WORLD CONFERENCE ON TIMBER ENGINEERING 2025
BRISBANE, AUSTRALIA
Advancing Timber for the Future Built Environment

Mass Engineered Timber Buildings in Southeast Asia: Overcoming Obstacles and Unlocking Opportunities

Dr Andrew Magub [1], Callum Lillywhite [2]

ABSTRACT: The tropical rainforests of Southeast Asia provide a rich natural resource and the region has hundreds of years of experience and expertise in traditional timber construction. Furthermore, states such as Sarawak on the island of Borneo are committed to the development of renewable rapid growth hardwood plantations as a key pillar of their carbon trading strategies, whilst the likes of Singapore are making increasingly challenging demands on developers to deliver more modular low carbon buildings.

And yet, the delivery of modern, mass engineered timber (MET) buildings remains rare outside of a handful of exemplar projects supported by research institutions, hampered, in part, by lack of specialist expertise, regulatory inertia and supply chain difficulties.

Through a series of case studies, the speakers will explain how they have overcome these challenges to deliver some of Southeast Asia's most notable modern timber buildings, and the efforts they are making to work with governments and industry to help build a modern, economically sustainable, indigenous MET ecosystem for the region.

KEYWORDS: Timber, MET, Southeast Asia, Low Carbon Buildings

1.1 Brief History of Timber on Construction

The earliest evidence for the structural use of timber has been discovered in Zambia, Africa, dating to at least 476,000 years ago [1]. Timber has been one of the most enduring primary construction materials, dating back to the Stone Age. It is widely thought that the first wooden structure was built over 10,000 years ago. The Neolithic Longhouses built in early Europe date back to 5,000-6,000 B.C. Timber as a primary material was used by the Egyptians, Greeks and Romans for roof construction. During the Saxon period and the Middle Ages, timber was used as a cladding material and structural framing [2] [3] [4].

Until the era of timber processing by industrial mill, timber construction was a hand crafted, timely process. The Industrial Revolution led to significant greater production rates of smaller/dimensional timber from new industrial mills. This led to timber frame construction using smaller timber members connected to create larger structural members, which is still popular today globally.

In the 1860s the process of glueing smaller timber members together in the same direction to create a larger structural beam was used in the King Edward VI College School assembly room in Southampton, UK [5]. This method of construction was later patented in Germany in 1901 and is now a common structural building process called Glu-laminated Timber (GLT).

In the 1990s, the innovative Cross-laminated Timber (CLT) was developed in Germany and Austria [6]. Similar to GLT, CLT uses smaller timber members, however laminated together in different grain directions to create larger structural timber slab elements.

1.2 Why do we use timber in construction

Globally there are many choices and options for construction materials and methodologies in the modern construction market. There are many compelling reasons why timber has been a primary construction material and methodology historically and currently.

[1] Dr Andrew Magub, Principal, KIRK, Brisbane, Australia, am@kirk.studio

[2] Callum Lillywhite, Associate, Buildings Structural, Aurecon, Brisbane, Australia, Callum.Lillywhite@aurecongroup.com

https://doi.org/10.52202/080513-0111

ADVANCE SUSTAINABILITY

Globally, climate change has and is a major concern and one of the top risks in terms of severity in the next decade [7]. The increasing level of greenhouse gases in our atmosphere, mostly Carbon Dioxide (CO_2), are considered the primary cause of climate change. From the pre-industrial era to 2022 the level of CO_2 in our atmosphere has increased by approximately 50% [8].

Whilst most sectors contribute to Green House Gas (GHG) emissions, the building and construction industry is considered one of the significant contributors, accounting for 21% of global GHG emissions. If just the emission of CO_2 is considered, the building and construction industry is responsible for up to 31% of global emissions [9]. The building and construction industry GHG emissions consist of 82% from energy use and 18% embodied emissions from materials in building and construction processes [9]. There is little doubt that the reduction in GHG emissions from the building and construction industry, decarbonising, is essential and critical.

Trees have the ability through photosynthesis to remove CO_2 from the atmosphere and convert the Carbon (C) into a solid form of sugars which is stored throughout the trees and assists in growth, and Oxygen (O) which is released back into the atmosphere. This process is called Carbon Sequestration where the trees (wood) store the atmospheric Carbon (Biogenic Carbon).

