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The Tall Frontier of Timber in Australia: Opportunities for Promotion Versus Industry Hurdles

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Abstract The use of Engineered Wood Systems (EWS), especially mass-timber, as a structural alternative or complement to steel and concrete is gaining interest and acceptance across different sectors of architecture, engineering, and construction, including in high-rise buildings. Focussing on the Australian context, this study examines the levels of adoption and barriers to using timber as a primary structural material in multi-storey buildings. Data collected from semi-structured interviews with stakeholders at the forefront of adoption in structural design, construction, and property development indicates that timber in multi-storey projects in Australia still faces industry-wide challenges. Designers' awareness and attitudes towards timber adoption are generally positive and suitable for flagship projects, including tall buildings, but for enduring and widespread impact, long-term investment in education within and outside the range of stakeholders already committed to promoting timber adoption is needed.

Keywords Engineered Wood Systems, Multi-Storey Timber, Innovation Hurdles, Australia

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1. Introduction

Engineered Wood Systems (EWS) are building technologies suitable for multi-storey building design and construction, including high-rise buildings. The acronym EWS is used here to denote a family of technologies that contains, but is not limited to, commonly known mass-timber construction materials like Cross Laminated Timber (CLT), Glued Laminated Timber (GLT) and Laminated Veneer Lumber (LVL) (Figure 1).

The definition of EWS is however broader than these three products and encompasses other engineered timber materials and systems. Among these are systems generally less known or appreciated outside specialist audiences like prefabricated systems based on traditional timber construction, cassette floor systems and timber-framed wall panels, and emerging or relatively experimental hybrid technologies that use mass-timber in structural applications such as composite with steel (e.g. pre-stressed timber columns and beams) or concrete (e.g. timber-concrete slab systems).

The prevailing academic literature concerned with the adoption of timber in multi-storey timber construction shows that there is a growing wealth of interest in the topic worldwide, as there is an abundance of evidence concerned with the environmental benefits of mass timber construction systems. The growth of timber as a suitable and feasible alternative to steel and concrete appeals more to the medium-rise sector than it does to the high-rise sector, despite the fact that timber has been shown as a viable structural material for the construction of high-rise buildings (Connolly et al., 2018; SOM, 2013). The provisions in some building regulations reflect the fact that timber is an appropriate material for the construction of medium-rise multi-storey buildings. For example, the National Construction Code of Australia prescribes deemed-to-satisfy conditions for multi-storey timber construction that is generally lower than 25 meters in effective height (ABCB, 2016). These conditions apply to multi-storey timber construction that has fewer than three stories. Despite this, the term “Tall Wood Buildings” (TWB) is frequently used to refer to the growing trend of utilising timber in building construction that is not limited to the realm of traditional low-rise residential buildings (Green at al., 2017). Although its relevance in that sector pertains so far to examples of relatively low height when compared to the contemporary global tall building stock (Foster et al., 2016), the term “tall” reflects the industry's intent to advocate for the expansion of this technology in the broader market of multi-storey commercial construction.

1.1. Scope and significance

This research builds from these precedents, with the intent to reassess the prospects of growth in high-rise timber applications based on a qualitative assessment of the strengths, weaknesses, awareness and attitudes of

Figure 1. From left to right: Cross Laminated Timber (CLT), Glued Laminated Timber (GLT) and Laminated Veneer Lumber (LVL) (Source: G. Marfella)

developers, design, engineering and building professionals with direct experience with the adoption of Engineered Wood Systems (EWS) in mid-rise and high-rise construction projects in Australia.

The findings of this study stem from research that was conducted in two stages in 2020. The first stage involved online survey of 518 professionals in the design, construction, engineering, and development industries who were deemed to have at least a cursory understanding of EWS products based on their involvement with an organization promoting the use of timber in Australia (Marfella and Winson-Geideman, 2021). The purpose of that stage was to gain an understanding of the perceptions of a broad group of professionals regarding the use of timber in multi-storey construction. Participants provided responses on a range of environmental, social, and economic questions to better understand the costs, benefits, and barriers to EWS use in the Australian context. Results support the notion that EWS is widely perceived to be an environmentally friendly product and a technically appropriate complement to traditional construction materials such as concrete and steel. Fire resistance, procurement, technical knowledge among trades, and regulatory issues are perceived as impediments to wider use, requiring the provision of future education for the various industries over the long-term.

