WORLD CONFERENCE ON TIMBER ENGINEERING 2025
BRISBANE, AUSTRALIA

Advancing Timber for the Future Built Environment

MACQUARIE UNIVERSITY AINSWORTH BUILDING (SYDNEY)

Kengo Takamatsu[1], Nicola Shear[2]

ABSTRACT: The Ainsworth Building at Macquarie University, a flagship for the Medicine and Health Sciences Faculty, exemplifies advanced mass-timber construction, blending education, research, and medical practice. This four-storey building, completed in July 2020, provides dynamic, flexible spaces and state-of-the-art learning environments. Constructed on a constrained site in Sydney, the building's erection took just over a year, with three months dedicated to installing the timber elements. The structure integrates glulam European spruce for internal columns and beams, CLT European spruce for floors and shear walls, and glulam Victorian ash hardwood for external columns. Lateral stability is ensured by CLT floors and walls, supplemented by Victorian ash W columns. A robust structural strategy was developed by assessing element removal and substantiating alternate load paths. Precise BIM coordination facilitated pre-cut timber fabrication, minimising campus impact. The design reduces embodied carbon and promotes efficient, quieter construction methods.

KEYWORDS: robustness, connection, building services integration

1 – INTRODUCTION

Macquarie University's Ainsworth Building is the flagship building of the university's Medicine and Health Sciences Faculty. This four-storey structure, completed in July 2020, is a prime example of advanced mass-timber construction, integrating education, research, and medical practice. The building, which consists almost entirely of mass-timber above ground, provides a dynamic and flexible environment for students and staff, housing state-of-the-art lecture theatres and team-based learning spaces.

Constructed on a constrained site on the Macquarie University campus in Sydney, the project was completed in just over a year, with the timber elements installed in three months. The building incorporates glulam European spruce for internal columns and beams, CLT European spruce for floors and shear walls, and glulam Victorian ash hardwood for external columns. The structural design ensures lateral stability through the use of CLT floors and walls, supplemented by Victorian ash W columns.

The project also emphasises sustainability, with a significant reduction in embodied carbon and the use of efficient, quieter construction methods. The robust structural strategy, including the assessment of element removal and alternate load paths, ensures the building's integrity. Precise BIM coordination facilitated pre-cut timber fabrication, minimising campus impact and enabling swift construction. The integration of building services was meticulously planned to maintain the strength and stiffness of the structures. Acoustic and vibration performance standards were met through careful design and testing.

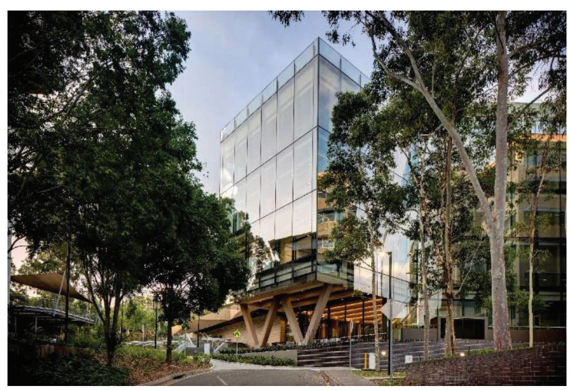

Figure 1: Macquarie University Ainsworth Building

[1] Kengo Takamatsu, Arup, Associate Structural Engineer, MEng MIEAust CPEng NER, Sydney, Australia, Kengo.Takamatsu@arup.com

[2] Nicola Shear, Arup. Structural engineer, Sydney, Australia, Nicola Shear@arup.com

 https://doi.org/10.52202/080513-0372

2 – STRUCTURAL SYSTEM

2.1 – OVERALL STRUCTURE

The building integrates three types of engineered timber:

glulam European spruce for the internal columns and beams; cross-laminated timber (CLT) European spruce for the internal floors, lift core and shear walls; and glulam Victorian ash hardwood for the external columns. The structural frame was formed from a 2.4m x 15m grid of glulam columns (800mm x 350mm) and beams (1,380mm x 350mm). The glazing mullions were aligned with the columns at 2.4m centres, helping to minimise the depth of the edge beams and enabling the double-glazed glass façade to draw optimal daylight into the interior spaces. See Figure 2 for the structural layout of the building.