The use of timber in construction, typically sustainable sourced timber, locks away the biogenic carbon for the life of the timber. The regrowth of the commercial forests allows new tree growth to sequester carbon from the atmosphere. Timber reuse and recycling allows the biogenic carbon to remain stored [10].

The total GHG emissions produced during the manufacture of products and materials for use in construction and the actual construction process are called Embodied Carbon (or Upfront Carbon) [11]. Before construction work has even started onsite, there are already GHG gasses being released through the extraction, processing and transport of raw materials and manufactured materials. Research has estimated that 82-87% of all GHG emissions from building construction are related to embodied emissions of the materials themselves and that 94-95% of these are from steel and concrete [12].

Recent project estimates have shown that a typical new building using a timber superstructure can have significantly less embodied carbon than the equivalent steel and concrete structured alternative.

Hence using timber as a primary structural material and construction methodology has a significant sustainability advantage over traditional construction materials and processes.

TOUCH THE EARTH LIGHTLY

As building professionals, we all have a responsibility to consider the environment when we design and construct. This means that we need to consider how our designs and built structures can minimise the impact on our environment. This can be achieved by selection of materials and building systems that reduce extractive operations, minimise manufacturing production, are recyclable, treating the building site with respect & conservation, and through the integration of nature into the design/built structure.

Building materials and processes that use renewable natural materials rather than highly processed materials greatly help us to 'Touch the Earth Lightly'. The use of sustainable timber in construction is a prime example of a construction material and building process that allows us to 'Touch the Earth Lightly'.

RENEWABILITY & AVAILABILITY

Natural materials are the only construction materials that have the ability to regenerate or regrow, replacing their stock and supply. As timber is the only mainstream construction material that is grown and regrows, the environmental and sustainability credentials are far superior to the extractive and highly energy intensive traditional steel and concrete approach.

A recent example of a built structure using timber as the primary structural system is the 'NIOA Timber Tower', a 5 storey 1,250m^2 commercial building which used 564m^3 of XLam Australian pine as CLT and GLT for the building's main structure. The timber was estimated to have regrown from the Australian softwood commercial forests in approximately 45min, before the logging truck had even left the forest. By using MET as the primary material for the superstructure, it was estimated to have saved approximately 63 tonnes of CO_2-equivalent compared with a traditional concrete approach to the same building.

BIOPHILIA

Many studies have focused on the psychological and physiological benefits of human interaction with nature [13]. Biophilia is the term used to describe the human intrinsic inclination to connect with life and life-like processes.

Biophilic Design extends this theory and is defined as *"…the deliberate attempt to translate an understanding of the inherent human affinity with natural systems and processes—known as biophilia—into the design of the built environment.*" [14] p.3.

Biophilic design principals can be applied to any space or built structure through the inclusion of nature, selection of materials, consideration of natural light and appropriate colours & textures.

Research has shown that human exposure to nature and natural systems, particularly indoors, has an overall positive effect including enhanced mental health and wellbeing, increased creativity and productivity, improved cognitive function, reduction in stress and lower blood pressure [12] [15]. All of which are advantageous to the occupants of built structures and spaces.

The use of timber in built structures and spaces follows the biophilic design principles, providing a connection to nature, particularly when exposed and visible as a finished surface. Occupants regularly touching timber surfaces and leaning on timber columns have been witnessed in office environments with significant exposed timber and timber surfaces.

SPEED & CLEANLINESS OF CONSTRUCTION

Timber construction, particularly using CLT and GLT, is considered a pre-fabricated construction process as all of the elements are manufactured off-site and then transported to site cut, sized and ready to be lifted into place and fixed by a small number of on-site workers. The pre-fabricated construction methodology typically produces faster, cleaner and quieter construction sites than traditional construction methodologies [16] [17].

The prefabricated timber construction approach allows the structural elements of the buildings to be fabricated while the footings and foundations are being constructed, saving significant construction time. For multi-storey buildings, the prefabricated timber construction approach allows workers to work unobstructed underneath a structural floor slab immediately after erection, whereas a concrete slab construction approach required significant propping for 28 days before this space is freely available for workers.

Research has estimated an average of 20-35% savings in construction time for pre-fabricated timber buildings compared to traditional concrete and steel buildings [12] [17]. On-site construction experience from the 'NIOA Timber Tower' project in Brisbane, Australia, suggested a saving of up to 50% in construction time.

