders, including house owners and financiers. These negative perceptions come from early prefabrication schemes which focused on quantity and speed over quality and aesthetic aspects, and the fact these schemes were often linked to shortages of conventional building materials.

**Keywords:** Prefabrication; housing; housing shortages; material shortages.

# 1108. Investigating design and construction opportunities for Medium Density Housing on hillsides using concrete pre-fabrication

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Medium Density Housing (MDH) is one of the strategies to address problems within New Zealand's housing situation, namely the shortage of affordable urban housing. Land shortage and/or increasing land cost, overall low productivity and high production cost in the construction sector have been identified among the main drivers of this situation. This paper addresses MDH from a perspective of dwelling design, by adapting typologies to specifically suit hillsides, which tend to be less expensive land types; further it focusses on options to increase construction productivity by way of pre-fabrication, and it explores concrete based construction systems for increased building performance and productivity within the NZ context. This is of particular relevance to the implementation of MDH as a denser typology of dwellings, which often entails the use of higher performing components. Generic hillside MDH typologies and a MDH case study design were developed for a Wellington site, by way of cross-referencing construction systems, performance requirements and hillside typologies. The case study design was further examined with options for site logistics. Trade-offs between productivity (small vs. large pre-fab panels) and complexity/cost of site logistics became obvious and led to a proposal for a multifunctional stay-in-place formwork system, which could increase performance and productivity in NZ housing construction.

**Keywords:** NetZero Energy Home (NZEH); energy simulation; energy monitoring; performance improvement.

# **ARCHITECTURAL SCIENCE, PRACTICE, COMMUNITY AND INDUSTRY ENGAGEMENT**

# 1131. Increasing the capacity for built environment students to connect community to decision making on space

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Place Agency is a collaborative project focused on the theory and practice of placemaking and its various strategies. The project aims to build capacity, test theory, experiment with processes and identify methods to evaluate placemaking decisions in order to create vibrant, citizen engaged public places and ultimately, better cities. A consortium of five universities has co-created a comprehensive suite of placemaking educational modules informed by the industry and have created a framework to deliver 'sandbox studios' where students engage with, design and/or build real-world placemaking interventions. This paper outlines how the project intends to assess the learnings of the students participating in a sandbox studio as understood based on the feedback from the community, the lecturers and the students themselves. Is it increasing the capacity for understanding and implementing placemaking? Is it creating place agents? This paper will present the theory, the practice and the outcomes of those who have participated in the project in 2018.

**Keywords:** sandbox studios, practice-lead teaching, participatory teaching, placemaking.

# 1247. Operationalising the sublime: bringing the sublime from abstract to concrete

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The challenge of meeting the increasing residential demands in New Zealand cities has seen development of urban centres in landscapes of industry, farmland, or natural spectacle. Quarry landscapes which were previously located close to the city are now found surrounded by intensification or even subject to it. Once quarrying ceases, these dramatic landscapes have the potential to play a major role in the public realm. This paper approaches this question of the public potential of deceased quarries by exploring the aesthetic notion of the sublime, specifically how to operationalise it into a productive and practical concept to designers. Contemporary approaches remain too general and mired in cliché to be connected with what creates these experiences. This research argues that the use of stronger representation and design technique can allow the sublime to be engaged with in a stronger manner. The notions of assemblage and affect enable the use of representation to connect to the experience of the sublime. This paper uses a real landscape example to describe a design led methodology of fieldwork, representation and design techniques oriented towards engaging with the sublime that affirms the primacy of sensation with design and research.

**Keywords:** Landscape Architecture, Sublime, Quarry, Representation.

# 1305. Developing an evidence-based understanding of hospital space planning efficiency

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Over the last two decades there has been a steady increase in the demand for healthcare services and a commensurate rise in the global expenditure in health (WHO, 2014). Given the significance of the financial investment in capital works programmes required to meet growing healthcare needs and the expanding environmental impact of the healthcare industry, it is important to gain a detailed understanding of how healthcare infrastructure assets currently perform, the strategic drivers impacting on hospital space use efficiency, and the complex interrelationship of factors that impact on the healthcare environment.

This paper outlines a research project that was conducted by the University of Melbourne in conjunction with a local architectural practice partner, to examine space planning efficiency and emerging trends in hospital space planning requirements. To assist in developing a greater understanding of the space planning efficiency of healthcare infrastructure, and changing trends in hospital space planning, this study examined a range of measures across 31 hospitals against regional and international benchmarks. This paper outlines a novel multi-modal research methodology established to examine the complex range of interconnecting planning measures impacting space planning efficiency, and some of the difficulties in assessing hospital space planning efficiency.

**Keywords:** Healthcare design, space planning efficiency, evidence-based design.

# 1297. Understanding housing design and expectations of Assamese rural communities: Case Study Selection

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An examination of a house design proposed by the Department of Rural Development of India's Affordable and Appropriate rural housing scheme showed a major cultural gap of understanding between urban perspective and rural expectation. Significance of community value and cultural ecology have been compromised in planning and implementation of grand housing schemes. This research argues that mere design of rural housing runs the risks of not being culturally inclusive. This paper elaborates the description of the cultural ecology as defined by the literature review within the context of the research to be conducted in Assam. The culture of the place or region is the product of a cultural ecology that is the intersection of environment, community and interactions. In a rural household as the cultural ecology; the house and its boundary signify the environment where the members of the household are the community and activities of each member are the interactions. To reflect the culture and value as an integrated design element, the emancipatory research paradigm is highly significant. The approach is demonstrated by developing a questionnaire/survey which encompasses the family structure, life style and income for collecting relevant data necessary for designing culturally inclusive housing for rural community.

**Keywords:** Rural Perspective, Cultural Ecology, Case Studies, Selection Criteria.



**THURSDAY, 29 NOVEMBER 2018**



# **ARCHITECTURAL SCIENCE: BUILDING SCIENCE AND BUILT ENVIRONMENT QUALITY (II)**

# 1191. The influence of demographic and locational factors on occupants' perception scores for their buildings

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The authors and their collaborators have surveyed the 4,662 occupants of 57 medium sized commercial and institutional buildings around the world. All were surveyed using the BUS Methodology's standard two-page questionnaire. The overall aim of these surveys was to assess the occupants' perceptions of a range of factors related to their performance. The objective of this paper was to explore the influence of demographic factors such as age, sex, and working location on their scores for comfort overall, productivity and health; together with a range of Indoor Environment Quality (IEQ) factors. Significant differences were identified between the perception scores for all of these factors between the under and over 30s and between male and female respondents, the former group rating themselves better in both cases. Evidence of a downward trend in perceived productivity was also found as the numbers sharing an office increased. Some current survey protocols related to length of time worked in the building were reinforced.

