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# RETROFITTING LOW-RISE BUILDING STOCK THROUGH MASS TIMBER ADDITIONS AND PERFORMANCE-BASED FIRE ENGINEERING: DARLINGHURST WORKPLACE

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**ABSTRACT:** The need for adaptive reuse to increase density is critical for reducing embodied carbon emissions in construction. Though mass timber presents a lower carbon alternative to conventional Australian construction (reinforced concrete), the embodied carbon of the existing building fabric is of great value to retain. This paper aims to demonstrate how mass timber can extend the lifespan of existing low-rise structures and furthermore, how performance-driven fire engineering can allow the timber to remain exposed to garner environmental and social benefits. The two case studies are located within Australia and are built upon low-rise commercial buildings. The use of mass timber enabled a light-touch addition of structure with the additional floors being supported primarily by existing structure. If conventional construction was employed, significant reinforcement of the base structure, or complete demolition may be required to meet the desired density. Through advanced performance-based fire engineering design, an architectural outcome was achieved that is typically impossible when following prescriptive fire certification pathways. The case studies presented act as benchmarks for future projects to deliver flexibility and community conscious outcomes that minimise material use and maximise benefits of exposed timber structure.

**KEYWORDS:** Retrofit, Education, Workplace, Performance-Based, Fire Engineering.

## 1 – INTRODUCTION

Australia, especially within its urban centres such as Sydney, Melbourne and Brisbane, contains a wealth of low-rise buildings of commercial and industrial origins. There is opportunity to uplift such building stock in terms of usable area and occupant amenity. Vertical extensions on existing buildings enable an increase of density on a developed site, retaining a portion of its structure. In Australia, an increasing number of such projects that employ Mass Timber Construction (MTC) as the primary construction material to both modernise and uplift, extending the building's lifespan.

The main values for MTC vertical extensions are:

- Low embodied carbon.
- Increase density on existing structures
- Retain operations of the remaining building.
- Biophilic and Aesthetic quality of exposed timber.

It is considered that mass timber is the ideal structural material to promote these values, particularly when in conjunction with performance fire engineering. This paper investigates two case studies, each an example of MTC used in conjunction with existing conventional reinforced concrete structures that with minimal adjustment could bear additional floors.

Both projects saw improvement in their amenity, environmental performance, and contribution to wellness through the strategic use of MTC. In addition, how the Australian industry has grown to allow local expertise and manufacturing to play a key role in retrofitting our existing buildings.

### 1.1 METHODOLOGY

The contents of this paper are based on literature review, technical work and research performed during the design and construction of the case studies, and interviews with the design and consultant team, most notably the fire and structural engineers from Darlinghurst Workplace. Interview questions focused on the capacity and familiarity of the Australian construction industry on MTC, and the key enabling factors of the projects. The findings are limited to the scope of the case studies, both specific to New South Wales (NSW), Australia.

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## 2 – BACKGROUND

### 2.1 NEED FOR RETROFIT

Retrofitting can unlock density, yield improvements in occupant amenity and thermal performance in existing building stock, without losing the value retained in existing structure [1].

Increased density is particularly difficult to achieve in Australia due to many suburbs having low density zoning, heritage conservation regions, or a combination of both. These leads to few opportunities to uplift sites, usually in the form of 'warehouse conversions' for those with an industrial past.

The need to retrofit our buildings is paramount for reaching the desired density Australian cities demand [2] whilst balancing carbon impact and social disruption. The City of Melbourne's *1200 Buildings Program* demonstrated the opportunity to retrofit or otherwise uplift a significant sum of its existing building stock. However, most was in relationship to mechanical systems and façade design. Retrofitting can "improve the environmental performance, health and value of their buildings" [3].

'Feasibility' is currently a challenge to retrofitting within Australia, determined by factors beyond just financial measures including speed of construction, carbon savings, support by local council, reuse incentives [3]. In a holistic view, retrofitting becomes viable. Furthermore, mass timber can serve as an optimal pathway. Yet, doubts remain in the industry, demonstrating the "need for education to illustrate and raise the awareness of the possibilities that adaptive reuse presents" [3, p. 29].

### 2.2 WHY MTC

This paper aims to illustrate the use of MTC for adaptive reuse and increased density, where conventional construction may not be appropriate or feasible. MTC has an advantage when creating vertical extensions due to its high strength to weight ratio, and less disruptive construction process.

Existing concrete structures may require minor reinforcement, if any, to bear the weight of additional MTC floors due to reserve capacity [4]. In addition, MTC provides environmental value from lower embodied carbon and potential for carbon sequestration, as acknowledged by Australian building certifications [5].