The pre-fabricated timber construction methodology also allows for a significant smaller construction site area. All the prefabricated panels are delivered to site on the back of an articulated vehicle, and are lifted off in the erection order, allowing immediate installation without the need to double handle and store the timber members onsite before installation.

The prefabricated timber construction approach can significantly reduce and remove multiple wet and dirty trades from the construction site, typically related to concrete work, interior linings and ceilings. Site based construction inspections typically reveal cleaner and quieter construction sites than traditional concrete and steel based construction sites.

LIGHTER STRUCTURES

Timber has a high strength to weight ratio and when used appropriately can add significant benefits to a building structure. Typical Australian softwoods have a mass of approximately 500kg/m^3 compared with reinforced concrete that is approximately 2500kg/m^3. It is not uncommon to see the total mass of a building constructed using MET to achieve 60% savings in weight compared with concrete. With reduced mass, this can reduce the earthquake demand on buildings and reduce foundation requirements, especially in poor ground conditions.

1.3 MET DEFINITION

Mass Engineered Timber (MET) can be defined as building materials comprised of engineered wood (timber) members producing improved structural integrity, including Cross Laminated Timber (CLT and Glu-laminated Timber (GLT) [18].

CLT uses layers of timber (typically softwood like pine and spruce) lamella, glued in different directions at 90 degrees, providing large timber panels with structural strength in multiple directions.

Figure 1 Cross Laminated Timber (Source: Wood Solutions TG16)

https://doi.org/10.52202/080513-0111

GLT uses layers of timber (softwood or hardwood) lamella, glued in the same directions, providing large timber columns and beams with structural strength in a single direction.

Figure 2 Glue Laminated Timber (Source: XLAM Australia)

2 - BACKGROUND (SOUTHEAST ASIAN CONTEXT)

Recent research has identified far greater adoption and implementation of MET structures in Europe (early adopters 70-80%), North America (early adopters 15-20% and Australia/New Zealand (early developing 5-10%) than in Asia (underdeveloped 1%) [19].

The low levels of adoption of MET in Asia (China, Japan, Korea and SEA) are concerning given the projected and required increase in built floor area is expected to grow by approximately 55% from 2015 to 2025. Built Floor Area in South East Asia (SEA) is projected to more than double within this time frame [20].

Singapore appears to be bucking the trend of low adoption of MET in SEA and has delivered a number of significant MET structures. This is likely to be influenced and driven by the Singapore Government through the Building & Construction Authority (BCA) promoting the use of MET to help achieve greener, smarter and increased quality developments through the Construction Industry Transformation Map (CITM) [17].

Although Singapore is successfully delivering a larger number of MET structures, this is still low in global terms and still hindered by barriers and obstacles to widespread adoption.

3 - OBSTACLES FOR MET ADOPTION IN SOUTHEAST ASIA

The low uptake of the MET building approach in SEA suggests significant obstacles to adoption in this region. Recent research into the Industry Perception of MET Construction in SEA concluded that the attributes having a negative or least positive perception from SEA research participants were:

"(a) fire safety, and durability for 'Safety and Comfort';

(b) adoptability by the current workforce, and robustness in delivery and construction in inclement weather for 'Buildability';

(c) ease of repair and maintenance after completion, and repairability after fire or water damages for 'Sustainability'; and

(d) less variations during construction for 'Control on Time and Cost'." [19, p. 1557]

Similar research into the adoption of MET in Singapore concluded that the top barriers were:

"1) Getting raw materials is challenging;

2) Lack of commercial opportunity, decreasing the motivation to adopt;

3) The amount of wood needed is large, leading to higher initial costs;

4) Lack of knowledge, especially among architects, contractors, and engineers;

5)Materials must be imported, increasing costs;

6) Technical information is not available;

7) Increased costs for fire protection and termite protection;

8) Lack of market for MET systems;

9) MET may not be compatible with building codes;

10) Maintenance costs of MET is high.

11) Requires a shift in thinking;

12) Insufficient support from upper management;

13) MET is susceptible to degradation from rot and mould;

14) Not possible to reach high-rise limits safely;

15) MET is vulnerable to termite attacks;

16) Fire safety rating of MET is low;

17) Costs may be high for residential buildings" [17, p. 5]

Both these relevant research findings can be summarised down to a number of specific common areas of obstacles to MET adoption:

- Lack of relevant local experience and technical information;
- Perceptions of supply issues;
- Perceptions of additional costs;
- Suitability with local building codes; and
- Suitability to the SEA environment.