**Keywords:** Building Performance; Occupants' Perceptions, Post-Occupancy Evaluation.

# 1231. Study on the thermal and visual performance due to highly reflective façade in Singapore

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This study preliminarily investigates the impact of highly reflective building façade material on the thermal and visual performance of surrounding buildings in the tropics. A 9-story commercial building with curved stainless-steel façade was observed and indicated as the source of reflective glare. Field measurement was conducted on nearby a 4-story school building which is directly affected. Indoor globe temperature, glass and wall surface temperatures, and illuminance were measured in six selected classrooms. Parameters such as weather condition, horizontal location, vertical location, and shading were analysed based on the data collected from the on-site measurement. The measurement data on a sunny day and a cloudy day were selected and compared. From the measurement data, it is found that weather condition plays a vital role in determining both indoor thermal and visual performance; while horizontal and vertical locations also have a considerable effect. On the other hand, horizontal overhangs can help to reduce air temperature, surface temperature and illuminance value which can help to achieve a better indoor thermal and visual environment.

**Keywords:** Reflective material; building façade; thermal performance; visual performance.

# 1193. Longitudinal field study of thermal comfort in a low energy mixed-mode building

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It is commonly assumed that high levels of occupant comfort and energy efficiency are mutually exclusive. To challenge this misconception and to demonstrate that it is possible to maintain comfort without increasing energy use, a case study was carried out in an exemplary low energy building in Australia. This study was performed under the umbrella of the International Energy Agency's Energy in Buildings and Community Programme (IEA-EBC) Annex 69 – Strategy and practice of adaptive thermal comfort in low energy buildings. Longitudinal field observations were made for eleven months between 2017 and 2018, through instrumental indoor climate measurements (temperature, humidity and airspeed) and the collection of building operational data (operation of HVAC and windows), coupled with right-here-right-now occupant comfort surveys delivered to the participant's smartphones. Time-and-place matching of the collected objective and subjective data enabled the quantitative analysis of the relationship between building operational decisions, climatic factors, and occupants' perception of comfort.

**Keywords:** Thermal comfort; mixed-mode; PMV; continuous monitoring.

# 1209. Enhancing students' experience in real-time data collection and utilisation: A cloud-based post-occupancy evaluation app

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This paper presents the process of developing and testing a cloud-based post-occupancy evaluation (POE) app to enhance students' experience in real-time data collection and utilisation. A pilot POE study was developed and conducted as part of student class activities in a lecture theatre during an undergraduate course. Three parameters on perceived indoor conditions - temperature, humidity and air freshness - were selected in correspondence with physical parameters. A cloud-connected wireless sensor network was used to collect physical measurements (quantitative data) such as temperature and relative humidity through TelosB sensors, and a smart phone app was used to collect data on occupants' perceptions (qualitative data) and to update the data repository in real-time. An immediate visualisation of the collected data was presented during the pilot study, explaining how the cloud-based POE app works and how further statistical analysis can be conducted. The pilot study confirmed that the cloud-based POE app is capable of capturing occupant feedback with great speed and convenience. The immediate visualisation of both quantitative and qualitative data also encouraged the student participants to enhance their experience in real-time data collection and utilisation in the building science course. Further statistical analysis and reporting capabilities of the real-time system can fill the current methodological gap of POE data collection and utilisation in building management.

**Keywords:** Post-occupancy evaluation (POE); real-time; indoor conditions; students' experience.

# 1120. Building with timber across Australian climatic contexts: an hygrothermal analysis

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This paper aims to improve understanding of timber-based envelope hygrothermal performance in relation to five different Australian climate regions, ranging from subtropical hot and humid to cool temperate and including all of the country's major cities. A standard apartment unit is used as a case study to analyse the hygrothermal performance (expressed as thermal resistance, condensation and mould growth risk) of two selected external wall types: massive wall and timber-frame panelised components. The different scenarios are assessed through the adoption of a multi-criteria approach, accounting for both steady-state and transient behaviour. The thermal analysis is performed in a transient state to create the yearly profile of indoor humidity and temperature. These are then used as the input data to assess the hygrothermal behaviour of the external wall solutions. Results show how the massive timber wall system performs better across the Australian climate zones, with consistent thermal behaviour and higher indoor temperature stability. Condensation phenomena and mould growth risk are significant for all scenarios and must be closely considered during the building design phase, especially in very hot and highly humid climates.

**Keywords:** HAM analysis; indoor thermal environment; timber-based envelope; mould risk.

# 1192. Measuring the Daylight Performance of Classrooms: Can a One Point Sensor Measurement Predict the Daylight Distribution within a Space?

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The New Zealand Ministry of Education (MoE) has begun measuring the light, temperature, noise and CO2 level of 21 selected schools using a single sensor. This sensor is being developed as a method for routine measurement in order to understand the performance of New Zealand's school buildings. This study used a Climate Based Daylight Modelling to appraise the MoE methodology, to determine what can be learned from the use of a single sensor in one location in a classroom, to estimate the lighting comfort across a space. Daylighting is focused upon because it has the most spatial variation in a space. The findings of this study support the assertion that a one-point sensor measurement on a vertical wall could predict illuminance across the centre of the horizontal work plane; and provide a useful benchmark to estimate the light distribution across a space. However, regardless of how representative of a space a one-point measurement is, it is difficult to quantify the daylight distribution over time throughout the space. If various daylight indicators are well documented and analysed alongside the measured data, a strategically positioned one-point sensor on the vertical wall could be useful in predicting the daylight quality of a space.

**Keywords:** Daylight, Temperature, Measuring, Sensors, Classrooms.



# **ARCHITECTURAL SCIENCE: ARCHITECTURE, DESIGN AND ENVIRONMENT (II)**

# 1122. Regeneration of unused buildings within Wellington to attract family living, in response to the Wellington demographic

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Studies have found that the population of Wellington is continuing to increase, therefore, creating an increased demand for housing. To accommodate this increasing population and housing demand, there has been a push towards creating higher densities. Research states that higher-density living is an effective response to increasing populations and housing demand, however, it raises the issue of higher-density housing neglecting family-friendly living. Therefore, this paper aims to identify why higher-density housing is not family-friendly, and how this can change to support family-friendly living.

**Keywords:** Higher-density family housing.

# 1166. Establishing a comprehensive database of construction material environmental flow coefficients for Australia

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A large increase in the building stock will be needed over the coming decades to cater for forecast global population growth. Such an increase could result in tremendous strain on the environment, both from operating these new buildings and from the demand for resources required to construct and maintain them. Life cycle assessment is a tool that can be used in the design of new building projects, or during the refurbishment of existing ones, to assess and improve their environmental performance. Life cycle assessment is typically complex and time consuming, especially when used for analysing whole building projects. This is particularly the case when it comes to analysing construction-related, or embodied, environmental flows. To facilitate ease of use for projects that are often highly time and budget constrained, product-based environmental flow coefficients are typically used, providing an indication of the environmental flows associated with a particular building (e.g. energy or greenhouse gas emissions). Construction-related coefficients are rare in Australia and those that do exist are out of date. In this study, we demonstrate a semi-automated approach for compiling coefficients for construction materials using the Path Exchange method. This forms the basis of a comprehensive database of construction material environmental flow coefficients that is urgently needed by the construction industry to inform environmental decision making. These values can be used independently or easily integrated within existing life cycle assessment tools to streamline improvements to the environmental performance of construction projects.