This paper covers the second stage of the research which involved a series of in-depth interviews with key stakeholders across different disciplines designed to test the potential reception of these technologies. The information collected provides rare insight to an industry where stakeholders are often reluctant to share information for fear of losing competitive advantage, making critical areas of enquiry difficult to investigate. This research fills that gap by identifying barriers to adoption and strategies to overcome them with lessons that are applicable to a broad spectrum of current and future projects. The responses from the interviewees established themes that are multi-faceted and relevant for different disciplines, building typologies, and socio-economic interests. Although this study focuses on Australia, the findings are relevant in other geographic areas, particularly those involved in a paradigm shift towards re-industrialization of local building practice and labour, where timber construction systems are becoming more popular in medium as well as high-density building typologies.

1.2. Methodology

The first stage of the research assisted in the development of guiding questions for interviews with ten senior leaders in development, architecture, engineering, and construction.

The interviews gave the opportunity to learn more from users with direct experience of timber in multi-story commercial projects ranging from medium to high-rise and were designed to provide an in-depth understanding of the experience of industry professionals involved at the forefront of adoption of EWS in multi-storey projects.

Participant selection was guided by the following criteria:

- That participants have senior standing in the industry and their respective field;
- The sample ensured a diverse mix of disciplines, projects and size of organisations.
- All participants to the interviews have significant experience working with EWS.

The final participant count included twelve interviewees from ten organisations representing four key industry disciplines: architecture (3 participants), structural engineering (2 participants), property development (3 participants), and construction management (4 participants). Two of these participants were able to provide feedback from both the developer and the builder perspectives. All interviews took place in person. Despite that all participants were from Victoria, several had national experience, business ties, and project experience that extended to Western Australia, South Australia, Queensland, and New South Wales. At least half of the participants were from organisations with multiple offices and clients across Australia, and in some cases, internationally.

Face-to-face interviews were conducted with the goal of clarifying topics pertaining to, above all, entry barriers for Engineered Wood Systems in Australian construction projects, namely:

- The current awareness of EWS in the Australian market, specifically where, when, how and why it is used;
- Opinions regarding EWS and its potential for further growth in the Australian and/or local urban (Melbourne or other capital cities) markets;
- Barriers to entry and other resistance factors to innovation;
- Perceived costs and benefits from a construction and/ or end-user perspective;
- Opinions regarding the quality of EWS relative to comparable traditional construction materials and techniques, like steel and concrete.

With the intention of maintaining a consistent theme without constraining the responses of participants, the researchers structured the interviews around a set of guiding questions (Table 1).

Participants were free to express their opinions and cite examples relevant to the guiding questions during the interviews, with the goal of gaining insight from direct knowledge and experience working with timber rather than merely generic perception. The majority of the examples provided by participants came from projects based in Victoria, Australia. Some participants also talked about their experiences in other states.

Table 1. Interview Questionnaire

	Question
I	What is your experience working with/using engineered wood systems (EWS)?
II	In what type of project were these materials used?
III	What are the major drivers that promote the use of timber in multi-storey projects?
IV	What are the major barriers to the use of timber in multi-storey projects?
V	Are traditional procurement methods an obstacle for the adoption of timber in multi-storey buildings?
VI	Did you experience any unexpected technical shortcomings related to the use of timber, during design, construction or occupancy?
VII	How did timber co-exist with the other materials used on your projects and between trades?
VIII	Are finance and insurance obstacles for the adoption of timber in multi-storey projects?
IX	Do you have any experience with projects that did not move forward due to financing or insurance issues related to the use of timber products?
X	Where do you see wood products going in the future in Australia given the current state of the industry?

2. Findings

The interview results reveal several recurring themes provided in response to the guiding questions. Several benefits of EWS are revealed although the comments that outline the current barriers to the use of timber in multi-story projects are of particular interest. Because of the participants' level of direct experience and seniority, the findings provide qualitative insight into the barriers to adoption, supplementing the quantitative findings on issues of resistance to change determined by the survey found in prior research by Marfella and Winson-Geideman (2021).

The interviewees also provided valuable insight into other topics. They explained the major drivers for timber adoption, how procurement and supply chain issues may influence its selection and adoption, what technological shortcomings may arise in construction, how timber co-exists or conflicts with other materials, and what financial considerations may influence developments where timber is used or considered as a primary structural material. Finally, all interviews were concluded by gathering a summary of the interviewees' viewpoints by explicitly asking them to comment on future prospects for timber in multi-story projects.