As timber can perform as both structure and finish, it provides biophilic and aesthetic qualities. The ability to expose mass timber structure contributes to occupant wellness [6] and avoids unnecessary materials.

### 2.3 CHALLENGING DEEMED-TO-SATISFY

The Deemed-to-Satisfy Requirements relate to the prescriptive rule-based guidelines within the Building Code of Australia (BCA). However, an alternative pathway is also available, being a performance-based design pathway which is objective-based, allowing for the overarching objectives of the BCA to be satisfied in lieu of following prescriptive guidance. [7] The Deemed-to-Satisfy model is based on precedents, agreement by consensus, and published tested solutions to typical construction methodologies. As a result, any new building technology is at an immediate disadvantage. Performance methodologies bypass this bias, through purely looking at the material properties, not certifications and rules of thumb.

As Australian knowledge of MTC is steadily increasing, the range of new timber-based products grows year on year and the local supply chain densifies. However, Australian legislation is slow to respond to new building products. The BCA stifles the allowance of exposed timber for most medium-rise uses and above due to a requirement within the Deemed-to-Satisfy Provisions to protect specific elements and their supporting parts. These specific, rigid rules and solutions favour the 'protection' of all timber members with fire-rated linings, independent of project specific fire risk. This results in the waste of materials to cover timber where it may not be necessary, contributing embodied carbon, cost, and censoring the use of timber.

The current model for fire engineering in Australia focuses on BCA compliance issues in isolation, applying a more risk-based approach favouring a Deemed-to-Satisfy pathway. Comparatively little fire engineering design work is undertaken from first principles, which can diminish holistic fire safety. The case studies demonstrate that engagement with an engineering team experienced in MTC, exposed timber in complex fire scenarios can be achievable and straightforward in adaptive reuse low-rise and medium-rise construction.

## 2 – OUR LADY OF THE ASSUMPTION

This project originated as a light touch refurbishment and developed into an uplift of a three storey 1970 brutalist commercial building, once unfit for purpose, into a four-story vertical school. The project was built across two stages. Stage 1 was completed in 2015, marking the opening of the school. Stage 2 was completed in 2018. Once completed, the project contained 5200 m$^2$ of formal classrooms, informal social spaces, a main hall and a range of support spaces, each celebrating timber construction as the primary material and finish.

### 3.1 CONTEXT

Our Lady of the Assumption (OLA) is the primary facility of a Catholic primary school of the same name,

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the site is located adjacent to North Strathfield Station, NSW (Fig.1 ).

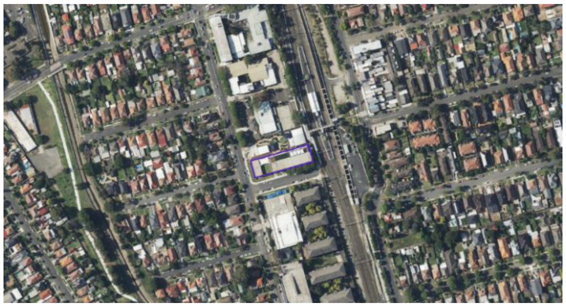

*Figure. 1 Aerial Photograph of Site*

The case study is an adaptive reuse of a telecom provider's training centre (Fig. 2). It was acquired by the school with plans to uplift the building and become their main facility. Although the concrete structure was sound, the facilities were unfit for teaching spaces due to poor natural lighting and internal amenity.

*Figure 2. Telecom Training Centre External Photo*

## 3.2 BRIEF

Key project objectives from the stakeholder group were speed of construction, student wellbeing, and learning environments that foster creativity, collaboration, and independent learning. Adaptive reuse was a consideration introduced by the client to expedite the first full student term.

## 3.3 DESIGN RESPONSE

Initial design options included a decanting strategy, and temporary classrooms built against a separate building. Mass timber was pursued as it allowed a two-stage solution, one where some classrooms could function during construction.

Stage 1 saw a retrofit for the ground floor of the existing training centre, providing classrooms to house the school's first cohort. Stage 2 was an expansion and complete retrofit of the remaining building frame to provide a wide range of teaching spaces, student amenities, and a rooftop play area.

## 3.4 PROCUREMENT

OLA employed early sub-contractor and supplier involvement (ECI) to entirely resolve the structural strategy prior to appointing the head contractor. In doing so would compress the project programme and gain certainty by coordinating the systems used.

The successful tenderer Sustainable Building Resources (SBR) is a supplier and importer based in South Australia. SBR offered a supply and install service, coordinating each European manufacturer and the local installer. This arrangement is desirable as it mitigated risks of gaps in local knowledge of the building systems. It also allowed confirmation of the preferred systems for design certainty, and future coordination challenges be understood.