While these are likely to contribute to the lack of commercial opportunity and/or stakeholder decision making to adopt MET, there are processes to tackle and break through these barriers.

The lack of relevant local experience and technical information can be overcome through partnering with international experts in MET construction. The relevant technical information is readily available and supplied by the relevant MET suppliers and this can be applied to a project through partnering with international experts. Not only will this insert the required experience, this will also value add to the local practitioners who will learn through this process, training the local industry.

The perceptions relating to the supply of MET product need to be corrected. Very little MET is manufactured and/or supplied from SEA currently. Globally approximately 80% of MET is supplied from Europe, the majority of the remainder is supplied from North America and the rest supplied from Australia/NZ [21]. This is readily and cost effectively shipped around the world in manageable timeframes with SEA as a major global shipping hub.

The perceptions of additional cost were also seen in the early Australian market, added to by the lack of experienced Quantity Surveyors and builders at the time, able to accurately estimate MET construction. The Australian MET market has matured to a point where the cost difference is minimal and often further supported by other project benefits such as speed of construction and environmental benefits.

Suitability with local building codes is a real issue and it is often a slow process to affect change. SEA member Singapore is a successful demonstration where the Government has backed, sponsored and promoted MET leading to amendments to local building codes, particularly the fire code in 2014 [17]. The key component of affecting building code change is through Government promotion and support of MET construction.

The suitability of MET to the SEA environment is directly related to the protection of the MET material. MET, particularly softwood, left exposed to the hot and humid climatic conditions of SEA may be prone to rot and/or mould. Any timber that is in direct contact with the ground presents a risk of termite attack. The solution to both of these is achieved through considered design/detailing by an experienced design team.

In all of these areas, the knowledge and expertise in relation to MET and project adoption can be added to a project through partnering with international experts in MET construction.

4 - OPPORTUNITIES FOR MET ADOPTION IN SOUTHEAST ASIA

Whilst the adoption of MET construction methodologies in SEA is low, there are a number of examples, hence projects and their sponsors have been able to break through the obstacles and build with MET structures. This therefore suggests that there are opportunities for MET construction in SEA.

Recent research into the Industry Perception of MET Construction in SEA concluded that enabling parameters for MET construction from SEA research participants were:

"(1) Timber product supply;

(2) Engineered timber technology and standards;

(3) Policies and codes in timber construction; and

(4) Practitioners' knowledge and experience" [19, p. 1560]

It is no coincidence that the opportunities for MET adoption mirror the summary of the obstacles for adoption.

The research into the adoption of MET in Singapore concluded that the top 10 drivers were:

"1) Aligned with Green Mark Scheme, Green Building movements;

2) Enhanced beauty of buildings;

3) Reduced on-site waste;

4) More efficient due to shorter construction time;

5) Positive effects due to decreased carbon footprints;

6) Renewable and recyclable resources;

7) Local governments provide sufficient support;

8) Positive effects on indoor comfort and air quality;

9) Reduced disturbances to site's surroundings;

10) Sustainable forest harvesting;

11) Less labour required, reducing labour costs;

12) Improved acoustic performance;

13) Reduced occurrence of accidents;

https://doi.org/10.52202/080513-0111

14) Good seismic performance;

15) Superior structural strength;

16) Provides opportunity to increase revenue and profits; and

17) Reduced energy consumption due to better energy efficiency" [17, p. 5]

It is interesting that the majority of these drivers are based around sustainability and the environment, often intangible benefits and metrics. The tangible drivers around structural/acoustic performance and reduced labour costs appear lower in the list.

However, the research into the MET adoption in the Singapore construction market demonstrates that this methodology is possible with the assistance and support of the Government and appropriate changes to local building codes.

5 - CASE STUDY 1 - NIOA TIMBER TOWER

With high and growing densities in SEA cities, smaller lots and multi storey developments are common and appropriate. A recent MET commercial development in Brisbane, Australia, can provide a building typology that may be suited to SEA, small lot development and speed to get to market for returns.

NIOA Timber Tower is a 1,225m^2, 5 storey commercial development, based on 245m^2 floor plates, designed by KIRK and built by Besix Watpac through the COVID period on a constrained and active, live site.

Apart from the concrete ground slab and low height dado walls, the main building structure is fabricated from Australian CLT and GLT supplied by XLam Australia. The MET structure was erected in only 28 days and used 564m^3 of Australia Plantation Softwood (pine). This regenerated from the Australian commercial forests in approximately 45 minutes.

