International Specialised Skills Institute

THE IMPLEMENTATION PROCESS

of Innovative Timber Building Technologies

An International Specialised Skills Institute Fellowship.

NICHOLAS CINI

Sponsored by The George Alexander Foundation.

THE GEORGE ALEXANDER FOUNDATION

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i. Executive Summary

The Australian construction industry is only really just beginning to use innovative timber technologies like Cross Laminated Timber (CLT) in mainstream construction. Already there is huge interest in the practical implementation of these types of construction in actual project situations. One drawback currently is the lack of broad practical experience when implementing these types of technology in Australia. The body of knowledge in Australia is limited to a handful of building professionals and suppliers leading the way.

European use of a broad range of innovative timber construction products is very well developed and has demonstrated the benefits over decades of improving techniques from project to project.

The Fellow carried out a series of lessons learnt case studies with architects, engineers, contractors and suppliers that are using all types of timber technologies in innovative ways. The Fellow managed to gather a body of knowledge from a number of perspectives that identifies the practical issues faced by building professionals when using these timber products and the unique ways that problems are overcome.

The result has been the compilation of two comprehensive case studies that delves deeper into the practical hands on issues that are being faced by the local Australian construction industry as it discovers the best way to use these construction techniques in the Australian context. This will add to the growing body of knowledge in Australia and provide building professionals here with insights gathered and refined over years and decades of experience.

ii. Abbreviations & Definitions

AIA Australian Institute of Architects

CPD Continuing Professional Development

CLT Cross Laminated Timber

LVL Laminated Veneer Lumber

1. About the Fellow

Nicholas Cini, Architect

Nicholas is the Principal and co-founder of CO.OP Studio. Co-op is an innovative architecture and design practice based in Melbourne, Australia.

As a multidisciplinary designer with 12 years experience in the architecture and construction sector Nicholas has been involved in projects across diverse market sectors in Commercial, Infrastructure, Transport, Education (Secondary and Tertiary), Civic and Commercial design fields.

His work has ranged from international sporting facilities to small one room mediation and wellness facilities. For the past 7 years Nicholas has specialised in leading multidisciplinary design teams in delivering predominantly public and civic architectural projects both in Australia and overseas. He has a keen interest materials research and materials science and using this knowledge to inform his practice and their design process. In 2013 the Fellow's design work was recognised in the Timber Design Awards where he was awarded the Rising Star Award for designers aged 35 or under. This experience as well as his overall design focus on sustainability of materials and use of timber sparked an interest in the sustainability of timber construction techniques and the potential for the innovative use of these materials.

Qualifications:

Registered Architect ARBV 18152 (Victoria)

Registered Architect ARBV 18152 (NSW)

Masters of Architecture (Hons), University of Newcastle, New South Wales, 2008.

Bachelor of Science (Arch), University of Newcastle, New South Wales, 2005.

Memberships:

Australian Institute of Architects

2. Fellowship Background and Aims

The overall aim of this Fellowship has been to make an in-depth enquiry into the European use of timber technologies in order to better understand the process used in the implementation of CLT and other innovative timber building technologies in unfamiliar markets.

This Fellowship allowed the Fellow to:

1. Investigate the innovative use of timber products such as CLT in two complete projects;

2. Work with the specialist teams involved to find out what they did and how they did it; and,

3. Reflect on the Australian context and how best to support professionals here to use these techniques.

The Fellowship drew on the international expertise of the teams from J. Mayer H. Und Partner, Architekten (Knesebeckstrasse, Berlin, Germany) and Waugh Thistleton Architecture (London, UK).

3. The Australian Context

Australian context is typified by the use of steel and concrete construction as the preferred structural solution, with the exception of the use of timber for cladding and lightweight framing. The benefits of timber structural solutions have not been as greatly adapted in the Australian context as they have been received in the European context, with only a few very sustainably conscious uses.

The one limitation of innovative timber technologies implementation could potentially be accredited to the lack of local manufacturers as well as the very limited numbers of importers of some of these emergent technologies, namely; Cross Laminated Timber (CLT). Products like Glulam and LVL play a significant role in the residential construction sector but as part of suite of structural members that often include steel and concrete as opposed to a holistic approach to timber construction.