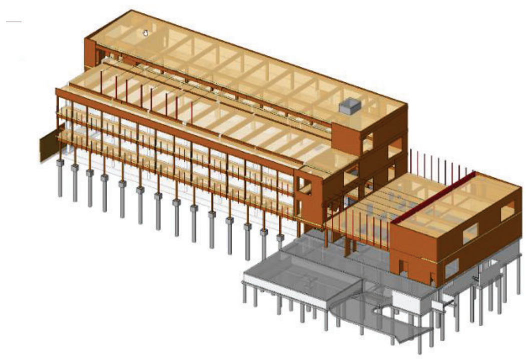

*Figure 3. OLA Structural Model*

The structure consisted of three main products and manufacturers: Neue Holz AG (Switzerland) provided Glulam beams and columns; Lignotrend (Germany) provide their proprietary system [8] for the roofs and floor slab assemblies; and KLH (Austria) for the CLT walls. As SBR performed as the facilitator between Australia and Europe, the characteristics of each system could be accounted for and integrated into the architectural proposal. Neue Holz led the detailed engineering and production of shop drawings.

The head contractor was later determined via 'lump sum' tender. The timber structural solution was fully documented, priced and provided to each potential tenderer to ensure parity. Successful tenderers then needed to coordinate and deliver the remainder of the project.

## 3.5 COORDINATION

The proprietary systems used in OLA provided advantages in performance to local timber products yet introduced complexity. Each system must be understood in isolation, and in combination. This additional


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coordination requires a shift in mindset to maximise performance.

An example is the Lignotread slab system as it allowed a reduction in the combined floor and ceiling depth, integrating engineering services into the slab itself. The system resembles a castellated beam (Fig. 4) containing voids and has a deeper cross section than solid timber. It afforded greater integration of services into the slab zone, and for the acoustic ceiling to be integrated into the floor rather than as a separate layer.

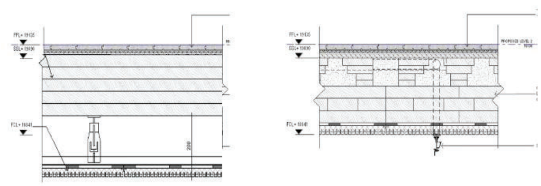

*Figure 4. Side by side, CLT vs Lignotrend*

The system was appropriate for most classrooms as its shorter spans and integration of services fit the brief requirements. It was, however, not familiar to the Australian industry. The fire and structural engineers of the local project team benefited from the advice of equivalent engineers on the manufacturer's side.

As there were knowledge gaps in application of MTC, structural depths may have increased to meet deem-to-satisfy fire requirements and prescriptive FRLs. This may increase floor to floor heights and require 'protecting' the timber through covering. Through collaboration between local and international engineers, a performance solution could be achieved avoiding the need for fire protection.

## 3.6 STAGE 1 RETROFIT

During Stage 1 all concrete structure including floor slabs were maintained on the ground floor. The concrete façade was traded for double glazing in timber frames. Wooden internal joinery and sliding doors formed the fit-out.

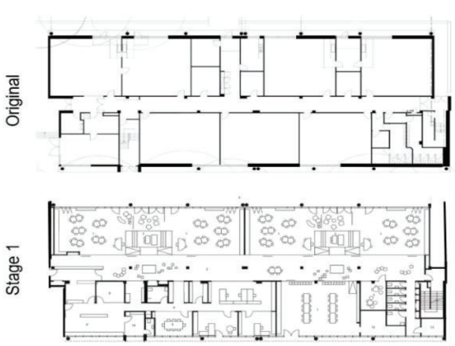


*Figure 5. Comparison of ground floor*

Internal walls within the northern side were removed, introducing a new raised central 'bridge' that provided connection between two open-ended teaching zones, and a range of specific enclosed classrooms. Two multi-functional 'pods' were placed at the centre of the zones for storage and focus study areas.

*Figure 6. OLA Stage 1 interior*

The completion of this stage provided stakeholders with visible proof of the benefits of timber and the design ethos of interconnected teaching zones. As planned, Stage 2 could begin while the ground floor continued operation.

## 3.7 STAGE 2 UPLIFT AND EXPANSION

Beyond just a retrofit of the remaining levels, Stage 2 included timber extensions both horizontally and vertically. As a part of Stage 1 the concrete frame was entirely stripped bare of fitout, façade and roof structure in preparation for Stage 2. Once the major timber members arrived, the installer CWC Carpentry (Gosford, NSW) began works to attach the new GLT members to the existing concrete structure and provide new structural bays.