**Keywords:** Construction materials; environmental performance; hybrid coefficients; life cycle assessment.

# 1123. Comparative Design Evaluation of Dementia Support Facilities in Victoria from the Perspectives of Carers

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This paper presents an ongoing study of a comparative design evaluation of three residential facilities for people with dementia in Victoria from the perspectives of the employed carers. Through photo elicitation and interviews with carers, the aim of this evidence-based research is to identify desirable characteristics of dementia support facilities for the delivery of care for residents in Victoria. The three facilities are evaluated in terms of scale, sightlines, domestic kitchen accessibility, homely atmosphere, wayfinding and colour contrast, toilet design, as well as access to outdoor space. The significance of this project is to identify key design factors that can promote the quality of life and wellbeing of residents in dementia support facilities.

**Keywords:** Design for dementia; dementia support facilities; residential care; design evaluation.

# 1125. Smart Silver Towns: Prospects and Challenges

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The recent rise of residential developments for the aged in Korea, combined with smart technologies is underpinned by a confluence of social and technological changes. Korea is one of the countries with significant increase in aging population. The rapid increase of the elderly combined with lack of supporting facilities have led to recent building developments in Korea in the form of silver towns, i.e. high-rise building units targeted specifically at the aging population. These developments incorporate information technology infrastructure, in which Korea has invested heavily in recent decades. The silver towns are increasingly being conceived, designed and marketed as smart living environment for the elderly. The research investigates changes in patterns of use in silver towns integrated with smart technologies from the perspective of aged residents.

**Keywords:** Aged living environment, Silver town, Smart technology, Elderly perspective.

# 1188. Incremental Strategies for Suburban Densification

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Sprawling, low density development dominates and destroys natural landscapes and productive farm land at the edges of urban centres. Yet, suburbs continue to grow outwards, requiring continual development of green field sites to keep up with housing demand. Additionally, existing dwellings are demolished to make way for new developments with minimally increased density, creating waste in an industry that generates over 50% of New Zealand's landfill. In spite of this, New Zealanders' reported preferences for stand-alone dwellings on private sections and NIMBY attitude challenge higher density settlements, perceiving them as less safe, less visually appealing and less able to provide an enjoyable lifestyle. This research addresses the need for higher density living within the Wellington suburban context, while attempting to meet these challenges through the incremental implementation of accessory dwelling units that fit around existing dwellings. The implementation of this strategy has been tested within the Wellington suburb of Kilbirnie through the dimensional analysis of existing sites and the iterative design of accessory dwelling units. From this, possible new levels of density have been estimated within various areas of the suburb to investigate the feasibility of achieving higher density by adding small scale dwellings to front, side and back yard sites.

**Keywords:** Accessory dwelling units; suburban densification; incremental construction; New Zealand.

# 1214. Diversified façade architecture for optimizing air flow in tall residential buildings in tropics: a field investigation based on a literature review

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In this paper, a theoretical framework was developed to assess optimization of diverse vertical wind climate in tall, residential buildings in enhancing indoor comfort. A total of 200 papers were reviewed in respect to two subject areas; i.e. preferred air speeds for indoor comfort and vertical climatic behaviour around high-rise buildings. Both subject areas were then combined to create an air-flow responsive Theoretical High-rise Model (THM) in relation to a tropical, tall residential building, as the base framework. The THM reveals that the façade should be integrated with different interventions when responding to both, the diversity of wind climate around the building and its height. The evaluation involved assessing of design strategies employed on buildings in 3 key areas: reducing internal heat gain, enhancing preferred air flow distribution across the unit layout and utilizing the vertical climate diversity to harness the preferred air speed along the full height.

Results from the field investigation on 43 residential buildings revealed that buildings that do exist in the studied context have poor implementation of design strategies, when it comes to harness the vertical wind climate for preferred air flow speed with building height. Furthermore, it was found that uniform facades, repetitive floors and symmetrical building forms were found to be most common building characteristics in this building population which is contrary to the projections by the THM.

**Keywords:** Tall residential buildings; Preferred air speed; Diversified façade architecture; Vertical climate diversity; Tropics.



# **ARCHITECTURAL SCIENCE: BUILDING ASSESSMENT AND EVALUATION (I)**

# 1234. Influence of wind on indoor convective floor heat transfer of single-sided naturally ventilated cubical enclosures

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In mild climatic conditions, residential houses are often ventilated by opening windows. However, the resulting bi-directional airflow mechanism in single-sided naturally ventilated spaces is complex due to the involvement of buoyancy and wind driving forces along with wind turbulence and turbulence created at the opening. In addition, the wind effect might be reinforcing or restricting the buoyancy-driven natural ventilation. The consequence of these numerous effects on indoor flow-fields and particularly convective heat transfer on the floor needs further examination. In this respect, the earlier studies demonstrated that heat transfer of the floor was strongly influenced by the Rayleigh number ( $Ra$ ) and the Window Opening Fraction (WOF) particularly in a buoyancy-driven single-sided natural ventilation set up. In an attempt to understand the influence of varying wind conditions, this work utilized Computational Fluid Dynamics (CFD) for numerically, examining a single-sided partly opened air-filled cubical enclosure. The results indicate that both the indoor flow-fields and heat transfer on the floor are strongly influenced by the outside wind conditions. As such, there is a significant scope of lowering the uncertainty of floor heat transfer estimation of a naturally ventilated buildings by including the effect of varying outdoor wind conditions in the existing empirical correlations.

**Keywords:** Natural ventilation; heat transfer; residential house; CFD.

# 1119. A comprehensive model for quantifying the environmental and financial performance of cities

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Current models to quantify environmental performance in the built environment are flawed as they typically focus either on one scale of the built environment (e.g. buildings), on a limited range of environmental flows (e.g. energy), or a particular life cycle stage (typically building use). There is a need to develop a more comprehensive model to assess and improve the environmental performance of cities. This paper proposes a multi-scale, bottom-up, dynamic life cycle assessment model for the built environment. The model combines nested systems theory with life cycle assessment and dynamic modelling. It covers all scales of the built environment, from materials to cities. In particular, it considers material, energy, greenhouse gas emissions, water and financial flows required to produce construction materials and replace them (embodied flows); operate buildings and infrastructure assets (operational flows); and for the mobility of building users (transport flows). Furthermore, the model evaluates the value created by a particular real estate development. The paper describes how the model operates and the methods used to quantify each flow. By covering spatial and temporal boundaries across multiple environmental and financial flows, this model will significantly improve environmental assessment and decision-making for actors of the built environment.