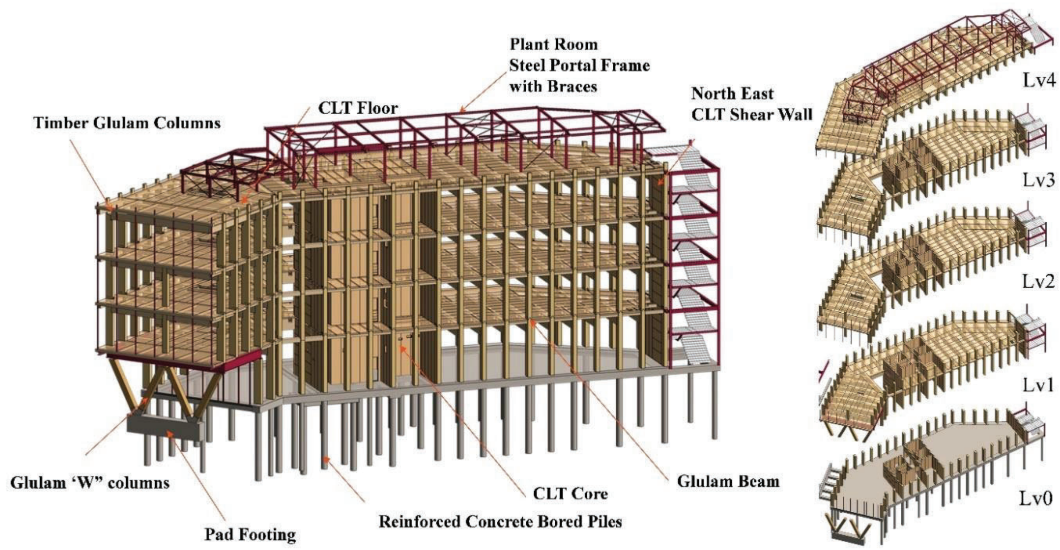

Figure 2: Structural layout of the Ainsworth Building

2.2 – LATERAL STABILITY SYSTEM

The building was initially designed with concrete cores to provide lateral stability, however it was a contractor lead decision to achieve the lateral stability with timber cores and timber structures where possible.

140mm-deep CLT floors and CLT walls were used for lateral stability, using the 180mm-thick and 240mm-thick CLT cores in the centre of the building. Due to the eccentric and slender shape of the building in plan, lateral stability elements where utilised at both ends of the building, with a 180mm-thick north-east shear wall at one end and W-shaped Victorian ash hardwood 550mm x 550mm glulam columns at the other end. The W columns provide both a lateral stability function and a architectural function, framing the entrance of the building.

2.3 – CONNECTION DETAILS

The connections were designed for strength, durability, appearance and ease of assembly. Importantly, they ensured that the final pre-cut European spruce pieces from Austria were of a length that could be readily transported to the site in Sydney. For the beam and column connections, a notched column design was used, with the beam typically bearing 150mm on the notched column, rather than connecting to the column face. This improved construction time – taking less than 20 minutes for each installation – and lessened the shear load, allowing a reduction in connection and timber member size.

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3 – CONSTRUCTION AND PRE-FABBRICATION

The adoption of an almost entirely mass-timber structure above ground meant that many structural elements could be pre-fabricated off site to a high degree of accuracy; construction was quick and efficient; and the construction methods used were far quieter than those adopted for non-timber structures, meaning construction did not disturb the adjacent sensitive buildings, including Macquarie University Hospital and surrounding Macquarie univerisy campus.

The use of timber enabled construction to take place as close as 10m from the external wall of the vibration-sensitive functions in the adjacent hospital, such as oppertating theatres, radiology rooms and intensive care unitis.

Figure 3: W Columns and Entrance to Building

4 – ROBUSTNESS STRATEGY

Robustness of the Ainsworth Building was considered by assessing element removal and substantiating alternate load paths. Staggered two-bay CLT floor panels were used to ensure that vertical load could be spread to adjacent glulam beams and supporting columns, in the event of column removal.

The design featured an inclined glulam W-column that supported the base of the building. Its removal was also considered. A steel beam joining the tops of the columns was designed to redistribute the vertical load in the event that a column was removed. The remaining glulam columns were assessed for this load case.

Figure 4: CLT Shear Wall

5– BUILDING SERVICES INTEGRATION

Precise multidisciplinary coordination was essential for the penetrations in the glulam beams. Working within a BIM environment from concept phase through to fit-out, the firm produced a detailed model that was imported by the contractor into the fabrication software, allowing the timber to be factory pre-cut for swift assembly on site and thereby minimising the construction impact on Macquarie's campus environment. All timber details, including connections, recesses, penetrations and notches, were developed and integrated into the model.