*Figure 7. Construction of Stage 2, new balcony framing on left.*

To the north, a new colonnade and balcony zone were added, introducing new piles to retain the timber framing. The balcony surface spanned the new frame and existing structure and the façade remaining aligned to the original buildings.

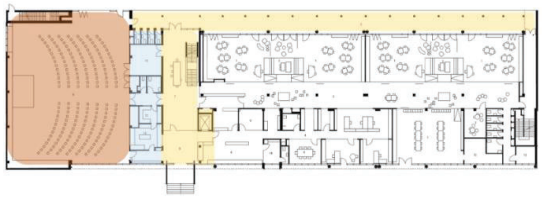

Fig 8. Stage 2 ground floor.

To the west, a generous atrium and vertical circulation, including a lift and timber stairs were added, as well as 'nets' to foster informal social gatherings and knowledge sharing between students of different classes and year groups. Performance fire solutions such as introduction of sprinklers, and fire compartmentalisation of areas adjacent to the atrium were developed between local and overseas fire engineering. Each was critical in allowing timber to remain exposed in these vertical connections.

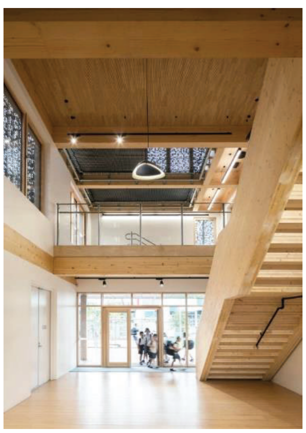

Figure 9. OLA Stage 2 atrium and stair.

Beyond the atria are buffer zones including toilet amenities separating the main hall from the circulation space. This hall employed a hybrid timber strategy through use of a steel transfer frame to achieve an uninterrupted span. The previous roof structure was replaced with GTL beams that sat atop the existing concrete columns. These beams were able to withstand the additional loads and created the new fourth storey.

## 3.8 COMPLETION

Once completed, the retrofit transformed the school into a light-filled contemporary teaching institution that fosters wellness via connection to natural elements through exposed timber [9], natural light and ventilation. Public reception of OLA claimed it "sets a new benchmark for the emerging vertical school typology" [10].

The total volume of mass timber used included 1,175 $m^3$ of CLT slabs, 210 $m^3$ in GLT structure, and 240 $m^3$ for CLT walls. This saved an approximate 1400 tonnes CO2e, a 60% reduction from a reinforced concrete scenario, not including the savings of retained structure or costs to reinforce to bear weight of an additional floor.

Figure 10. Perspective section rendering of OLA Stage 2, existing concrete frame highlighted on right.

Though a lack of local familiarity and fire certification pathways may otherwise limit the expression of mass timber structure, the case study indicates that international knowledge can be transferred to meet local requirements.

## 4 – DARLINGHURST WORKPLACE

The case study is in Darlinghurst NSW, a suburb adjacent to Sydney's Central Business District. It is surrounded by a range of low to medium-rise post-industrial warehouses and low-density townhouses, typical throughout Sydney.

Figure 11. Aerial Image of Darlinghurst Workplace Site

The client acquired the building as the site for their new headquarters, hosting a workforce of over 300. The project consisted of an uplift of the first floor and above, removing the existing roof and adding an additional storey. The project required a range of remedial and reinstatement works due to the complex history of the original building.


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## 4.1 CONTEXT

The existing building underwent a series of expansions and transformations over its nearly 100-year lifespan. Built originally in 1927 for the Motor Services Company, the then three-story building was made of reinforced concrete frame and timber frame roof. It included a car ramp and could withstand the weight of vehicles on each floor. In the 1960s, the neighbouring block was acquired, and the building expanded horizontally with concrete and steel construction following the same structural grid and façade expression.

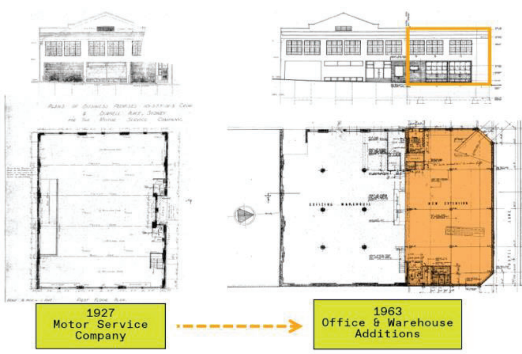


*Figure 12. Comparison between 1927 and 1963 plan and eastern façade.*

The building was once again adapted in the 1990s to reflect the need for office space, adopting the corporate architecture style of the time. An additional floor was added using concrete columns and aligning the slab to the building grid.