Additionally, the desire for engineers to create innovative structural solutions in timber in the commercial sector is not as prevalent as in the European experience where timber often forms the primary and secondary structural solutions. This results in the market for these products and skills relying imported timber products and a small number of engineers that specialise in innovative use of timber. This doesn't need to be the case. In accrediting the lack of a strong local CLT market it would suggest that there has not in the past been a demand for the product, this is due in part to a lack of knowledge and effective implementation.

Demand for emergent timber technologies is growing rapidly, boosted by landmark projects such as the Forte residential tower by Lend Lease in Melbourne. This demand needs to be underpinned and further established in the Australian context through effective communication and education of local building professionals regarding best practice implementation.

If the use of these materials continues to lag behind the rest of the world we will continue to waste the numerous advantages of increased timber construction; material efficiency, carbon capture, thermal performance, low embodied energy, etc.

The successful introduction of innovative timber solutions in the Australian context is dependent on the continued communication of the advantages to the construction industry (and public) in order to encourage demand for the skills and processes required and establish a local demand. This process is currently building momentum with a number of international and local companies in the process of setting up in Australia to provide a local presence to cater for the future demand of this growing sector of the construction market.

4. Identifying the Knowledge and Skills Enhancement Areas

There are examples of areas in Australian industries and communities where there are weaknesses in innovation, skills, knowledge, experience, policies and/or formal organisational structures and relationships to support the ongoing successful development and recognition of individuals.

The focus of all ISS Institute Fellowships is on applied research and investigation overseas by Australians. The main objective is to enable enhancement and improvement in skills, knowledge and practice not currently available or implemented in Australia and the subsequent dissemination and sharing of those skills and knowledge throughout the relevant Australian industry, education, government bodies and the community, with recommendations to address the identified weaknesses.

Within the context in which the demand for innovative timber products is being established, the demand is primarily for knowledge of the implementation of these technologies. These need to be sufficient to create a culture of confidence when detailing and promoting timber solutions. It is to this purpose that the predominant area of skills entrancement relies on case studies to succinctly communicate skills in:

1. Design application and use of innovative timber products

Outcome: To explore the experience of international practitioners in discovering and overcoming issues with the design and use of innovative timber building products.

2. Understanding the production process and material properties, sufficiently in order to understand the potential and limitations of the material when used in specific applications.

Outcome: Document the primary issues found by architects and engineers when using untested timber products in complex building designs to allow insight into potential considerations for local practitioners.

3. How to manage the regulatory compliance and approvals process of using innovative timber products with design teams who are unfamiliar with the technologies and also with government institutions.

Outcome: Document the process undertaken by architects and engineers when using innovative timber products with public and private partners that are not familiar with those materials/techniques to provide awareness of potential ways to both educate those partners as well as meet local legislation and regulatory requirements in the use of untested building materials.

The basis of these skills is to hopefully develop the ability to confidently consider, detail, specify and deliver buildings that use innovative timber solutions. In most circumstances this type of knowledge must first be disseminated in the market in order to aid in establishing a market awareness, confidence and demand, inducing broader performance of innovative timber products.

This Fellowship allowed the Fellow to visit two projects in Europe which has led to the development of two case studies, which form the basis of this report.

5. The International Experience

5.1 Case Study 1: Metropol Parasol Seville, Spain

(J. Mayer H. Und Partner, Architekten. Knesebeckstrasse, Berlin, Germany)

This visit was to meet the project architect from J.Mayer.H and Partners to discuss their Metropol Parasol project.

The Metropol Parasol in the Plaza de la Encarnación, in Seville, Spain consists of several canopies creating a new expression for the city square. The project includes a museum, shops and market stalls at street level, as well as a new elevated city square. The canopies house a new restaurant and walkway which has become a popular tourist attraction.

Image 1: View of the parasols from the redeveloped urban square below - David Cardamone

The 28 metre high canopies consist of 6 tree like parasols to shade the city square, the entire structure is built exclusively of LVL (Laminated Veneer Lumber). This project is widely considered to be one of the most complex timber buildings that has been completed to date with significant development of materials, coatings and structural solutions needed to make its construction possible.

The meeting with the staff at J.Mayer H was primarily to discuss this process of working together with manufacturers and suppliers and to find out what were the key innovations that made to make this structure possible.