Where possible, services were reduced or grouped together to minimise the reduction in strength and stiffness of the structure where they ran through the engineered notches in the beams. The ends of the beams were notched at the perimeter just below the slab to enable the services to run close to the soffit of the floor above, with the services distributed to the interior of the floor plate by running parallel to the glulam beams. With the ceiling installed, the services are concealed, giving a clean soffit with only the timber beams and ceiling visible to building occupants.

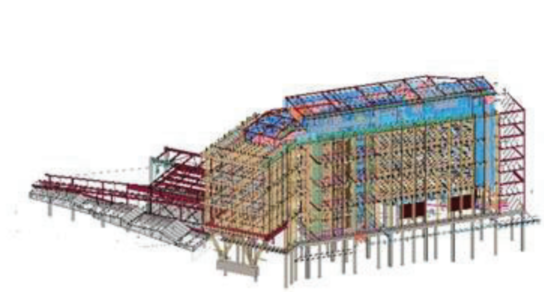

Figure 5: BIM Services Coordination Model

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6 – ACOUSTICS AND VIBRATION

Although CLT has the benefit of a smaller mass compared to concrete, it provides limited airborne and impact sound insulation and limited reverberation control. Therefor, acoustic testing was undertaken to determine the appropriate floor build up to achieve the university's desired outcome. The final floor buildup is carpet tile/timber flooring on acoustic packing, 40mm screed and 140mm thick CLT structure. Two layers of 13mm thick plasterboard were fixed to the underside of the CLT and rockwool insulation placed above the ceiling. Vibration isolators were placed in the junctions between CLT walls and floor panels of the building's core and teaching spaces to control flanking sound between the spaces.

Footfall vibrations were analysed using GSA FEA analysis software to ensure the response factor was kept below 8, as per guidelines. Screed added the the floor provided the necessary mass to meet footfall requirements.

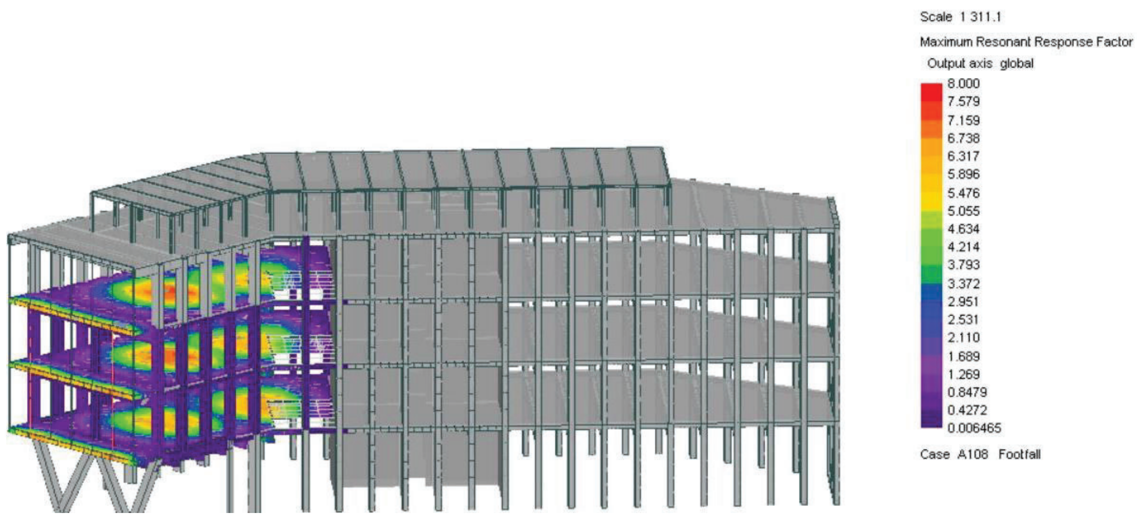

Figure 6: Footfall Dynamic Analysis Model

7 – SUSTAINABILITY

The design includes sustainability strategies to improve the precinct's energy efficiency. The use of approximately 700 tonnes of timber is estimated to offset carbon emissions equivalent to five to six years of operational energy use[4]. Additionally, high-efficiency building services are expected to reduce both energy consumption and operational costs for Macquarie University. These measures not only support environmental sustainability but also enhance the long-term economic viability of the precinct by lowering utility expenses and promoting a healthier indoor environment.