The fully documented and coordinated design process was undertaken in approximately 6 months and the full construction completed in 7 months including the integrated fitout. Anecdotal advice suggested that if the development had used a traditional steel and concrete structural system, the build time would have taken an additional 6 months and AUD$500,000 in additional builders preliminary costs.

The use of CLT as flooring/roofing systems and vertical structural shear walls allowed for column free space providing flexibility for internal fitout and future reconfiguration.

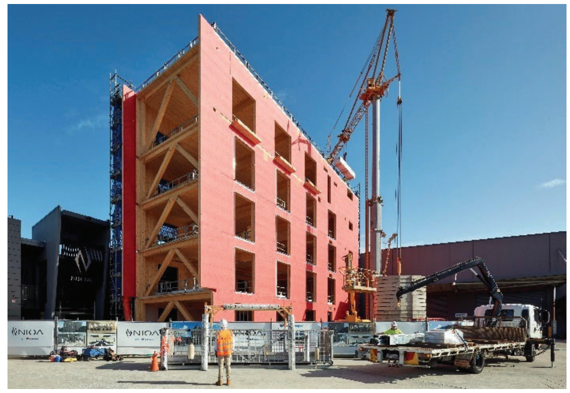

Figure 3 - NIOA Timber Tower MET structure (KIRK & Aurecon) - Photographer: Christpoher Fredrick Jones

KIRK approached the Timber Tower project as a prototype that adopted a set of building systems, timber structure, structural timber glazed façade, and zinc skin.

The site itself is complex, with highly corrosive air, aircraft noise from all directions, height restrictions, high winds and an operational business. These conditions informed material selection, detailing and construction system methodologies.

All elements were able to be manufactured in advance of the main contractor, starting on-site or with very limited lead times. The timber structure was shop drawn from the architectural model prior to the contractor's engagement - minimising the usual downtime (12 weeks) in projects.

Apart from the obvious time benefits, this prefabricated approach minimised on-site waste, significantly reduced construction site size and laydown area, streamlined the entire build process and demonstrated what decarbonisation can mean for the construction industry.

Figure 4 - NIOA Timber Tower (KIRK & Aurecon) Photographer: Scott Burrows

https://doi.org/10.52202/080513-0111

The NIOA Timber Tower is a proven demonstration of the benefits of using a MET structure approach for a small lot infill project where site area is limited, a quick build time is needed and significant sustainable outcomes are to be embedded within the project.

6 - CASE STUDY 2 - BCCK2

The Sarawak Government (East Malaysia) initially commissioned the expansion of the existing Borneo Convention Centre Kuching (BCCK) to bolster Sarawak's premium tourism industry by increasing the site's capacity for international, large-format events and exhibitions. Recognising that BCCK2 could be a catalyst project for the local engineered timber industry, the Sarawak Timber Industry Development Corporation (STIDC) invited KIRK and local partner, Arkitek KDI, to present a design demonstrating engineered timber's full potential.

BCCK2 sits adjacent to the existing Convention Centre, set on a sprawling waterfront site in Kuching, overlooking the Sarawak River.

Timber was chosen for its environmental performance, significantly reducing carbon emissions compared to traditional materials, in line with global targets and Sarawak's Post-Covid-19 Development Strategy 2030. Prefabrication of timber components would also streamline assembly and fast-track project delivery, even for a building of this significant size. If locally sourced, it was estimated that the timber required to build this project could triple Sarawak's GDP contribution.

Figure 5 - BCCK2 (KIRK & Aurecon) - Design for MET Structured facility in Eastern Malaysia

The design of the BCCK2 was set to be one of the world's largest single floor timber structures if built as designed, spanning 15,500 m^2 under roof. A timber building of this scale will all but necessitate the rapid development of the local timber industry and could have positioned Sarawak as a hub for engineered timber distribution and construction. Given the potential size of the project, it was important to engage with local industry from the outset. KIRK and Aurecon Structural Engineers immediately engaged with local Glulam supplier Woodsfield Group to ensure schemes presented were achievable.

In an attempt to educate and invigorate the Malaysian market, STIDC and KIRK organised and held an international conference on Engineered Wood in Sarawak in 2023. The conference brought together global experts in timber to speak on the immense economic opportunity of engineered timber, using the BCCK2 MET design as an active example, targeting government departments, the Fire and Rescue Department of Malaysia (BOMBA), suppliers, developers, constructors and related industries.