**Keywords:** Life cycle assessment; life cycle cost; environmental performance; Python.

# 1219. A Framework for Predicting Development Feasibility

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To determine the development feasibility of a parcel of land, a potential purchaser is required to synthesize multiple information sets including local planning data, land records, financial metrics and most importantly the design rules and criteria for compliance. The information sources for the data required for a feasibility are often found on separate databases and systems and are usually not in standardised digital formats. This paper outlines the framework for a Development Feasibility Framework, highlighting the extent of data required to determine feasibility, exploring the integration of geospatial databases and parametric modelling techniques to achieve the framework. The framework consists of three components; The Rules Engine, the Parametric Building Generator and the Feasibility Calculator. The first component, the Rules Engine, collates the planning rules and criteria required to determine if a design is feasible. Once the rules have been codified, the determination of the possible building designs are calculated using parametric modelling techniques through the Parametric Building Generator. Finally, once solutions have been generated, the final part of the platform is the feasibility calculation. The platform integrates with a Geographic Information System (GIS) database to allow for mass assessment of development feasibility and can also be used for urban planning.

**Keywords:** Parametric, GIS, Urban Planning, Prediction.

# 1177. Calibrating the energy simulation model of an aquatic centre

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An aquatic centre is defined as a community or public venue that provides at least an indoor pool and three different types of amenities such as gymnasium, sauna/spa, café, crèche and stadium. There have been insufficient studies that examine the energy performance of aquatic centres worldwide. Building energy simulations provide opportunities for economic and time-efficient analysis of the energy performance of buildings in order to identify the benefits of different control strategies, design or occupancy variables. This paper describes the simulation and calibration process for analysing the energy performance of an aquatic centre using a selected building as case study. Simulating the energy performance of an aquatic centre is a complex exercise due to the interaction between water and air (evaporation) occurring within the swimming pool hall. EnergyPlus and DesignBuilder were used to perform the building energy simulations. Manual calibration method based on an iterative approach was adopted and statistical indices (Mean Biased Error (MBE) and Coefficient of Variation of the Root Mean Square Error (CV(RMSE)) were used to verify if the model was calibrated accurately against the measured energy data (utility bill data).

**Keywords:** aquatic centre; energy performance; building energy simulation; calibration.

# 1262. Communication and Participation in Virtual Environments

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We seek a framework for engaging people in urban design decision-making process by employing virtual tools. We adopt our previously developed parametric tools for design communication as a bridging method between conventional and participatory urban design approaches. We hypothesise that a virtual participatory urban design platform can provide more design associated information for laypeople to participate in design decision-making. The conventional urban design approaches investigate urban form as purely through the lens of urban professionals. In participatory urban design approaches the design decisions remain as general assumptions because of lack of enough associated information. Therefore, we have developed a methodology to produce urban forms by taking advantages of computational tools to engage stakeholders in complex urban design decision-making processes. This paper focuses on designing the charrette tools. We propose a mixed method of virtual and actual to orient people in the design discussion. We investigate our tools for Karori, a neighbourhood in New Zealand. We critically conclude the paper with an overview of our virtual design communication tools which is destined to engage people in a later stage.

**Keywords:** Informed design methods; decision-making; rules-based system; virtual environment.

# 1127. The Importance of Site on House Heating Energy Modelling

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Site is known as one of the important factors which influence the energy performance of buildings. However, in many cases when energy simulation modelling is included in the design process, it does not consider site factors. The consequences of this are unknown. Frequently, the weather data used in the energy simulation is based on the local weather-station rather than the site-specific micro-climate. In the case of Wellington, New Zealand, micro-climates vary widely as they are influenced by the local topography. Different sites are highly likely to have different access to sun, wind, temperature, etc which all strongly affect the heating energy use of houses. This paper reports on the initial findings of a study into the impact of site factors in energy simulation software, EnergyPlus. Some EnergyPlus limitations were found in modelling site factors. To solve this limitation, three approaches to the generation of site-specific weather files were investigated: ENVI-met, UWG (Urban Weather Generator) and CFD (Computational Fluid Dynamics). The paper explores the importance of different site parameters, and diagrammatically sets out how they can be included in the energy simulation.

**Keywords:** Site; Microclimate; Energy Simulation; Site modelling.



# **ARCHITECTURAL SCIENCE: THEORY, PHILOSOPHY AND SOCIETY**

# 1114. Tacit knowledge transfer for city design

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This methodology paper aims to inform a multinational competitive research grant application on research approaches for knowledge sharing and in particular, tacit knowledge. The overall project involves researchers, planners and city designers from three continents: Europe, Asia and Africa. The project aims to facilitate knowledge transfer from European model-cities to recipient cities in developing regions. The paper develops a critical review of research methods and techniques for tacit knowledge elicitation coupled with explicit knowledge sharing. Current methods for knowledge capture and its application in urban design overlay on explicit knowledge including the knowledge sharing frameworks under the EU Integrated Urban Development, Directorate-General Regional and Urban Policy. This paper proposes a complementary side to the current framework by applying the Repertory Grid Technique (RGT). RGT provides an approach and a method to externalise participants' knowledge and their tacit cognitive process. The technique links to Personal Construct Theory, thus building a sound theoretical framework. Knowledge transfer for the collaborative project is expected to take place across eight model and recipient cities. This paper provides an appropriate framework showing how knowledge elicitation can take place across project participants including expert city designers, planners and non-cognate stakeholders such as community representatives.

**Keywords:** city design, personal construct theory, repertory-grid technique and tacit knowledge.

# 1104. Ephemeral Crossroads: seven lamps, six years, seven lux-pavilions

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Building materials in the modern era have assumed significance in architectural theory which they had not possessed in the past. The change was no doubt due to the multiplicity of materials, newly minted due to the innovative industrial production, which imposed and invited new ways of building. John Ruskin (1819-1900) proved to have a great appreciation for the inherent qualities of building matter, its materiality and innovation by recognising the validity of the honest structure: Truth of the materials or rather honesty in the use of materials. However, the modern era has become the manifestation of the temporal, the momentary, the transitory, the ephemeral, the impermanent and as such this phenomenon is aligned closely to the innovation of materials/materiality within building practices. This paper deals with the manifestation of this modern paradigm in a series of lux architectural pavilions/folly over a period of six years: seven projects paralleling Ruskin's Seven Lamps of Architecture (1849).

**Keywords:** Live build projects, Temporary Architecture, Architectural History, Experiential Practice.

# 1233. Revenge of the fragmented metropolis

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The time seems ripe in architectural science for urban researchers to re-examine and further discuss the idea of the city. On the verge of Anthropocene change, architectural scholars seem not to have moved beyond their characterisation of the contemporary city as a fragmented metropolis. What comes next? Cities are likely to survive – as well as to thrive. This paper discusses the major features of contemporary cities and how they address survival and continue to thrive, selecting the urban components they share vis-à-vis urban society's stance towards contemporaneity. The paper ultimately points to the need to intensify the quest for a new diagram that can suitably represent the new conditions of contemporaneity in cities. If this diagram is inserted within the domains of architectural science, it might lead towards a more straightforward focus on the crucial elements of the city's future. Two emblematic metropolises are closely examined, revealing innovations towards the containment of urbanized land to prevent unsustainable sprawl. There is also consideration of current uses typical of contemporary life and territorial discontinuities during the advance of the conurbation. Vague trends towards polycentrism are then considered, together with tendencies pointing towards containment of sprawl and the creation of new places that will somehow act in 'gluing together' the fractures. Architectural science is now challenged to outline a new diagram.