Structural embodied carbon emissions were assessed for four structural systems: a mass timber scheme, a post-tensioned concrete structure, a steel and CLT hybrid structure, and a steel–concrete composite structure.

Figure 7: Beam Column Junction with Penetrations for Services

Although the CLT and glulam used in the building were imported from Europe, with transportation impacts accounted for under module A4, the use of timber still results in a significantly lower embodied carbon footprint compared to the other structural typologies.

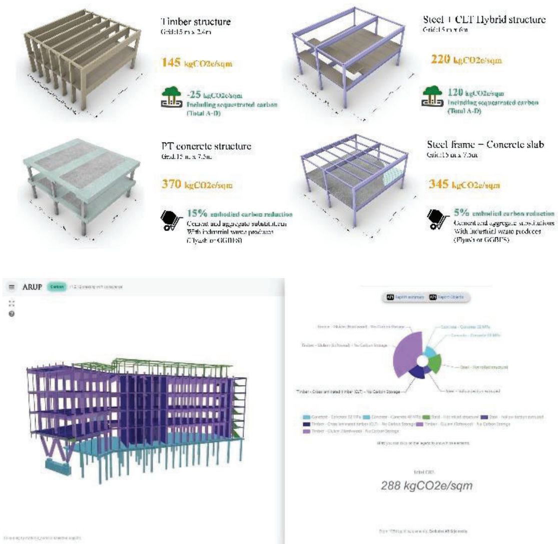

Figure 8: Structural Embodied Carbon Emissions

To improve the accuracy of carbon benchmarking in mass timber projects, the additional embodied carbon associated with typical connection details, fire protection systems, and acoustic insulation within a representative building bay must also be accounted for. The embodied carbon of the superstructure (A1–A5) is increased by a factor of 1.2 to account for the contribution of these supplementary components.

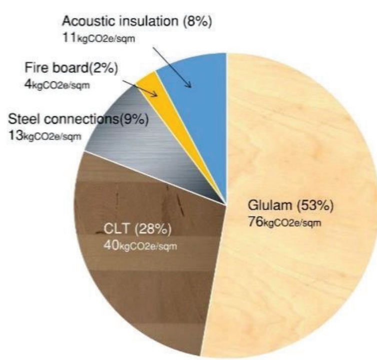

Figure 9: Carbon addition of supplementary components

8 – CONCLUSION

The Ainsworth Building at Macquarie University exemplifies advanced mass-timber construction, providing dynamic spaces for education, research, and medical practice. The use of glulam and CLT timber significantly reduced the building's embodied carbon footprint. Precise BIM coordination allowed for efficient pre-cut timber fabrication, minimising campus impact and facilitating a swift construction process. The robust structural strategy ensured the building's integrity, while the integration of building services was meticulously planned to maintain strength and stiffness. Acoustic and vibration performance standards were met through careful design and testing. The construction process was quiet, respecting the proximity to the Macquarie University Hospital. Overall, the Ainsworth Building demonstrates the potential of mass-timber construction to deliver high-performance, sustainable buildings that meet the complex requirements of modern educational and medical facilities.

Project credits:

Client: Macquarie University

Architect: Architectus

Contractor: Buildcorp

Timber fabricator: Binderholz

Audio-visual and multimedia, acoustics consulting, civil, structural, building services, façade and vibration engineering, sustainable buildings design: Arup

9 – REFERENCES

[1] King, M., Takamatsu, K., and Zara, E. (2021). 'Macquarie University Ainsworth Building: Taking multi-storey timber structures to the next level', *The Arup Journal*, Issue 2, pp. 44-51. Available at: https://www.arup.com/projects/the-arup-journal/the-arup-journal-2021-issue-2/ (Accessed: 20 March 2025).

[2] Hewson, N., Gilbert, B., Hodsdon, T., Guan, H., Zecevic, A., Butler, T., & Jockwer, R., 2023. **Robustness in Structures**. *WS TDG 39*, pp. 51-52

[3] Credit: Architects/Brett Boardman Photography

[4] Johnson, L. , Collings A., Elias N., Morris, S., Dryden H. at Architectus , 'Macquarie University Ainsworth Building', at: https://macquarie.architectus.com.au/project/ainsworth-building

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