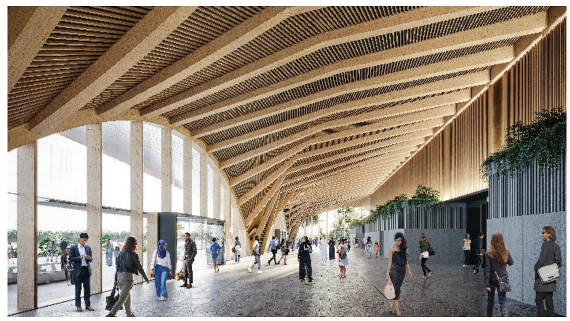

Figure 6 - BCCK2 (KIRK & Aurecon) - Internal MET Structure design for public concourse

Although the BCCK2 project did adopt partnering with international experts in MET construction, this alone was not sufficient to get the MET project methodology ultimately accepted.

7 - CASE STUDY 3 - NTU BUILDING SOUTH, GAIA, SINGAPORE

A 6 storey, mass engineered timber building was completed at Nanyang Technological University (NTU), Singapore, SEA in 2022. The building is named ‘Gaia’, after the Greek goddess of Earth and was formally known as the Academic Building South and is now the new home for the Nanyang Business School.

At 40,000m^2 floor area and a volume of Mass Engineered Timber of over 13,000m^3, it was Asia’s largest MET building and Stora Enso’s largest delivery to a single building [21].

https://doi.org/10.52202/080513-0111

Figure 7 - Gaia (source NTU Singapore)

The Gaia superstructure consists of CLT slabs, walls and stairs and Glulam columns, beams and braces.

Figure 8 - Gaia exposed internal MET structure and finishes (source NTU Singapore)

DESIGN TEAM AND TIMBER SUPPLIER COORDINATION

Tackling a project of this size in a Mass Engineered Timber emerging location presented significant challenges. The initial approach to these challenges and to aid in reducing risk for the project, was to establish a project team with experience in sustainable outcomes and particularly MET buildings supplemented by local consultants for local industry experience. Key Project team members included:

- Client/Developer: Nanyang Technological University, Singapore;
- Architect: Toyo Ito & Associates, Architects; RSP Architects Planners & Engineers (Pte) Ltd;
- Structural Engineer: Aurecon Pte Ltd;
- Timber supplier: Stora Enso (CLT), WiEHAG (Glulam);
- Main Contractor: Newcon Builders Pte Ltd;
- Mass Timber and Steel subcontractor (design, supply and install): Steeltech Industries Pte Ltd; and
- Subcontractors providing installation support for Steeltech: Woodtek (Taiwan), Savcon (Australia), Steel Ally (Singapore), Forest Road (Singapore).

The architectural vision called for a fully exposed MET building, which meant exposed services throughout. Early collaboration between architects, engineering disciplines and the timber supplier was necessary to ensure slabs and beams were cut to specification in factories, including the openings and slots for MEP services. Furthermore, the early collaboration among the design teams produced an innovative layout of alternating long and short span grids which worked best for lecture theatres/seminar rooms and the corridors leading to them [22].

In the concept phase, Stora Enso worked very closely with the design team. Utilising BIM (Building Information Modelling) 3D modelling tools, all parties could visualize the infrastructure and break it down into components. The Stora Enso Project Support Centre optimised panels for maximum raw material optimisation (a cost-saving and sustainability must for most developers) [21].

CERTIFICATION

Local building code regulations and in particular fire requirements can differ significantly from country to country. Up until approximately 2014, The Fire Code of Singapore required all elements of a structure to be constructed of non-combustible materials. With the potential uptake of MET in Singapore, the Singapore Civil Defence Force (SCDF) released a circular in 2014 and then a subsequent circular document in 2016 that amended the Singapore Fire Code with respect to building construction using Mass Engineered Timber [23]. This document addressed the use of MET in more detail and set out conditions that allowed the use of MET such as conformance of the timber to European standards and sprinkler protection requirements.

As with any MET building, early consultation with the building authorities and conformance to approved pathways was paramount to success.

