Timber Queensland Growth Scholarships

Vibroacoustic Study Tour

A learning expedition of the Australia and New Zealand timber industry

Author

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A Timber Queensland Growth Scholarship offers funding to Queensland based forest and timber industry professionals and workers who are in their early or mid-career years. Growth Scholarships facilitate access to learning experiences and opportunities that will foster a passion for working in the forest and timber industry and enhance career pathways. This report was completed post learning project activities.

Introduction

Timber framed housing makes up around 80% of new and existing domestic dwellings across Australia with the forest and timber industry in Queensland alone supporting close 21,200 workers and generating $3.8 billion towards the state economy [1]. Engineered wood products (EWPs) provide a means of reducing the impact of defects in standalone sawn material through peeling, jointing, or bonding to produce a high-quality refined product. Upscaling of EWPs has increased the material applications to multi-storey developments for residential, commercial or industrial structures. These products are commonly referred to as mass timber.

The use of mass timber products in construction has been steadily increasing both locally in Australia and globally with more construction projects considering timber for its many benefits. Some example structures include Forte (Melbourne, 2012), Library at the Dock (Melbourne, 2014), 25 King Street (Brisbane, 2018), and Monterey Kangaroo Point Apartments (Brisbane, 2021). The benefits behind the use of these materials consists of, but are not limited to sustainability, ease of construction (weight difference and time taken to install), and occupant perception [2, 3]. However, like all materials and given its relative infancy in the Australian construction industry, mass timber comes with its own challenges. Some of these include fire resistance, mechanical design, and vibration and acoustic performance [4]. Following on from Faircloth [5] and Karampour, et al. [6] the standardised techniques of predicting and designing for vibrational performance in timber floor systems has questionable accuracy when compared with experimental analysis. Furthermore, little is known of the composite performance and complexities surrounding mass timber elements regarding acoustics in both airborne sound and foot fall induced sound scenarios.

From initial research, a gap was identified in the understanding surrounding these properties for mass timber and timber hybrid developments, and thus a solution was needed with insight on the current state of knowledge within the Australian timber industry. This enables industry's priority areas to be targeted in collaboration with researchers. Therefore, the aim of this study tour was to conduct a detailed consultation period with industry regarding their knowledge, perception, and methods for incorporating vibration and acoustics within their projects. For interest and transparency, industry groups across Australia and New Zealand were targeted to identify possible parallels that exist between the two countries regarding structural design for vibration and acoustics. New Zealand was considered due to the number of parallels with Australia such as resource, product design standards for timber products, and climate (and therefore related service class conditions). The participants targeted provided a representative selection of active groups along the supply chain (producers, manufacturers, designers, builders, consultants, and academic institutions) and through this, priority areas in mass timber production and its application, between countries were identified. The knowledge gathered was used to better direct research focuses for Mr. Faircloth and bring necessary knowledge back to Queensland.

Focus of Learning Project

The aim of this learning project (study tour) was to consolidate industry knowledge regarding vibration and acoustics in mass timber or hybrid structures across the trans-Tasman between Australia and New Zealand. This knowledge would be brought back to Queensland (QLD) and used to better direct current and future research efforts. To ensure the information being collected was representative of the majority of the industry, contacts were targeted across most states in Australia (QLD, New South Wales (NSW), Tasmania (TAS), Victoria (VIC), South Australia (SA), and Western

Australia (WA)) and major cities and towns in New Zealand (Auckland (AUK), Rotorua (ROT), Wellington (WEL), and Christchurch (CHR)).

This enabled a greater understanding of the parallels (or differences) between the two countries and identified novel approaches to designing for vibration and acoustics in structures. The outcomes of this study tour better directed additional research and development planned to be undertaken by Mr. Faircloth in the form of a PhD in the future to support the Queensland industry.

Significant Learnings & Outcomes

During the study tour, over 40 individuals and organisations were visited and interviewed over a period of 30 days. The study tour took place in both Australia and New Zealand, across the locations noted in the previous section. Through the conducted travels, several priority areas for future developmental work were identified and are detailed below.

Boundary Conditions

The way in which a material is supported has a significant impact on that materials' measured response to excitation; this is referred to as the boundary condition (BC). The BCs can vary greatly when comparing an isolated material test as in Faircloth, et al. [7] with the in-situ (field) performance of a material or system [8]. This is true for both vibration and acoustic assessment where both properties are difficult to simulate in a laboratory setting for comparison to the material/ product's use within a structure. This extends to the clear spanning length of floor elements, installation quality of doors and windows, and stiffness of joints and connections [9-11]. Greater understanding of the practical installation aspects and various connection effects were highlighted as areas of interest for industry.