2.1. Environmental issues

Interviewees almost unanimously praised the lightweight nature of engineered wood systems, as well as other well-known benefits such as carbon storage and reduced site labour requirements. However, in some cases, the intention behind the adoption of EWS is to promote the environmental credentials of some of the more significant market players. Tier one construction companies and tertiary education institutions, for example, can amplify the benefits of these technologies by serving as prominent “patrons” for timber, while also benefiting from being perceived as organisations committed to addressing climate change challenges. However, the driving element of environmental promotion can be negatively offset when such intentions are implemented during the construction phase. According to one construction manager, full recognition of sustainable credentials for timber through rating schemes of environmental certifications is often difficult to achieve unless the material's chain of custody can be verified in certainty and detail.

2.2. Fire resistance and regulations

According to the interviewees, the primary barriers to the adoption of timber are fire safety and the regulatory implications that come with it. One structural engineer mentioned that the approval process for fire safety poses the greatest risk not only to the Australian industry but also to other international contexts. The ‘cladding crisis’ appears to be playing a significant role in slowing the adoption of timber, adding concerns and perceptions that mass-timber adds risks significant enough to abandon its

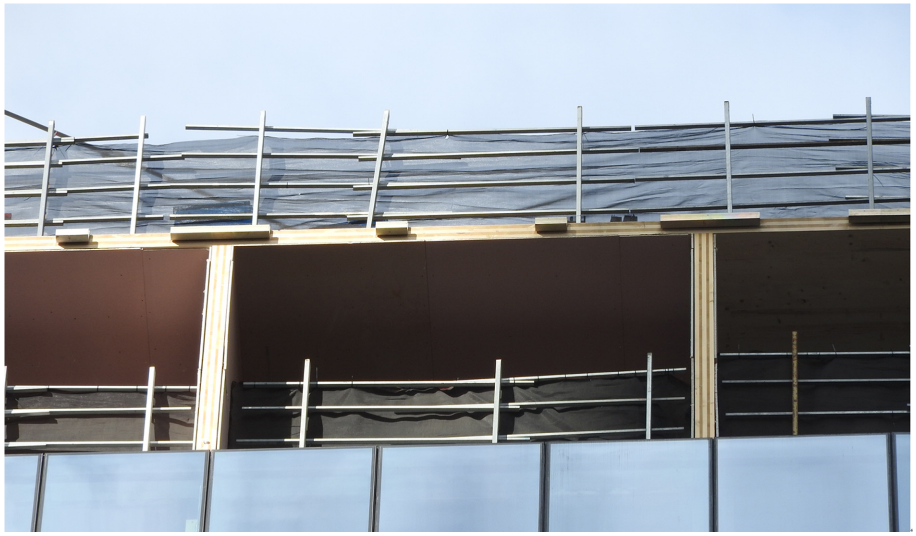

Figure 2. Multi-storey mass timber construction with encapsulating fire protection. (Source: G. Marfella)

consideration in favor of more conventional construction systems. Other obstacles identified include a lack of local supply, limited technical guidance from the Australian National Construction Code (NCC), and difficulties meeting acoustic performance standards. These regulatory and technical barriers, when combined with small profit margins, cost constraints, and lower returns in the market conditions observed at the time of this study, can act as insurmountable barriers for smaller developers and contractors. In such circumstances, tier-two and tier-three medium-rise developers and builders are generally not positioned to test the market and absorb the financial and technical risks associated with the use of innovative products such as mass-timber.

2.3. Procurement

The interviewees' perspectives on procurement issues are twofold. To begin, the limited capacity of the local market to compete in tendering is regarded as a significant impediment. In the current market, timber suppliers and structural contractors must be involved in the very early stages of projects, or “from day one,” as one interviewee put it. Second, lead times for timber procurement are generally longer, frequently necessitating additional design and, not infrequently, supply from overseas. These elements, when combined with the limited availability of local skills, add significant uncertainty to project feasibility by concentrating too much risk on a single point factor along the critical path for project delivery.

2.4. Technical shortcomings

Among the few technical shortcomings mentioned in the interviews, participants focused primarily on fire resistance, water ingress, and long-term durability. Despite being familiar and highly experienced with performance-based design solutions, the structural engineers lamented concerns about limited access to guidelines and research on mass-timber structures for matters related to proprietary connections, the self-extinguishing of charred members, and the possible long-term impact and behavior of creep and floor deflections. In addition to these issues, participants report widespread concerns, particularly about fire safety, mould during construction, and the potential for water ingress in service. One builder stated that he was dubious of the use of EWS in large residential developments, particularly in wet areas.