PROTECTION AGAINST THE ENVIRONMENT

Singapore has significant annual rainfall and typically high humidity which posed significant challenges for the design. During the construction, Singapore experienced the most rainfall in 40 years [21]. Some of the mitigation measures that were used include:

- Designing for appropriate Service Class in accordance with Eurocode with adequate detailing and ventilation to prevent moisture build-up;
- Detailed construction sequencing and planning with the supply team to ensure members were not stored on site externally for long periods;
- Before shipping, Stora Enso protected elements by adding:
  - Coatings to protect against insects and termites;
  - End Grain Varnish to the narrow sides for protection from water ingress, stains, swelling and shrinkage;
  - All exterior vertical fins were double-side clad in larch and pre-coated for weather protection;
  - CLT floors were pre-fitted with metal inserts to facilitate easy and fast crane lifting;
- Contractors started each day, sweeping off pooled water from the wood and would repeat after the afternoon showers. Industrial-sized vacuum cleaners were also used; and
- Moisture content monitoring.

SUSTAINABILITY ACHIEVEMENTS

The use of MET for Gaia is reported to have saved significantly on emissions. As the timber used for the construction of Gaia was sourced from sustainably managed forests it meant new trees are planted to replace those that are harvested. The carbon offset from planting trees to replace those used in Gaia totals 5,800 tons of CO_2 – this is a similar carbon footprint of about 17,000 return flights between Singapore and Hong Kong [24].

8 - CONCLUSIONS

There is no doubt Mass Engineered Timber (MET) is now a mainstream global construction methodology. The sustainability and environmental benefits of building with timber are well documented and appreciated. Other benefits such as reduced construction time, cleaner and quieter construction sites and lighter structures are also apparent.

South East Asia (SEA) is considered an underdeveloped construction market in relation to MET. Whilst Singapore presents some optimistic advances, the majority of SEA is well behind Europe, North America and Australia/New Zealand for MET adoption.

Three relevant case studies have been presented, demonstrating:

- A relevant and successful building typology for SEA development using MET methodology;
- A MET project in Malaysia that showcased the potential of MET and the benefits, however failed to get MET across the line; and
- A successful example of a significant MET structured development in Singapore.

Key obstacles that need to be addressed to improve the adoption and positive stakeholder decision making for successful MET adoption in SEA include:

- Lack of relevant local experience and technical information can be mitigated through partnering with international experts in MET construction. This will also provide upskilling of local design consultants.
- The perception of supply issues needs to be corrected. Internationally supplied timber to Southeast Asia is already occurring. Engagement with local timber suppliers is also important to ensure it is a collaborative approach and the local industry continues to develop and grow.
- Perceptions of additional costs need to be addressed through previous project analysis and the use of Quantity Surveyors and Building Estimators who have experience in MET construction.
- Suitability with local building codes needs to be addressed as has been achieved successfully in Singapore. This is a fundamental area of change and will require support and assistance from Government across all regulatory authorities.
- Suitability to the SEA environmental conditions must be at the forefront of designers' minds to ensure appropriate solutions are in place to guarantee the longevity of facilities.

https://doi.org/10.52202/080513-0111

9 - REFERENCES

[1] L. Barham, I. Candy, G. Duller, C. Scott, C. Cartwright, J. Peterson, C. Kabukcu, M. Chapot, E. Melia, V. Rots, N. George, N. Taipale, P. Gethin and P. Nkombwe, “Evidence for the earliest structural use of wood,” Nature, pp. 1-5, 2023. M. Bekin, “A History of Timber,” 2023. [Online]. Available: https://ecochoice.co.uk/history-of-timber.

[2] International Timber, “Timber: The past, present and future,” 2018. [Online]. Available: https://internationaltimber.com/resources/timber-the-past-present-and-future/.

[3] S. Wood, “A History of Wood from the Stone Age to the 21st Century,” 2016. [Online]. Available: https://www.architectmagazine.com/technology/products/ahistory-of-wood-from-the-stone-age-to-the-21st-century_o.

[4] L. Booth, “Henry Fuller's Glued Laminated Timber Roof for Rusholme Road Congregational Sunday School and other early Timber Roofs,” Construction History, pp. 29-45, 1994.

[5] S. Gagnon, C. Pirvu and Fpinnovations Institute, “CLT handbook : cross-laminated timber,” Fpinnovations, Québec, 2011.

[6] World Economic Forum, “The Global Risks Report 2024, 19th Edition,” World Economic Forum, Geneva, 2024.

[7] T. Stein, “Carbon dioxide now more than 50% higher than pre-industrial levels,” National Oceanic and Atmospheric Administration, [Online]. Available: https://www.noaa.gov/news-release/carbon-dioxide-now-more-than-50-higher-than-pre-industrial-levels.