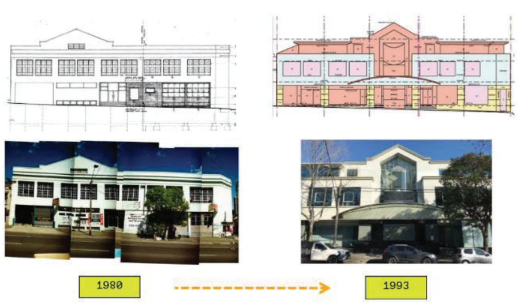


*Figure 13. Comparison of façades from 1980 to 1993.*

## 4.2 PROJECT BRIEF

The primary project goal was to preserve and amplify the strong office culture of the client's organisation. Their previous office spanned multiple floors, separating the team visually and physically through a conventional office layout. The client desired an innovative, sustainable architectural response that respected the history and formal character of the original building.

Beyond the workplace requirements, the project needed to avoid disruptions to the surrounding community. This required the ground floor tenant, a Government social services provider occupied the, be able to maintain operations during the construction period.

## 4.3 WORKPLACE BRIEF

Darlinghurst Workplace required a variety of work settings, community and wellness functions, and varied environmental conditions. The brief reflected an ongoing trend of de-emphasising purely task-based models and prioritising human centric design [11].

*Figure 14. 1990's interior of existing building.*

The value of vertical connections including atria are observed as contributing to social and informal knowledge exchange [12] (learning) as was found in OLA, providing passive participation in social zones through acoustic and visual connection.

A potential risk is that a central connection provides a clear and unimpeded pathway for fire and smoke spread through the building, thus could compromise or complicate the holistic fire safety design. This was addressed through performance-based fire engineering to avoid the onerous and costly fire safety measures required under the Deemed-to-Satisfy Requirements of the BCA.

## 4.4 RESERVE CAPACITY

During early site walks it was determined that the building had reserve structural capacity, as is common in building stock of this era [4]. Due to the previous extensions much of that capacity had already been used. An additional storey in concrete was deemed infeasible, as it would require increasing footing sizes, columns and introducing micro-piles. Additionally, the ground floor tenancy would have to be vacated adding significant extensions of programme, costs and social disruptions.

A lightweight structural system could unlock the remaining reserve capacity, maximising floor area within the height limit. In combination with environmental, social and biophilic benefits, mass timber construction was the most appropriate structural system in alignment with the client brief.

## 4.5 DESIGN RESPONSE

The initial development application and design response was established by the architecture firm MHNDU. It was at this stage that adaptive reuse and mass timber strategies were first established. BVN was engaged at a later stage to redevelop the internal organisation in alignment with the workplace brief and deliver the building. BVN's response to the workplace brief informed the central void, and the subsequent need for performance-based fire engineering.


*Figure 15. Cross section through atrium of case study.*

The atrium addresses both functional and cultural requirements. Functionally, it provides daylight access into the centre of the building, and connection between floors. Light access was a challenge for the second floor where the façade is in line with the external parapet. Level 2 hosts the key social spaces of the workplace, including the communal kitchen, dining area and the balconies introduced by BVN. Without the atrium, the communal balcony would be the only source of natural light on this level.

*Figure 16. Level 2 Plan, highlighting community spaces.*

## 4.6 STRUCTURAL STRATEGY

Levels 1, 2 and 3 of the case study building each employ a different structural system in response to site and development constraints. Level 1 was stripped back internally to reveal the original concrete structure to celebrate the original warehouse character. On Level 2, the 1990s steel framed roof and supports were replaced with new CLT floor slabs atop GLT beams and columns, provided by Australian producer XLAM. The timber structure provided the new floor slab for Level 3, with GLT columns extending to support a new low profile steel frame roof.

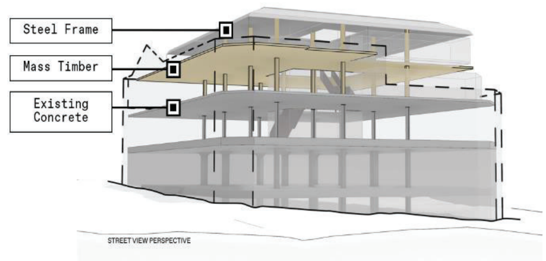


*Figure 17. Design strategy and primary structural materials. Outline indicates the façade zone*

Mass timber had been investigated for the roof structure as well, but due to the height limits imposed by council (as a part of the Darlinghurst Heritage Conservation Area) a steel frame was used to provide adequate floor to floor heights. Flexibility in such controls could have enabled use of mass timber for the entire vertical extension structure.