The project team said that in the end the success of this project came down to 3 major factors, the project team, glue/structural connections and paint/coatings.

Image 2: View of the parasols dynamic timber geometry – David Cardamone

Team

The makeup of the team was essential to success, each member from architect, engineer to suppliers was selected for their ability to create innovative solutions, from this basis the team was able to encourage a dialogue of testing and finding solutions to problems rather than defaulting to what was currently available.

Coating

The timber structure is made up of a 1.5m grid of small timber plates, the entire structure is 120m long and 45m wide made up of no less than 3400 individual elements to the structure (about 3500m3 of timber in total. Each timber panel is made of a product called Kerto-Q, a high strength LVL timber panel. Each panel varied in width from 68mm to 311mm dependant on structural requirements.

The Kerto-Q panels are made up of a number of 3mm layers of rotary cut timber veneer that are bonded and vacuum treated to produce highly stable panels with good water resistance, something that not all LVL products have.

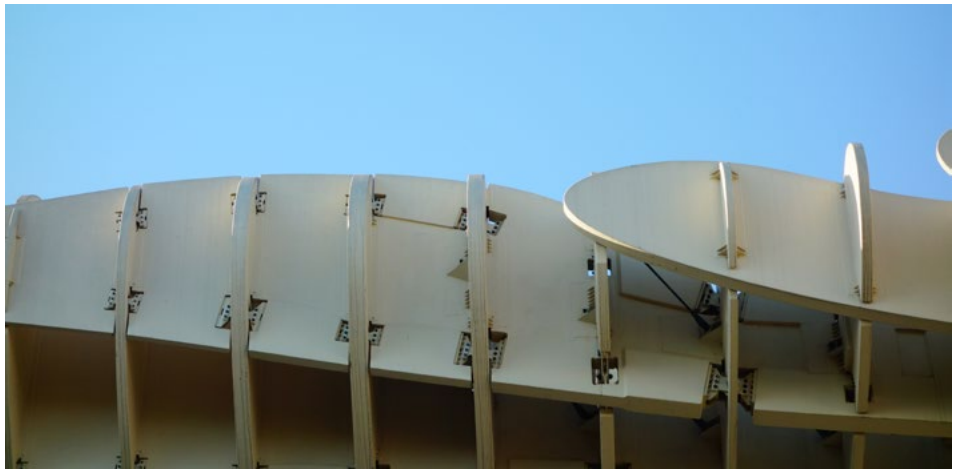

Image 3: End panel details - David Cardamone

Some members of the design team argued that the coating that they came up with for this project was the most important aspect of the project. To protect the timber parasols from the harsh environment in Seville a new type of coating was needed. In the end they used a product that they had originally used some years earlier on a university cafeteria building in Karlsruhe in Germany, indicating that previous project experiences are invaluable when creating new methods of construction.

Image 4: The rigid 1.5m grid structure allows for very large spans to be achieved out of very small timber members - David Cardamone

Image 5: The timber coloured coating seen from the visitor walkway - David Cardamone

Each LVL panel is coated in a 2-3mm thick polyurethane membrane. The coating was chosen for is excellent ability to maintain flexibility while having high adherence to the panel surface. Given that the structural solution put most of the timber in structural tension the coatings ability to cope was essential while also providing the panel with increased stiffness due to the thickness and strength of the coating.

The other key factor in the performance of the polyurethane coating is that it is vapour permeable, allowing for moisture changes in the timber panels. This permeability was another factor in the performance of the paint system given the huge variation in ambient temperatures and humidity in Seville.

Image 6: Construction of one of the first 'Trunks' - Finnforest

Glue / Structural Connection

With 3400 timber panels and approx. 2700 joints, coming up with both an economical and high performance connection detail was a key challenge for the design team. Due to the size of the structure each joint between a timber panel was exposed to 130 tons of force. The system uses a series of steel connectors with rods threaded into the panels and fixed with epoxy glue.

The summer temperatures in Seville in summer regularly reach 40 degrees Celsius, so the temperatures of materials with prolonged exposure to the sun can reach 70 degrees Celsius. This was a problem for the engineers as the epoxy they used was only safe up to temperatures up to 60 degrees. Several tests were undertaken that showed the internal temperature of the timber would reach over 60 degrees. The Design team came up with a solution to raise the heat resistance of the epoxy. They did this by tempering the epoxy. By heating the epoxy it consolidated the molecules of the epoxy essentially making it much more heat resistant.