**Keywords:** anthropocene; urban contemporaneity; places.

# 1221. Suburban liveability in Melbourne: a narrative approach

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The Melbourne brand has achieved unqualified and unquestionable success particularly if measured through various international rankings and, critically, via population growth of migrants 'voting with their feet'. The population is forecasted to double by 2050 and the annual growth rate in the past few years (based on census data) suggest the rate has already been exceeded. Hence, today, the pressure is already felt, most acutely in the more affordable suburbs that have absorbed the growth, notably to the west, north and southeast – resulting in compromises in quality of life amongst social groups, distributive injustice, and leading to the increased reliance on the private vehicle and the longer commute times. The paper adopts a narrative methodology to enter into the evaluation of sub-urban liveability. It develops individual narrative stories of liveability in different residential suburbs in Melbourne and identify the challenge of adopting homogeneous conception of liveability in different temporal and spatial settings. We observe that this challenge lies in the complexity and diversity of each society, city, parts of the city and their historic evolution where individual perceptions and experiences of quality of life differ. We also observe the phenomenon contributes to the socio-economic inequity and spatial division, based on a set of key criteria. The paper reports on a preliminary trial of the narrative method to understand urban liveability and discusses its potential for future research.

**Keywords:** Suburban liveability; inequality; narrative method; context dependence.

# 1111. Design with climate in ancient Rome: Vitruvius meets Olgyay

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The location and design of Roman cities, farmhouses and town houses took account of the climate, at least according to the works of several Roman authors spanning a period of about 500 years, beginning with Vitruvius' *De architectura*. Issues considered included latitude, site selection, heat, solar orientation, winds and daylighting. Vitruvius emphasised health, an emphasis of regulatory building codes today, rather than comfort and amenity. Victor Olgyay, writing *Design with climate* in 1962, and addressing similar issues, was more interested in comfort. The two works are compared.

**Keywords:** Vitruvius; Olgyay; climate; design.

# 1112. Learning from dense cities: Hong Kong spatial constructs as narratives

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Cities all over the world are being densified in the quest for sustainable urban development. Whether or not this is a viable strategy is an ongoing debate, but as densifying cities face certain challenges, they can learn from already dense cities, where interactions between interior and exterior space are explicit. This paper takes Hong Kong as a model for the densifying city to focus on three levels of spatial organisation in hyper-dense urban space. The paper will discuss urban life forms through seamless interconnection between interior and exterior space. Using a micro-narrative methodology for organising personal experiences and communication data, the paper will take the interior workplace, porous urban space, and the urban landscape as three conditions for dense urbanism. The paper will deploy Hong Kong as an intellectual framework and model for spatial design and construction in high density; it will explore three levels of space through micro-narratives; cross-analyse the micro-narratives to detect attributes and concepts for densification; and synthesise the findings to suggest directions for further research.

**Keywords:** city spatial organisation, high-density living, micro-narrative.



**FRIDAY, 30 NOVEMBER 2018**



# **ARCHITECTURAL SCIENCE: BUILDING AND ENERGY (II)**

# 1102. Investigating equivalence in compliance pathways to Australian housing energy efficiency

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Current regulatory pathways to compliance in energy efficiency for Australian housing are via provisions in the National Construction Code (NCC). This paper first identifies performance evaluation criteria set out in the code presented as a comparative analysis across the different methods of achieving compliance. Jurisdictional and concessional variations are discussed and thereafter an examination of the effect of specific design and location factors that impact the commonly used deemed to satisfy route to compliance. A study is presented in the paper investigating typical South Australian temperate climate housing styles in terms of their expected energy performance and compliance. This is done to test for measurable differences or test where equivalence can be shown to be reasonably achieved. This study highlights the issue of alternative pathways, being different options of using software modelling or elemental compliance based on specification details. The sample set is a modest seven houses only but carefully chosen to show the compliance pathway results for different options across this sample set. Further measures of house energy performance evaluation and comparison are drawn from the literature.

**Keywords:** NatHERs, Compliance, Energy Efficiency.

# 1109. Review of Holistic Research on NetZero Energy Homes: Energy Simulation, Energy Monitoring, and Performance Improvement

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A NetZero Energy Home (NZEH) is designed, modelled, and constructed to produce as much energy as it consumes on an annual basis, with the required energy generated from renewable energy resources. This paper reviews holistic research on NZEHs from the perspectives of energy simulation, energy monitoring, actual energy performance, and operation/design improvement. HOT2000, developed by Natural Resources Canada, is utilised as the tool to simulate the energy performance of NZEHs. Using multiple NZEHs as the case projects, sensor-based monitoring systems are developed to evaluate the actual energy performance of NZEHs, and the results are used to analyse the discrepancy among different NZEHs and to compare with the simulated results. Based on comprehensive analysis and comparison, operation and design strategies are proposed to improve the performance of NZEHs.

**Keywords:** NetZero Energy Home (NZEH); energy simulation; energy monitoring; performance improvement.

# 1137. NABERS – rating energy and water efficiency for apartment buildings

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The NABERS (National Australian Built Environment Rating System) program is well known for its work in the commercial sector. Apartment buildings represent a significant opportunity for energy and water efficiency and in many ways resemble the commercial sector in terms of the presence of “base building” services that are provided to occupants and metered separately from the balance of energy use within the individual apartments. However, the range of services provided varies widely, creating unique challenges in the creation of benchmarks for this sector. In this paper, the characteristics of the apartment sector are reviewed based on a data set of over 250 buildings in New South Wales, Victoria, Queensland and Western Australia. Factors demonstrated to have significant impact include the number of apartments, the degree to which air-conditioning is provided centrally, the presence and servicing of the car park, the presence and servicing of a swimming pool, and the presence of lifts and gyms. The application of NABERS style benchmarks for energy and water to this sector is presented. The sample distribution of ratings is shown to be a good match to expectation. The paper concludes with a review of the next stages in rating application and development.

**Keywords:** NABERS; Apartments; Energy; Water; Rating.

# 1255. User perceptions of building management systems in the continuous commissioning process

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This paper explores how Building Management Systems (BMS) are used to facilitate Continuous Commissioning (CCx) in large non-residential buildings. Professionals in the building industry (n=33) participated in an online survey that asked about the importance of BMS in facilitating CCx and their perceived level of satisfaction with current BMS capabilities. The characteristics of CCx reported by participants indicated the majority of participants use manual and bespoke methods. They also indicate limitations of BMS in providing continuous and automated streams of HVAC data trends which are essential for CCx. Participants reported the most important way BMS could facilitate CCx is through monitoring the required HVAC trends. However, the required data is not always immediately available. It is apparent that when BMS are initially installed, they are not set up to record and store the HVAC data trends. This prompts the question: how should BMS be set up to be best able to facilitate continuous commissioning?