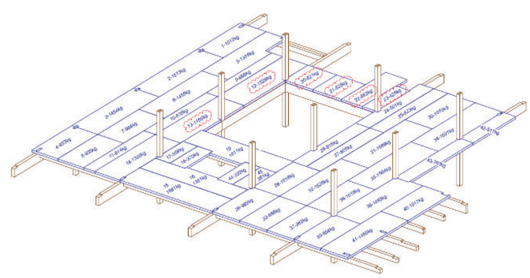

*Figure 18. Axonometric drawing of timber structure.*

The existing structural grid size (varied 7.45-8.4 m) was complimentary to mass timber structure, allowing spans and beam depths to fall comfortably within XLAMs standard offerings. The GLT used a Queensland mixed species pine (GL17). Columns were 3060 x 260 mm in cross section, supporting a primary and secondary beam structure, of 694 x 260 mm and 360 x 260 mm respectively. A total of 950lm of GLT was used for the project, and 90 $m^3$ of CLT.

Due to compromised site access and available crane positions, XLAM adjusted the CLT panel sizes and panel groupings. Smaller panels and groups were used to match the crane's capacity and for easier installation. The only cost beyond coordination was a greater number of loads, and some material wastage as smaller panels were not divisible by the CLT 'Buck' size of 2.4-3.4 wide by 16m


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long. GLT could remain unchanged as it was within the lifting constraints.

## 4.7 FIRE STRATEGY

The fire engineering brief described a safe, flexible and sustainable workplace, connected through a central atrium. Most of these requirements could be readily achieved via exposed mass timber structure. In combination, these were not possible through conventional 'rule of thumb' fire engineering. Several arbitrary inflection points exist in the BCA where the fire safety requirements increase significantly. For Darlinghurst workplace, reaching four floors applied onerous requirements on the building, equivalent to those of a building many times its height and size. Instead, a broad array of fire engineering modelling tools and analysis methods [5] were interwoven into a first principles design approach.

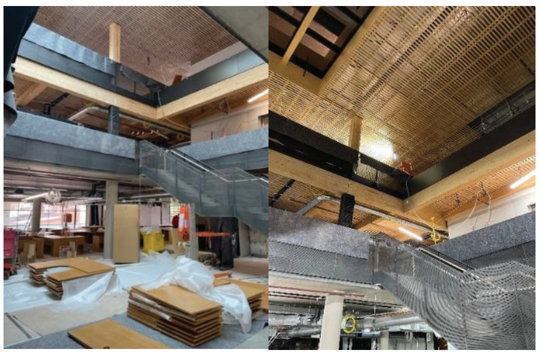

*Figure 19. Photographs of atrium during construction.*

Dynamic egress modelling was undertaken to determine the total time taken for all occupants to reach a place of safety. The models incorporated predicted occupant attributes such as size, walking speed, and choice of a preferred exit path, in addition to expected psychological response to alarm systems. Computational Fluid Dynamics (CFD) modelling was then undertaken to quantify the total fire hazard presented to occupants, determining the amount and movement of hot smoky gases throughout the building's interconnected spaces. Due to the presence of the large central atrium in the design, many redundancy and sensitivity scenarios were conducted within the CFD modelling.

The performance-based structural fire engineering approach assessed the actual structural performance of the building in the event of a catastrophic fire scenario [6]. This determined the overall global structural behaviour to evaluate and optimise which passive measures be implemented into the building, as appropriate to the intended functions of the space, and to aid in the structural design. The holistic fire safety assessment incorporated the range of timber products used, which in totality are poorly defined under the BCA. The structural material being mass timber, and the interconnections of the internal space via an atrium, tended to complicate the Deemed-to-Satisfy requirements for the project.

Performance-based fire engineering navigated the approvals pathway effectively with a detailed level of design quantification, and thus introduced a high-performing fire safety strategy which was far outside of what the BCA would prescriptively allow or even define.

Performance-based fire engineering enabled an architectural response sympathetic to the character of the building and improved the level of safety achieved through non-destructive and non-invasive means. When a key objective is to maintain heritage fabric or aesthetic, the design focus can shift to the fire safety measures which are not physical barriers or visible to the public, but which can activate or provide redundancy where there were none before.

Performance-based fire engineering allowed all mass timber to remain exposed within the building, the internal atrium was delivered with no additional requirements for smoke control systems or physical fire separation, and the architectural layout of the building was supported without the need to introduce additional stairs and exits.