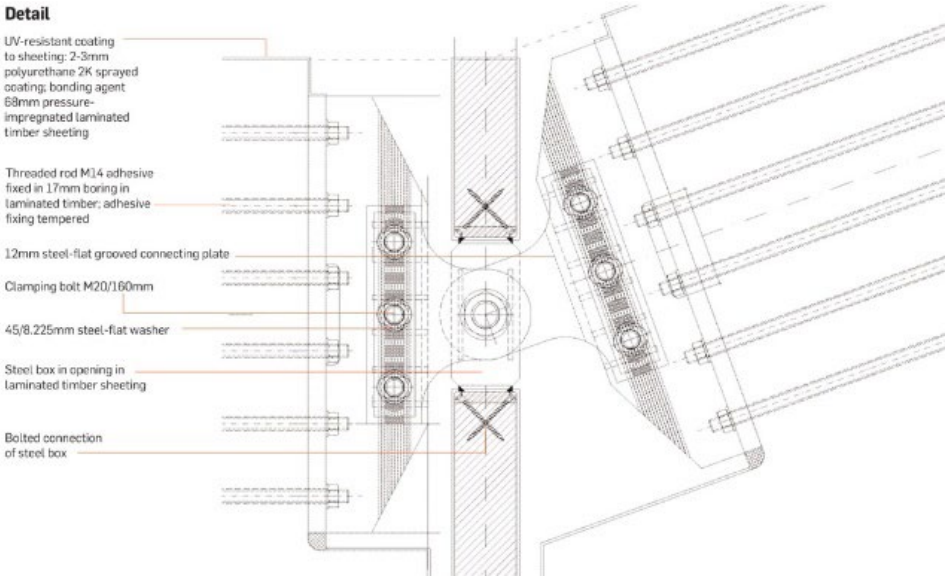

Image 7: Structural connection detail – Finnforest

Image 8: Structural connections – David Cardamone

5.2 Case Study 2: Stadthaus, Hackney, London, UK

(Waugh Thistleton Architecture, London, UK)

Stadthaus is a 9 storey apartment building in Hackney in London. The Building is made up of ground floor commercial spaces, 5 floors of private residential apartments and 3 floors of social housing. The entire building structure is made from CLT. The architects Waugh Thistleton completed the building in 2009 at which stage it was the tallest timber building in the world. Waugh Thistleton's goal in using CLT in this project was to showcase the considerable advantages of CLT in commercial construction. A comparable building of this type if built from concrete and steel would produce approximately 125,000kg of carbon and take 72 weeks to build. By using CLT this building stores 185,000kg of carbon in the CLT in the building and took 49 weeks to build, the timber structure itself took only 27 days to erect with 4 men working 3 day weeks and timeframe simply unheard of using traditional construction methods.

Image 9: Stadthaus Residential Project – Waugh Thistleton Architecture

In a number of technical and construction areas this project pushed the boundaries in using innovative timber technology however, it is the way that the regulatory and compliance aspects of the project were managed by the design team and client that make it a well suited case for consideration in the Australian market. In the mid 2000's the regulatory landscape in the UK was somewhat conservative in their approach to CLT buildings similar to the current Australian experience. The main dialogical and regulatory aspects that they faced were acoustic performance, fire resistance and overcoming concerns from the client and the market place that timber is an inferior product compared with concrete and steel.

Image 10: Stadthaus Typical Floor Plan – Waugh Thistleton Architecture

The acoustic separation between apartments was a key concern for the client and the design team, the normal practice of using mass concrete or blockwork walls for acoustic separation could not be used in this case. Timber is well known for dealing with high frequency noise however low frequency sounds transferring between apartments are of specific concern in the UK regulations and most usually pose a problem in the floor transferring to the level below. The project architect and the engineers trialled several different solutions before finding a solution that not only met the regulations but exceeded them, with an average of 55dB separation between apartment walls and 53dB between floors. They achieved this by laying compressed foam insulation panels over the timber floor slab followed by a 55mm thick screed of concrete, in this way they ensured that the concrete surface of the floor was physically and acoustically separate from the timber floor slab underneath.