Novel Materials

Experimental testing provides the necessary characteristic data to establish theoretical modes, refine standards, or provide technical guidance to the industry. Since its conception and use, research has been ongoing to characterise the performance of mass timber materials for such purposes [9, 12, 13]. These studies have mainly looked into the product performance in a laboratory setting with scarce publications focusing on the product performance within a completed structure (field testing); usually as a result of limited structures to conduct field testing in. Developments such as the Wood Solutions Technical Design Guide No. 44 [14] (TDG 44 [13]) highlights how experimental work has led to industry relevant guidance already. However, the new hybrid variations of material and construction types (for example: cross-laminated timber flooring with a screed of concrete) have yet to be characterised to this level of detail. Industry expressed an interest in developing greater understanding of these novel material types with increased testing focusing on the various layering stages and each stages' influence on the material performance. Other such priority areas specific to Queensland have been to define the fundamental characteristics of local timber species and possible optimisation techniques regarding material usage (sawn direction, grain angle, etc.). Questions were raised on the level of influence material characteristics (density, grain direction, sawn orientation, etc.) have on its vibration and acoustic response. From such information, product development and optimisation can take place for properties other than strength, stiffness, and appearance.

Standards and Policy

The methods and standards used in Australia and New Zealand originate in some form from our colleagues overseas where climate, resource, and perception of performance may or may not be the same. Because of these variations, the current methods require refinement to ensure they are relevant to our regional needs and performance expectations. Standards and building codes specify the minimum regulatory requirements a finished structure must meet to be deemed compliant. However, as these standards provide only a minimum threshold there is little added detail regarding methods to enhanced and measure performance. It is also understood that the standardised testing methods in place do not alone provide the necessary parameters to characterise these new materials [6]. The complexities mentioned prior regarding the BCs are not sufficiently accounted for in some of these methods as well as the variations inherent to the practical aspect of product installation (floors, partitions, doors, windows). Perception of performance also requires further consideration and incorporation within the testing approaches currently in use. Kremer, et al. [3] and Karampour, et al. [6] highlighted some of these inconsistencies through the current methods whereby new mass timber products are not specifically accounted for. Industry has expressed their interest in possible alternative means of measuring performance for the mass timber category of material types. A similar piece of work to TDG 49 [11] and TDG 44 [14] specific for these novel material types would allow for knowledge development regarding these material types to be expanded on.

Education

Across all the above sub-categories, a bridging priority for those interviewed was better knowledge generation regarding the topic of vibration and acoustics. These relate not only to industry but those in academia where solutions to one parameter may negatively affect another. For example, multi-storey apartment buildings would benefit from greater cavity size between floors to account for acoustic transmission however, ceiling height is a desired feature of designers and occupants. Knowledge specific to the materials discussed in other sections and contributing effects of altering various parameters is considered important. This is of particularly interest for acoustics as the current assessment methods and models are developed based on the assumed information gathered from conventional steel/ concrete structures with adjustments for density. Education of the contributing factors towards vibration and acoustic performance in structures was highlighted by the interviewees.

The findings presented herein highlights the industries weighting of vibration and acoustics in structures as well as the importance of further research into developing necessary fundamental material characteristics for Australian timber species. Identifying solutions to these focus areas will directly benefit the Queensland timber and construction industry as well as the national sector to ensure the growth with comprehensive knowledge and understanding when using sustainable building materials like mass timber products. The findings also present an opportunity to investigate the effects of alternative species and how their anatomical properties relate to vibration and acoustics. Furthermore, with the 2032 Olympic games approaching, Queensland is well positioned to showcase its ability to pioneer innovation through addressing and researching some of these challenges for the industry. Current and anticipated research hubs (advanced timber hub (ATH), national institute of forest product innovation (NIFPI)) provide a suitable medium for such challenges to be addressed in a collaborative and transparent manner.

Conclusion

The aim of this study tour had been to capture the state of knowledge and understanding across both Australia and New Zealand with the specific focus of identifying how vibration and acoustics are delt with in the current timber sector. Through over 40 industry interviews and visits, an overwhelming consensus for the importance of considering vibration and acoustics in new and existing structures was highlighted. This importance was not isolated to timber as a timber product challenge but a whole design and complete system one. The study tour considered several key impact areas to be addressed as i) vibration and acoustics must be delt with as a system and not in isolation, ii) there is limited experimental data available, further testing is required to develop better knowledge and a larger exemplar data base, and iii) evaluation methods across both measured performance and perception require further refinement and development for the inclusion of mass timber products.

This study tour has resulted in the reported knowledge gathering as well as the identification of priority areas for the timber and construction industry regarding vibration and acoustics in structures. The findings suggest that through deeper understanding of the material properties of some timber species, advantages may be possible for some species over others for certain vibration or acoustic sensitive applications. These outputs have supported Mr. Faircloth in beginning the initial stages of a PhD focused on vibration and acoustics in mass timber buildings.

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