2.5. Material and trade constraints

Participants discussed the coexistence of timber and other materials along two lines of thought. The first is concerned with compatibility and interfacing with other materials, and the second with issues due to separate or additional trades required to complete the work of engineered-timber structures. Most builders, engineers, and architects have stated that timber is rarely compatible with other materials. According to one architect, this could be a constraint for the design opportunities that designers want to explore by juxtaposing different materials for aesthetic reasons.

Concerning the need for complementary trades, one builder detailed a case in which, despite the favourable condition of a vertical extension, the work required for fire-proofing and acoustic treatment with plasterboard and insulation jeopardized the feasibility of a timber solution due to the additional cost and labour required to install these finishing materials.

2.6. Finance and insurance

Although some participants have mentioned fire safety issues as potentially affecting insurance premiums, there is disagreement on this point and little direct acknowledgement of instances where this has been observed. The

Figure 3. Hybrid multi-storey construction, combining steel framing, precast concrete and EWS. (Source: G. Marfella)

prevalent perception appears to be that if mass-timber is permitted by the building regulations, the provision of insurance should not be a significant barrier to adoption. However, one developer reported firsthand knowledge of difficulties in obtaining financing. Multiple lenders contacted by the developer denied financing for a socially progressive mid-rise residential project that was originally planned to be built with a mass-timber structure. According to the same developer, lenders were primarily concerned about a lack of alternatives in the event of default by a single off-site contractor or overseas-based supplier. The developer stated that such financing challenges are not an isolated occurrence and have been reported to have hampered previous projects based on three-dimensional modular prefabrication. Developers can only overcome financing challenges in projects with a high level of structural prefabrication by providing in-house equity contributions that can offset the increased risk posed by innovation. However, large equity contributions, rather than debt, render projects involving high technical risk financially unfeasible for smaller to medium-sized developers.

2.7. Other risks

In conclusion, the participants interviewed see the future of timber in multi-story construction differently depending on their roles, with developers appearing to be the most pessimistic, at least in the short term. Developers and other participants expressed concerns about high risk, a fragmented regulatory environment, and a lack of critical mass on offer in the Australian market. These sources of risk act as barriers to innovation, preventing the use of timber outside of a few specialised market leaders or tier-one builders. Builders expressed more optimism for the long term, though this was tempered by pessimism about current industrial conditions.

Participants agreed that it is reasonable to anticipate further growth for mass-timber in high-density urban scenarios. According to all interviewed participants, these prospects are not only likely to occur, but will be welcomed as a positive response to climate change. Several participants mentioned and discussed project details in which mass-timber was considered or used for a vertical extension on existing structures. The high frequency of comments about similar projects suggests that re-use, extension, and rehabilitation of existing buildings may become a market niche where engineered timber can gain a significant competitive edge in inner-city developments with difficult site access and subject to heritage control.

Prospects for growth, on the other hand, are dependent on regulatory change and reliant on the need for additional education to provide industry-wide knowledge, experience, and skills. According to the participants in this study's interviews, the process of change required for increasing EWS adoption in multi-story projects in Australia is likely to proceed incrementally over time and is unlikely to be subject to sudden change and growth in the short term.

3. Discussion

The adoption of EWS in multi-story and high-rise projects in Australia faces many challenges. This pessimistic attitude is most acutely felt by mid-size and small developers and construction firms. Several barriers to innovation, according to almost all interviewees, result in insufficient capacity in the industry to create a competitive point of entry for new players, particularly at the tier-two and tier-three level - the market where most of the medium-rise construction occurs in Australia.

Although a few large construction and development firms have successfully embraced EWS on a large scale with 'flagship' projects, these firms are able to do so, according to the participants, because they isolate the significant risks associated with the adoption of sophisticated engineered timber solutions in multi-story buildings. Tier-one companies that work with clients who want to 'patronage' sustainable technological innovation can justify their EWS investments through intellectual property protection. They also benefit indirectly from these investments by enhancing their public reputation as forward-thinking companies facing climate change challenges.

According to the feedback from medium to small-sized developers, the leading EWS innovators in Australia can secure funding more easily than smaller players, either through solid financial credentials or access to in-house equity. Smaller (tier-two or tier-three) builders and developers seeking to enter the engineered timber construction market instead face insurmountable obstacles. Despite their best efforts to be progressive and open to sustainable innovation, professionals in the mid-rise market complain that they are unable to implement projects built with EWS for the following reasons.