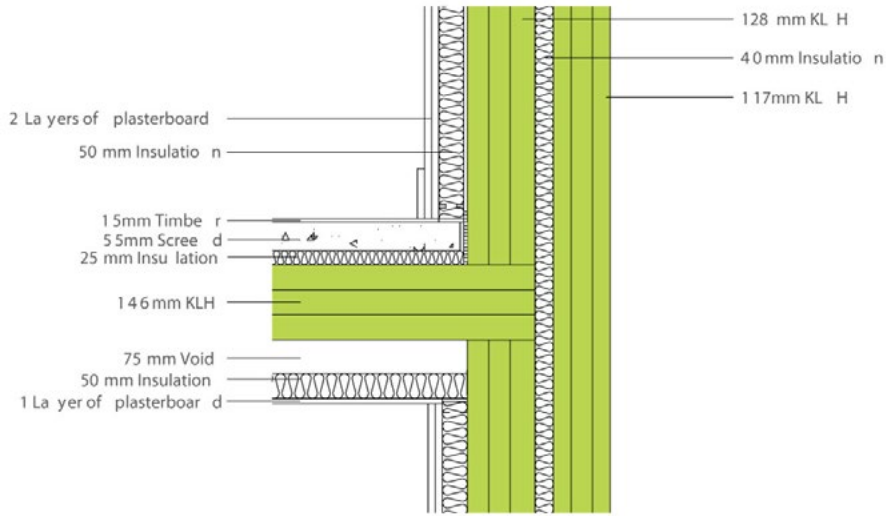

Image 11: Floor to Wall Detail illustrating the methodology to achieve compliant acoustic separation between floors – Waugh Thistleton Architecture

European regulations specify that building cores must be built from non-combustible materials but do not make any other considerations to their actual performance, likewise the regulations relating to fire resistance in tall buildings are predominantly based on concrete conduction models. In a fire solid wood chars as it burns producing a layer of charcoal which provides a natural protective layer to the structural ability of the timber. The architects and the design team undertook tests on samples of CLT of varying widths to understand the type of fire resistance that could be provided by different panel widths in specific circumstances and still maintain their structural integrity. The walls of the building have been rated to provide 90minutes of fire resistance. They provided this information to the local building certifiers and engineers to allow for full certification of the structural design and fire engineering of the building.

Image 12: Construction stage, at the completion of erection of the CLT building components before internal and external finishing – Waugh Thistleton Architecture

6. Recommendations and Knowledge Transfer Opportunities

Based on the experience gained by the Fellow the following recommendations are proposed to link the skill enhancement areas identified with outcomes that will increase knowledge and learning opportunities in the local market.

1. Utilise the experience of international practitioners and their approach to the use of innovative timber building products as an education opportunity for local students and graduates. The new generation of architecture students are the ones who will drive the next decades using innovating timber technologies. These should be a focus for current education institutions so as to best place the Australian market in playing a leading role in further innovation in this field.

   The Australian Institute of Architects (AIA) is encouraged to invest resources in communicating the importance of learning about innovation and in particular how to implement innovative building technologies in the architectural profession. To this end the AIA should lobby local universities teaching architecture to strengthen the ability of new graduates to discover, test and implement current and new building technologies through the content and structure of their curriculums.

   A program for scholarships for architectural students and graduates sponsored by local and international CLT and other innovative timber technologies would further encourage and broaden the exposure of these products in the local market.

2. Integrate technical learning modules from industry professionals on innovative timber technologies into the current structure of professional learning, called Continuing Professional Development (CPD), which is encouraged by the AIA. Use this process and others to articulate to current local practitioners the process of implementation of these products and the primary issues found by architects and engineers when using untested timber products in complex building designs. This would allow insight and a degree of safety in using these materials in current and future projects.

3. Lobby state and local governments to fund research and integrate technical learning modules on innovative timber technologies into the current regulatory approvals process with professions such as building surveyors and town planners.

4. Undertake presentations to local institute of planners and building surveyors on the processes involved in how to manage the regulatory compliance and approvals process of using innovative timber products on local buildings. In addition, translating international code compliance with local codes and regulations to provide local government institutions and building certifiers a level of surety when approaching these types of projects, given they will become increasingly common in the future.