## 4.8 COMPLETION

With each adaptation and additional floor, the existing building had its lifespan extended and program updated to reflect contemporary needs. The adjustments within the 1990s departed from a need for spatial flexibility, as was desirable for warehouses. Likewise, Darlinghurst Workplace is another stage in the building's history, reintroducing its outward appearance, and internal layout as one of flexibility and free plan.

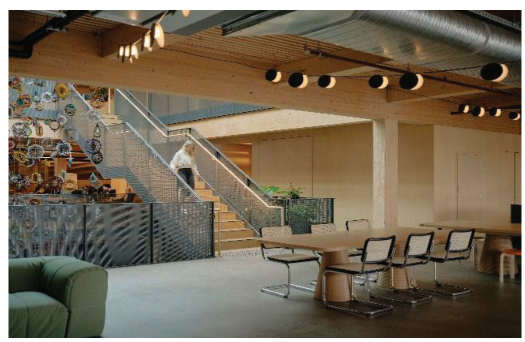

*Figure 20. Photograph from Level 2. Credit: Tom Ross.*

As a warehouse conversion, the Darlinghurst Workplace contributes to the local character of the precinct via the re-instatement of the 1960s façade. Despite not being of heritage significance, this aligns with recommendations from the Burra Charter [13]. It provides contemporary workspaces through a complimentary yet distinct language, the mass timber in contrast with the existing concrete structure.

The use of mass timber reduced embodied carbon through retention of existing structure and eliminating some internal linings at the point of completion, and future fit-outs [14]. The project is now used as visual evidence for the value of mass timber. Clients and collaborators are toured through the project, where on-paper benefits fall short, first-hand experience can create collaborators from sceptics.

## 6 – RESULTS

OLA was informed by the ambition to reuse existing structure to provide a student-centred learning environment that focused on provision of natural elements. Darlinghurst workplace required further development of fire mitigation strategies due to its higher complexity both in spatial configuration and range of occupancies.

The success of Darlinghurst Workplace stemmed in part from the project requirements to reduce environmental and community impact rather than a purely cost-efficiency standpoint. In this range of competing priorities, timber provided the optimal solution. The client's prior understanding of mass timber not only led to its use but also informed the composition of the project team with prior experience and understanding of their vision to facilitate successful delivery.

In both case studies, MTC provided greater speed of construction, continuous operation of the ground floor programs during construction, and minimised disruption for the surrounding precincts. Furthermore, performance-based fire engineering provided exposed-timber interiors that promoted biophilia, and open atriums that contribute to collaborative learning and working environments.

Changes between case studies demonstrated a significant growth in local capacity in two fronts. Firstly, that with multiple mass timber producers in Australia the tendering and procurement process can include entirely local products. Previously, it was considered a risk as with a single local producer, any issues in supply would significantly extend the project programme due to international lead times.

Second, improvement in access to fire certified products, or performance-based fire engineering. Though there is less Australian expertise in mass timber construction, especially the associated fire engineering, than compared to overseas, there is a growing market and appreciation for the advantages of architectural flexibility, structural and construction efficiencies, and environmental outcomes.

## 7 – CONCLUSION

The case studies contribute to the broader adoption of mass timber in uplift projects by demonstrating the potential for adaptive reuse to avoid structural reinforcement and reduce the need for finishes. Additionally, it highlights the subjective and biophilic benefits of timber, while challenging conventional office design standards to promote vertical connectivity within an emerging structural methodology. Such connections are noted in environmental building certifications as promoting physical activity [15] through an 'irresistible stair' [16].

As local manufactures provide products compliant with Australian Standards (AS), a deem-to-satisfy solution is becoming more feasible. GLT due to its non-flammable glue can be left exposed under certain circumstance, and when in compliance with AS/NZS 1328.1 [18], whereas CLT exposure remains impossible through this pathway under the constraints of the BCA in most configurations. Currently, a performance-based approach can challenge the constraints of Deemed-to-Satisfy pathways, providing flexibility in fire safety measures, structural solutions, and architectural outcomes.

Some identify record breaking landmark projects as key evidence of the growing MTC movement [17]. Where large scale projects require overseas procurement due to availability of timber stock in Australia, smaller, repeatable projects can support local manufacturing capacity and address broader carbon reduction and density targets. Timber retrofits can avoid urban sprawl, or 'knock-down rebuild' of buildings no longer fit-for-purpose, each presenting significant risks to ecological and embodied carbon footprints, respectively. The main enabling factors for similar projects were the project team's experience in and alignment on timber as the main structural strategy to ensure it is uncompromised. Such experience can be gained through collaboration with overseas manufacturing, through local expertise, or in combination.