**Keywords:** Continuous commissioning; building tuning; building management systems; energy efficiency.

# 1269. Impact of the mitigation of the local climate on building energy needs in Australian cities

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The minimisation of building energy needs for cooling is challenging as acting on the building envelope and services is not sufficient. To achieve significant cooling savings, the mitigation of the local outdoor climate is necessary. This is particularly relevant in Australian Cities. Here we show the cooling energy savings that can be achieved with local climate mitigation in Darwin and Western Sydney with greenery, cool roofs and cool pavements, water sprinklers and fountains, water technologies and greenery, or and water technologies and cool roofs and pavements. In Western Sydney, in the unmitigated scenario, the cooling energy needs 50 km from the coast are approximately 1.5 times than if the same unretrofitted buildings were in coastal suburbs. Cool roofs and pavements combined with water fountains yield to savings of 39% for the residential and by 32% for the office building. In Darwin, combined greenery, cool roofs and pavements and urban shading can reduce the annual cooling load by 7.2%. In both cities, our results indicate the need to improve both building quality and outdoor local climate. Acting on only one of the two sides is not sufficient to achieve nearly zero energy buildings in Australian climates.

**Keywords:** Urban Heat Island; Cooling; Energy; Building.

# 1144. Australian Commercial Buildings Window to Wall Ratios

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This work was inspired by the crucial need for development of the Australian National Construction Code and its Regulatory Impact Statements (RIS) to be based on Australian building data. It is known that a cost-benefit analysis conducted via a RIS is very sensitive to variations in the window-to-wall ratio (WWR) due to higher glazing costs. Regrettably, there is currently no publicly available data on the WWR for Australian commercial buildings. The focus of this work is to characterise typical WWRs for Australian commercial buildings within the past 30 years, specifically offices, education, retail, aged care, hotels and hospitals. The methodology employed the use of photography of the external building envelopes across central and regional cities, followed by measurements of ratios for these buildings. It is the intent of the Authors to publish this work and for the WWR of the building types referenced be made publicly available to the wider community of architects, Environmentally Sustainable Design (ESD) consultants, building modellers, glazing manufacturers, insulation industries and policy-makers.

**Keywords:** Window-to-wall ratio; commercial buildings; glazing; façade.



# **ARCHITECTURAL SCIENCE: CITIES AND OUTDOOR ENVIRONMENTS (II)**

# 1266. Developing experimental protocol for collecting large scale urban microclimate data through community participation

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Uncomfortable outdoor environments impact the liveability of cities and urban economy. This paper discusses the experimental protocols developed as part of a citizen science project on improving urban microclimates. The term “citizen science” broadly describes public engagement in scientific research in collaboration with professional scientists. This citizen science project aims to engage communities across Australia in the measurement of urban microclimates thereby educating citizens and empowering them in adopting various mitigation actions. The design of instrumentation for monitoring microclimates across various proposed urban themes is discussed. In addition, learning experiences from trialing the protocols through a pilot measurement is also presented in this paper.

**Keywords:** urban microclimate; community participation, experimental protocol.

# 1107. Seasonal Patterns of Thermal Stress in the Work Environment of Construction Workers in a Megaproject in Australia

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Construction site is the workplace of 8.9 per cent working population in Australia whereas heat stress is a concerning risk. This paper presents initial results of a field study conducted on the site of a mega construction project in Australia in the build-up season (a three months' period of transition between dry and wet seasons) and the wet season respectively. Heat stress was recorded on a daily basis at three typical workspaces on site: rooftop, at the jetty and in the material storage yard. Data were analysed with the Wet Bulb Globe Temperature and the Predicted Heat Strain model. The on-site recorded data were compared to the data recorded at the nearest station of Bureau of Meteorology, up to 7.7 °C difference between the two sources of data was identified. Comparison between the two seasons indicate that heat stress in the build-up season has a higher risk than that of the wet season, although the latter is normally assumed to be 'hotter'. The results suggest the organising and practicing of work activities construct the pattern of heat stress as critically as does the objectively measured environmental heat.

**Keywords:** Thermal stress, construction site, seasonal patterns, Wet Bulb Globe Temperature, Predicted Heat Strain model.

# 1304. Micro-climatic temperature trend as a basis of passive design for residential buildings

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The past two decades have witnessed concerns caused due to the global increase in surface temperatures. With the world exposed to a quickly changing climate, exposure to and impacts of events like heat waves, floods and droughts has become a concern. While this is happening outside an individual's dwelling, the impacts on indoor thermal comfort are significant. Maintaining comfort inside while the weather outside changes unexpectedly is the challenge for contemporary design. This study for the city of Roorkee, India tries to address this issue by identifying a trend in the daily maximum air temperature ( $T_{max}$ ), daily minimum air temperature ( $T_{min}$ ) and daily mean air temperature ( $T_{mean}$ ) values recorded from 1976-2016. Representative weather files for each decade have been created and selected residential buildings built in the last 10-20 years have been simulated using Design Builder against these representative weather files to analyse number of comfort hours on the tropical summer index. Using the analysis, several passive design strategies have been simulated and the best passive-design solutions have been proposed for composite climate of India. Validation of simulated data has not been considered for the current research context.

**Keywords:** Weather-trend; passive-design.

# 1314. Outdoor Neutral Temperature Assessment within Deakin University Campus at Melbourne City, Australia

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Outdoor thermal comfort is an effective attribute to the success of urban places. Various studies were employed to examine thermal perception and preferences of users within different geographical, functional, and climatic contexts. The complexity of the research led to the adoption of various definitions for terms and analysis methods even for similar benchmarks. However, to move forward with this topic, it is crucial to identify and when possible unify the different methods of analysis that are found to be accurate and reliable. This paper attempts to review the outdoor thermal comfort benchmark used in identifying users' thermal perception. Neutral temperature representing a main outdoor thermal comfort benchmark will be calculated for users in an educational campus in Melbourne city, Australia. The analysis are based on both the climatic characteristics of the place and the users' thermal sensation votes. The results of the different methods used to calculate this benchmark are then compared and analysed. The findings showed a variation in the calculated neutral temperatures using different methods, yet they were all within the acceptable calculated temperature. These findings are to help urban decision makers in designing comfortable outdoor urban places.

**Keywords:** Outdoor thermal comfort; Neutral Temperature; Physiological Equivalent Temperature.

# 1162. Designing functional urban open spaces: through user comfort & spatial analysis approach

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Due to peculiar topography and extreme high density, Hong Kong's open space per capita 2 sqm is far from the WHO standards of 9 sqm per person. Open spaces are often regarded as compliance to planning requirements rather than providing desirable outdoor amenities to the community. Due to challenging Summer conditions in Hong Kong such as high temperature & humidity and stagnant wind most urban open spaces are underutilized. This research investigates the factors effecting enjoyment of open spaces and design factors that may improve their function as public amenities. Exploration is based on user comfort, user behaviour, and design attributes. Data collection was conducted on seven urban parks within Tsuen Wan district on dry days during Summer. User comfort data gathered using a WBGT monitor and simulation methods supplemented by photographic survey of users' movement within the parks and user interviews. Findings indicate tendencies in using these parks in the afternoon between 3pm to 5pm for passive recreation and navigating in shady locations and areas with seating. Residents expressed close proximity and presence of mature trees as positive attributes in these parks, however voiced the need for rain shelters, more shady areas and better storm water drainage.