5. With the experience gained above, the Fellow recommends the future creation of an online reference tool complied with local and international CLT and LVL suppliers as a one stop location for architects, engineers, building surveyors and other building regulation professionals.

6. Local projects using innovative timber technology that are completed and delivered have been one of the most effective ways to promote innovative new products in a new market and this was certainly evident during the Fellow's international applied research experience.

7. Acknowledgements

Nicholas Cini would like to thank the following organisations and individuals that gave generously of their time and their expertise to assist, advise and guide him throughout the Fellowship program. Thanks also go to the international hosts that helped facilitate this Report who generously gave their time and provided the Fellow the benefit of their knowledge, extensive experience, expertise and passion for their field of operation

Awarding Body – International Specialised Skills Institute (ISS Institute)

The ISS Institute exists to foster an aspirational, skilled and smart Australia by cultivating the mastery and knowledge of talented Australians through international research Fellowships.

The International Specialised Skills Institute (ISS Institute) is proud of its heritage. The organisation was founded over 25 years ago by Sir James Gobbo AC CVO QC, former Governor of Victoria, to encourage investment in the development of Australia's specialised skills. Its international Fellowship program supports many Australians and international leaders across a broad cross-section of industries to undertake applied research that will benefit economic development through vocational training, industry innovation and advancement. To date, over 350 Australian and international Fellows have undertaken Fellowships facilitated through ISS Institute. The program encourages mutual and shared learning, leadership and communities of practice.

At the heart of the ISS Institute are our individual Fellows. Under the International Applied Research Fellowship Program the Fellows travel overseas and upon their return, they are required to pass on what they have learnt by:

- Preparing a detailed report for distribution to government departments, industry and educational institutions
- Recommending improvements to accredited educational courses
- Delivering training activities including workshops, conferences and forums.

The organisation plays a pivotal role in creating value and opportunity, encouraging new thinking and early adoption of ideas and practice. By working with others, ISS Institute invests in individuals who wish to create an aspirational, skilled and smart Australia through innovation, mastery and knowledge cultivation.

For further information on ISS Institute Fellows, refer to www.issinstitute.org.au

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The Fellow would like to thank the George Alexander Foundation for providing funding support for the ISS Institute and for this Fellowship.

In 1972, George Alexander AM (1910 - 2008) set up an independent philanthropic foundation as a way of sharing his wealth and giving back to the community. Today, the main focus of The George Alexander Foundation is access to education for promising young people, particularly students with financial need and those from rural and remote areas.

The George Alexander Foundation (GAF) Scholarship Programs form the core of the foundation's work, operating in partnership with major tertiary institutions, while our Fellowships and other Education grants provide a variety of other unique and challenging educational experiences. George Alexander believed in the notion of 'planting seeds and hoping they grow into pretty big trees'. The programs supported by the Foundation endeavour to support this ideal and as GAF students graduate and go on to contribute to the community, George's legacy and spirit lives on through their achievements.

George Alexander came to Australia as a child migrant, and went on to become a mechanic, an entrepreneur and a businessman and later, a generous philanthropist, who held that you do not own the possessions you have, 'you're just minding them'. This philosophy guided him to give during his lifetime and to hope that through his example, he might inspire others to do the same.

Employer Support

The Fellow would like to acknowledge that the whole team at Co-op Studio have given their full support to the Fellow in undertaking this opportunity. Co-op Studio have welcomed the environment of educational innovation that the Fellowship promotes.

Fellowship Supporters

The Fellow also acknowledges the following organisations and individuals who have played important roles in the development and execution of this Fellowship.

Organisations:

» Bentleigh Secondary College (AUS)

» DWP (AUS)

» Co-op Studio (AUS)

» Wood Products Victoria TPC Solutions (Aust) Pty Ltd (AUS)

» dRMM Architects (UK)

» Waugh Thistleton Architects (UK)

» Martinsons Timber (SWEDEN)

» Metsa Wood (FINLAND)

Individuals:

» Bill Thomas PSM - Head of Sustainable Practices, Bentleigh Secondary College.

» Karly Cini, Epidemiologist, Murdoch Children's Research Institute

» Clare Flannery, Marketing Coordinator, dwp|suters

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