3.1. Fire-safety stigma.

As a result of the Lacrosse Apartments fire in Melbourne and the Grenfell Tower fire in the United Kingdom, tightening attitudes in fire-safety regulations and control are leading to substantial approval and cost risks in fire-related engineering trades. An engineer stated that there is uncertainty about approvals and rising costs. Another engineer said the “cladding crisis” has created “paranoia” about premiums and risks associated with fire safety. A developer explained he decided not to use timber after learning from the building surveyor that the project would have to go through a statutory appeal process before being approved. Regardless of whether arguments in favour of the safe use of timber can be successfully demonstrated and argued, the same developer suggests that the prospect of adding six to eight weeks to the timeline of a development can be enough to discourage adoption at the feasibility stage.

3.2. Supply chain barriers.

The participants agreed that EWS can reduce the cost of construction preliminary work and significantly shorten the time spent on-site for structural erection. However, these cost savings are rarely sufficient to offset the higher material costs and longer lead times required for timber procurement, whether from local or overseas suppliers. Despite that EWS can be economically advantageous in some projects, the participants identified procurement issues ranging from currency risk when ordering from overseas to a lack of confidence and competitive alternatives in Australia. According to one of the construction managers, procurement is driven by the triangle of time, cost, and quality; most builders are likely to enter a new market only after they believe they can reduce risk while simultaneously reducing material cost and construction time.

3.3. Limited expertise and competition.

The participants identified a general lack of knowledge about EWS among designers and building trades. Due to the low level of competition, procurement methods that require the involvement of suppliers and subcontractors in the early stages of the project are necessary. This procurement method is common and essential in order to overcome designers' lack of extensive expertise. Although the Australian industry is becoming increasingly familiar with Early Contractor Involvement (ECI) procurement methods, the use of EWS frequently implies the early involvement of one or a few subcontractors, followed by the appointment of a general head contractor. The suitability and success of ECI procurement methods may differ from project to project. According to one developer, resistance to change stems from the allocation of too much risk to a “single point factor”, i.e., the hands of a single specialist supplier/contractor. These innovative procurement processes encourage positive early collaboration between designers and builders, but they can also discourage smaller builders from participating in tenders or jeopardize access to debt for developers who enter the market with limited equity.

3.4. Inadequate regulatory standards and guidance.

Although the NCC considers pathways for the adoption of EWS in multi-story projects through deemed to satisfy provisions, several participants believe that the current regulatory framework does not support widespread implementation of timber outside of the traditional sector of low-rise domestic construction. In Australia, the use of EWS in multi-story scenarios, and particularly mass-timber, is still reliant on significant engineering activity based on performance-based design and, subsequently, subject to approval processes for solutions that are alternative to the Code's deemed-to-satisfy provisions. Although the structural engineers interviewed have extensive experience and resources to engage in bespoke, project-based, performance-based design solutions, they indicate that there are significant areas of uncertainty and lack of guidance for mass-timber structure engineering. It is unlikely that widespread adoption will occur unless the industry shares its knowledge, removes intellectual property barriers, and creates conditions for standard practice for the benefit of the entire industry.

4. Conclusion

Traditional structural construction methods based on concrete and steel compete heavily in the Australian medium-rise market. Nonetheless, there is widespread belief and awareness that the qualities and benefits of engineered wood products will eventually find a consolidated market. Vertical extension of existing multi-story structures, particularly in high-density areas with limited or difficult construction access, could be a potential future growth area. Despite universal popularity of EWS - particularly mass-timber products such as CLT, GLT, and LVL - as viable alternatives to traditional construction methods, engineered wood products are not causing widespread disruption in Australia.

In Australia, the adoption of EWS is not driven by the lowest tiers of developers and contractors. On the contrary, it is primarily in the hands of tier-one designers, engineers, constructors, specialist suppliers, and installers, who can leverage in-house expertise delivering alternative solutions to mainstream practise and use their involvement in landmark timber projects to boost corporate sustainability credentials. As a result, these conditions favour the use of mass timber in tier-one large bespoke high-rise projects over the widespread use of EWS in smaller medium-rise projects.

Future growth in the use of EWS in multi-story construction in Australia will be determined by the simultaneous action of many factors that are subject to incremental change across the industry. Stakeholders interested in the long-term growth of these products should consider additional research, education, and engagement with various sectors and professionals in the Australian construction industry or accept the promotional role of these technologies in the context of 'flagship' projects such as tall buildings.

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