**Keywords:** user comfort; urban open spaces; microclimatic parameters; vegetation.

# 1280. Mitigation of urban overheating in three Australian cities (Darwin, Alice Springs and Western Sydney)

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The Urban Heat Island (UHI) has become increasingly important due to the increased vulnerability of urban areas to UHI effects and thermal risk for urban residents. In Australia, extreme heat and overheated outdoor environments adversely affect the well-being of the urban population, energy consumption for cooling, sustainability and liveability of cities. This paper examines microclimate characteristics of three Australian cities, namely, Darwin, Alice Springs, and Western Sydney using the microclimate model ENVI-met. The simulations involve urban environments both in the existing situation and after application of appropriate mitigation strategies in a representative warm summer day. This evaluation is of importance due to the potential of mitigation strategies to decrease the ambient temperature and provide comfort for residents. This study involved a selection of mitigation strategies (e.g., urban greenery, cool material, water-technologies, solar control, and combinations). Microclimate models were developed to assess the influence of the proposed mitigation strategies to reduce urban heat from these cities. This study found a possibility to decrease the maximum temperature of Darwin City up to approximately 2.5°C. In Alice Springs, the achieved decrease of the maximum ambient temperature is close to 1.2°C. In Western Sydney, a combination of the proposed strategies shows a reduction of 1.4°C.

**Keywords:** Urban climate; Urban Heat Island; Simulation; Heat mitigation strategies.



# **ARCHITECTURAL SCIENCE: BUILDING ASSESSMENT AND EVALUATION (II)**

# 1154. Energy Efficient Building Design using Building Simulation, Multi-Objective Genetic Algorithm, Multiple Linear Regression and Monte Carlo Approach

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Recently, there have been a number of researches on building design optimization by coupling multi-objective genetic algorithm with building simulation. The researches offered dozens of potential designs solutions as outcomes. However, little attention has been paid on the post-optimization process and how to use the optimization outcomes to facilitate the building designers and engineers to find near optimal solutions quickly and confidently. The GA-MLR-MCA approach presented in this study combined building simulation with a multi-objective Genetic Algorithm (NSGA-II) for optimization of thermal comfort and energy consumption for a typical residential house in five different cities across all the climatic regions in China. Results of the potential solutions based on the Pareto Front were then trained with multi-linear regression (MLR) models considering variables such as window-to-wall ratios, building orientation, heating air temperature setpoint, cooling air temperature setpoint, external wall insulation, roof insulation, and HVAC type. Typical R-square values for the MLR models both for thermal comfort and energy consumption were higher than 0.95. Monte Carlo approach was also applied to generate same amount of solutions and came out with results very close to the Pareto Front solutions.

**Keywords:** Building simulation; multi-objective genetic algorithm; multiple linear regression; Monte Carlo approach.

# 1160. Factors that Affects Maturity Level of BIM Implementation in Indonesia

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Construction industry is one of the strategic sectors in Indonesia's development. Investment in the sector increases significantly every year. However, the performance of Indonesia's construction industry is still poor, as indicated by high accident rate at construction site, building failure, as well as poor value for money of the construction product. Developed countries have regulated Building Information Modeling (BIM) as a mandatory practice to improve the performance of their construction industry. However, there is no BIM regulation in Indonesia. Even worse, maturity level of Indonesian construction industry to implement BIM is considerably low. This research identifies factors that affect the maturity level of BIM implementation in Indonesia. The result is expected to increase the level of confidence of the stakeholders in Indonesia's construction industry to implement BIM in their projects. Methodology used in this research is a distribution and comparative analysis to the interview results. Direct and questionnaire interviews are done to five actors of key stakeholders in construction industry. From the findings, it is clear that factors that affect the maturity level of BIM implementation are: the commitment of the leader; system and infrastructure development; and quality and capability of human resources.

**Keywords:** Building Information Modelling (BIM), construction industry, key-stakeholders, maturity level, significant factors.

# 1185. The design orientation and shading impacts on rooftop PV economics in the urban environment: a case study in Melbourne, Australia

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To deal with the environmental and energy issues, many researchers found high potential of adopting building photovoltaic (PV) systems in urban areas, especially on building rooftop. However, the optimal energy output performance is impacted by the usable roof area, layout of PV arrays, and shading ratio considering high city density. This study aims to understand the impacts of design orientation and shading in the urban environment on rooftop PV's economic performance. This study carries out a case study in Melbourne with 15 PV designs under three shading conditions to generate a total of 45 scenarios. Through lifecycle cost analysis including net present value (NPV), NPV per kW and payback year (PB) the results show the best and worst design scenarios under different shading conditions and the maximum shading loss that makes NPV become zero. This study reveals that in Melbourne: For buildings facing north, the rooftop PV system should also be oriented north to achieve the best economic performance. If the building orientation is 20 degrees counter-clockwise from true north, the recommended azimuth angle of the PV system is 10 degrees towards east. In order to enhance the ability to sustain shading loss, the azimuth angle of PV system is also suggested to be 10 degrees towards east.

**Keywords:** Building Photovoltaics; orientation; shading analysis; economic analysis.

# 1141. Using Virtual Reality and Participatory Processes to Design Interstitial Healthcare Places

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Within healthcare architecture, there is a void of attention directed towards the non-medical spaces; the waiting rooms, hallways and all 'between moments' where many people spend extended periods of time under acute stress. Nowhere is this more prevalent than in the emergency departments where patients seek care and treatment for real or perceived, serious injuries or illnesses. While waiting for medical attention, exposure to high levels of harsh lighting, sterile furnishings, chaotic activity and cavernous rooms with others in distress can cause and increase anxiety, delirium and high blood pressure. The emotional experience of such spaces changes based upon a user's unique sensory conditions and therefore their individual perception of space.