## 8 – REFERENCES


[1] P. A. Bullen, "Adaptive reuse and sustainability of commercial buildings," *Facilities*, vol. 25, no. 1/2, pp. 20–31, Feb. 2007, doi: 10.1108/02632770710716911.

[2] City of Melbourne, "Retrofit Melbourne," Oct. 2023. [Online]. Available: https://mvga-prod-files.s3.ap-southeast-4.amazonaws.com/public/SiteCollectionDocuments/retrofit-melbourne.pdf

[3] City of Melbourne, "Guidelines for the Adaptive Reuse of Office Buildings," City of Melbourne. Accessed: Mar. 25, 2025. [Online]. Available: https://mvga-prod-files.s3.ap-southeast-4.amazonaws.com/public/2024-09/guidelines-adaptive-reuse-office-buildings_1.pdf

[4] X. Mei, W. Hawkins, A. Darby, and T. Ibell, "Realising the reserve capacity in existing reinforced



https://doi.org/10.52202/080513-0112

concrete columns," *Structures*, vol. 63, p. 106360, May 2024, doi: 10.1016/j.istruc.2024.106360.

[5] Green Building Council of Australia, "Reducing upfront carbon at scale." Accessed: Mar. 26, 2025. [Online]. Available: https://new.gbca.org.au/news/gbca-media-releases/reducing-upfront-carbon-at-scale/

[6] S. Whyte *et al.*, "Exploring the Benefits of Mass Timber Construction in the Workplace: A Novel Primer for Research," *Buildings*, vol. 14, no. 7, p. 2072, Jul. 2024, doi: 10.3390/buildings14072072.

[7] JC Clampett, PJ Edwards, and RJ Webber, "The impact of fire safety engineering and performance based regulations on the approval process for fire safety in buildings," *Approv. Process Fire Saf. Build.*, vol. 3, 1988.

[8] Lignotrend, "LIGNO Rippe-x technical data," Aug. 2024. Accessed: Mar. 26, 2025. [Online]. Available: https://lignotrend.com/_Resources/Persistent/3/f/e/b/3feb2fe598d707018472d775e4ae96b1e4523212/2024-08-14_TD%20LIGNO%20Rippe-x_E-k.pdf

[9] C. Kelz, V. Grote, and M. Moser, "Interior wood use in classrooms reduces pupils' stress levels," Sep. 2011.

[10] "2019 National Architecture Awards: The Daryl Jackson Award for Educational Architecture," *ArchitectureAu*. Accessed: Mar. 28, 2025. [Online]. Available: https://architectureau.com/articles/2019-national-architecture-awards-the-daryl-jackson-award-for-educational-architecture/

[11] M. Öhrn *et al.*, "Productivity, Satisfaction, Work Environment and Health after Relocation to an Activity-Based Flex Office—The Active Office Design Study," *Int. J. Environ. Res. Public. Health*, vol. 18, no. 14, p. 7640, Jan. 2021, doi: 10.3390/ijerph18147640.

[12] X. Wu, P. Oldfield, and T. Heath, "Spatial openness and student activities in an atrium: A parametric evaluation of a social informal learning environment," *Build. Environ.*, vol. 182, p. 107141, Sep. 2020, doi: 10.1016/j.buildenv.2020.107141.

[13] International Council on Monuments and Sites, "The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance," Charter, Dec. 2013. Accessed: Mar. 26, 2025. [Online]. Available: https://australia.icomos.org/publications/burra-charter-practice-notes/

[14] F. Duffy, *The changing city*. Bulstrode Press, 1989. Accessed: Mar. 26, 2025. [Online]. Available: https://openlibrary.org/books/OL15200642M/The_changing_city

[15] International WELL Building Institute, "Interior fitness circulation," The WELL Building Standard. Accessed: Mar. 26, 2025. [Online]. Available: https://standard.wellcertified.com/fitness/interior-fitness-circulation

[16] International Living Future Institute, "BULLITT CENTER," Living Future. Accessed: Mar. 26, 2025. [Online]. Available: https://living-future.org/case-studies/bullitt-center-2/

[17] N. Hewson, "Is it time to normalise mass timber in construction?," ArchitectureAu. Accessed: Mar. 26, 2025. [Online]. Available: https://architectureau.com/articles/is-it-time-to-normalise-mass-timber-in-construction/

[18] Engineered Wood Products Association of Australia, "Glue Laminated Timber (GLT) Conformance in Australia," Technical note, Oct. 2022. Accessed: Mar. 26, 2025. [Online]. Available: https://ewp.asn.au/wp-content/uploads/2023/05/EWPAA-Technical-Note-Glue-Laminated-Timber-GLT-Conformance-in-Australia-NCC-2022-1.pdf