[8] IPCC, “Climate Change 2022: Mitigation of Climate Change,” In Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, 2022.

[9] World Green Building Council, “Bringing embodied carbon upfront, Coordinated action for the building and construction sector to tackle embodied carbon,” World Green Building Council, London, 2019.

[10] WWF Australia, “New Industry Alliance Set To Transform Embodied Carbon Emissions In Australian Construction And Infrastructure Industry,” 2021. [Online]. Available: https://wwf.org.au/blogs/new-industry-alliance-set-to-transform-embodied-carbon-emissions-in-australian-construction-and-infrastructure-industry/?gad_source=1&gclid=EAIaIQobChMIz-m_nYy2jAMVPAt7Bx0sujBNEAAYASAAEgKHCPD_BwE&gclsrc=aw.ds.

[11] J. Abed, S. Rayburg, J. Rodwell and M. Neave, “A Review of the Performance and Benefits of Mass Timber as an Alternative to Concrete and Steel for Improving the Sustainability of Structures,” Sustainability, vol. 14, no. 5570, 2022.

[12] J. Gaekwad, A. Sal Moslehian, P. Roos and A. Walker, “A Meta-Analysis of Emotional Evidence for the Biophilia Hypothesis and Implications for Biophilic Design,” Frontiers in Psychology, vol. 13, no. 13, 2022.

[13] S. Kellert, J. Heerwagen and M. Mador, Biophilic design: The theory, science, and practice of bringing buildings to life, Hoboken: Wiley, 2008.

[14] Integris Health, “What Are the Benefits of Biophilic Design?,” 2024. [Online]. Available: https://integrishealth.org/resources/on-your-health/2024/january/biophilic-design#:~:text=Enhanced%20Well%2DBeing%20and%20Mental,mood%20and%20enhanced%20cognitive%20function..

[15] R. Cesnik, “Why Mass Timber?,” 2022. [Online]. Available: https://www.hdrinc.com/au/insights/why-mass-timber#:~:text=Speed%20of%20Construction:%20Easy%20to,impact%20on%20human%20well%2Dbeing..

[16] S. Low, S. Gao and S. Ng, “The adoption of mass-engineered timber (MET) in the Singapore construction industry: Barriers and drivers,” Journal of Cleaner Production, vol. 327, 2021.

[17] Building and Construction Authority, “Mass Engineered Timber,” 2023. [Online]. Available: https://www1.bca.gov.sg/buildsg/productivity/design-for-manufacturing-and-assembly-dfma/mass-engineered-timber.

[18] F. Wong, P. Oldfield and P. Osmond, “Industry perceptions of mass engineered timber MET construction - a comparison of South-East Asia with other regions,” Architectural Engineering and Design management, vol. 20, no. 6, pp. 1543-1565, 2024.

[19] Global Alliance for Building and Construction, “Towards zero-emission efficient and resilient buildings - GLOBAL STATUS REPORT,” United Nations Environmental Programme, Kenya, 2016.

[20] O. Espinoza, V. Rodriguez-Trujillo and M. Laguardo-Mallo, “Cross-Laminated Timber: Status and Research Needs in Europe,” BioResources, no. November, pp. 281-295, 2015.

[21] Stora Enso, “Nanyang Technological University’s Gaia, Singapore,” 2023. [Online]. Available: https://www.storaenso.com/en/newsroom/news/2023/4/nanyang-technological-universitys-academic-building-south.

[22] Aurecon, “NTU Building South – Gaia. One of the world’s largest mass engineered-timber buildings,” 2024. [Online]. Available: https://www.aurecongroup.com/projects/education-research/nanyang-technological-university-academic-building-south.

[23] Singapore Civil Defence Force, “AMENDMENT TO FIRE CODE – FIRE SAFETY REQUIREMENTS FOR ENGINEERED TIMBER BUILDING CONSTRUCTION,” Singapore Civil Defence Force, Singapore, 2016.

[24] Nanyang Technical University, “NTU Singapore unveils Gaia, the largest wooden building in Asia,” 2023. [Online]. Available: https://www.ntu.edu.sg/docs/default-source/corporate-ntu/hub-news/ntu-singapore-unveils-gaia-the-largest-wooden-building-in-asia.pdf?sfvrsn=d3b7a5c4_1.