The architectural design tools and devices to explore these highly charged sensory spaces have been historically limited to technical plans and sections and rendered marketing perspectival images which do not fully communicate the immersive experience of these spaces when in use. Virtual reality is emerging as a powerful three-dimensional visualisation tool, offering designers the opportunity to comprehend proposed designs more clearly during the planning and design phases, thus enabling a greater influence on design decision making. This research explores the use of VR in a healthcare perspective, adopting a participatory design approach to simulate sensory conditions of blindness, deafness and autism and the emotions associated with these conditions within space. This approach diverges from a purely visual method of design towards an understanding of the haptic, exploring the critical phenomenology behind these non-medical spaces. The research finds significant potential for the use of virtual reality as a design tool to simulate the experience of these spaces in early design stages

**Keywords:** Virtual reality, participatory processes, phenomenology, emergency department.

# 1242. Pre-Occupancy Evaluation Tools (P-OET) for early feasibility design stages using virtual and augmented reality technology

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This research explores how parametric modelling integrated with environmental simulation, in combination with virtual and augmented reality, can be deployed at the early stages of design. Our approach is based on an integral design strategy, which gives equal weight to quantitative and qualitative evaluation. In effect, the study investigates how the qualitative aspects of post-occupancy evaluation can be brought forward to the early 'pre-BIM' stages, where the most added value can be delivered at the least cost. This paper reports the implementation of two software prototypes. A VR (Virtual Reality) application uses quasi-realistic graphics and spatial soundscapes to provide a virtual experience, where users undertake tasks and provide voice feedback, in combination with activity tracking and surveys. The second prototype uses AR (Augmented Reality) technology to compare design options: interactive models appear on a conference table; these are overlaid with environmental performance data; user activity tracking; survey data; and protocol analysis of voice comments. For the purpose of providing proof-of-concept a simple architectural design context is being examined – the simulation of a typical commercial office environment. The paper discusses preliminary feedback on the prototype applications, in advance of the next stage of the research where full evaluation with end users will be undertaken.

**Keywords:** Virtual Reality, Augmented Reality, Pre-Occupancy Evaluation, Design Evaluation.

# **ARCHITECTURAL SCIENCE: ARCHITECTURE, DESIGN AND ENVIRONMENT (III)**

# 1195. Towards a comprehensive hybrid life cycle inventory for Chilean building materials

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Economic growth often results in an increased demand for energy and resources. This is the case of Chile, a country that although has managed to become a leading economy in the South American region, is still strongly dependent on extractive industries and imported fossil fuels. In this context, the Chilean building sector is one of the largest consumers of energy and resources while responsible for a significant amount of its waste and greenhouse gas emissions. Although this has prompted initiatives targeting sustainable construction practices and building operational efficiencies, a comprehensive approach to account for the complete life cycle environmental performance of buildings remains an unmet need in part due to the lack of information on the performance of individual building materials. This paper addresses this issue by proposing a methodology to inform the compilation of hybrid life cycle inventories of Chilean building materials. The proposed methodology focuses on (a) gathering economic input-output, process-based, and environmental data, (b) data pre-processing, and (c) combining this information to generate hybrid coefficients based on the Path Exchange Method. The proposed methodology then used to calculate the embodied energy of seven locally manufactured building materials, demonstrating its capacity to inform the development of a comprehensive life-cycle inventory for Chilean building materials.

**Keywords:** Life-cycle assessment; hybrid analysis; inventory assessment; building materials; embodied energy; Chile.

# 1217. Prefabrication: New Zealand's golden ticket?

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The construction industry within New Zealand is currently experiencing a boom and is the largest sector of the country's infrastructure. Although substantial, the industry continues to suffer from inflated costs, low-productivity and lack of innovation. Sparsely developed methods from the beginnings of construction in New Zealand are still practiced today, attributing to low-productivity and the current 'housing crisis'. With recent government schemes that aim to provide 100,000 homes in a decade, the demand for innovation and efficiency in the industry is under pressure and prefabrication is suggested to help evolve the industry for the demand. Through a literature analysis, this paper will investigate a brief history of prefabrication on an international and national scale. Other industry models will also be analysed, including Sweden and Japan, providing insights to the questions concerning New Zealand. The analysis informs the conclusion that prefabrication is unable to instantly infiltrate the New Zealand construction industry. Additionally, implementation of this alternative method will require the servicing of other areas, including the supply chain and skilled labour.

**Keywords:** Prefabrication; Housing crisis; Government schemes.

# 1124. Well-being in vertical cities: beyond the aesthetics of nature

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There is a growing recognition of the need for daily contact with nature, to live happy, productive, meaningful lives. Biophilic Design enhances human well-being by fostering connections between people and nature in the built environment. Achieving these benefits has the potential to improve quality of life and provide direct and indirect financial benefits e.g. reduced health care costs, reduced costs of crime and violence, improve productivity and workplace performance, and consequently wellbeing and quality of life. Biophilic Design holds that good design must integrate nature and natural elements. Biophilic design therefore, is a design philosophy that encourages the use of natural systems and processes in the design of the built environment. Biophilic Design is based on Edward O. Wilson's Biophilia hypothesis, which proposes that humans have an innate connection with the natural world and that exposure to the natural world is therefore important for human wellbeing (Wilson, 1984). This paper is a review paper bringing current academic knowledge in the area of biophilia and their relationship to living and working in high-density cities.

**Keywords:** architecture, livability, biophilia, biomimetic design, restorative environments.

# 1249. Assessing Design Value systems: fragmentation, competition, and crisis in a global industry

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Measuring Design Value has always been a difficult task for architects. This paper begins to describe the landscape of design value tools currently utilised across the globe. Inherent in assessing design value are questions of its definition, measurability, and implementation. The identification of factors which contribute to design value includes economic, environmental, and cultural factors. Rather than seeking, or highlighting a single Design Value methodology—as so-called silver bullet—this paper provides an overview and a critique of the global industry that surrounds different notions of Design Value. This overview is by no means exhaustive. This is the paper's principal aim. Predominant and well known value frameworks and rating tools are identified, critiqued and summarised. These frameworks include CABC in the UK, The DQI, Leesman and multiple frameworks associated with Sustainability, Green Rating Systems and Post Occupancy Evaluation are surveyed. A number of policy frameworks developed by Australian Government architects are also discussed. The paper contends that the global industry that surrounds all these frameworks is highly fragmented, contested and competitive. This viewpoint arises because Design Value is not a fixed construct that cannot be easily templated and isolated from socio-technical contexts.

**Keywords:** Design Value, Metrics, Rating Systems.

# 1318. Students' perspectives on configuration design of universities' informal learning spaces

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Across the Australian tertiary education sector and worldwide, the number of informal learning spaces has increased in newly constructed and retrofitted university campus projects. Research on these informal learning spaces does not pay much attention to the importance of spatial configuration design and how the configuration characteristics of an informal learning space may influence students' selection of favourite spaces and their learning activities and outcomes. Therefore, there is an urgent need to investigate students' perceptions of the configuration designs of informal learning spaces on university campuses. Space syntactic theories are applied in this research to formulate the configuration characteristics of informal learning spaces, and students' perception indexes of designed spaces based on students' behavioural observations are used to represent students' perceptions. An empirical study based on the Geelong Waterfront campus of Deakin University explores how the configuration features of informal learning spaces affect students' approaches and choices. The research findings indicate that the individual learning behaviours of students tend to favour spaces with low integration and high depth values, but they reject completely quiet spaces. Designers and managers of university learning spaces could implement these research findings and approach to improve the configuration characteristics of informal learning spaces for onsite students' learning activities and the quality of their learning outcomes.

**Keywords:** informal learning spaces; spatial configuration; students' perception; university campus.











