

GOTTSTEIN FELLOWSHIP REPORT 2020



UNDERUTILISED TIMBER ACCEPTANCE THROUGH NORTH AMERICA & EUROPE
HARRY F MILLS

Joseph William Gottstein Memorial Trust Fund

The Joseph William Gottstein Memorial Trust Fund was established in 1971 as a national educational Trust for the benefit of Australia's forest products industries. The purpose of the fund is "to create opportunities for selected persons to acquire knowledge which will promote the interests of Australian industries which use forest products for the production of sawn timber, plywood, composite wood, pulp and paper and similar derived products."

Bill Gottstein was an outstanding forest products research scientist working with the Division of Forest Products of the Commonwealth Scientific Industrial Research Organization (CSIRO) when tragically he was killed in 1971 photographing a tree-felling operation in New Guinea. He was held in such high esteem by the industry that he had assisted for many years that substantial financial support to establish an Educational Trust Fund to perpetuate his name was promptly forthcoming.

The Trust's major forms of activity are:

1. Fellowships and Awards - each year applications are invited from eligible candidates to submit a study programme in an area considered of benefit to the Australian forestry and forest industries.
2. Seminars - the information gained by Fellows is often best disseminated by seminars as well as through the written reports.
3. Wood Science Courses - at approximately two yearly intervals the Trust organises a weeklong intensive course in wood science for executives and consultants in the Australian forest industries.
4. Study Tours - industry

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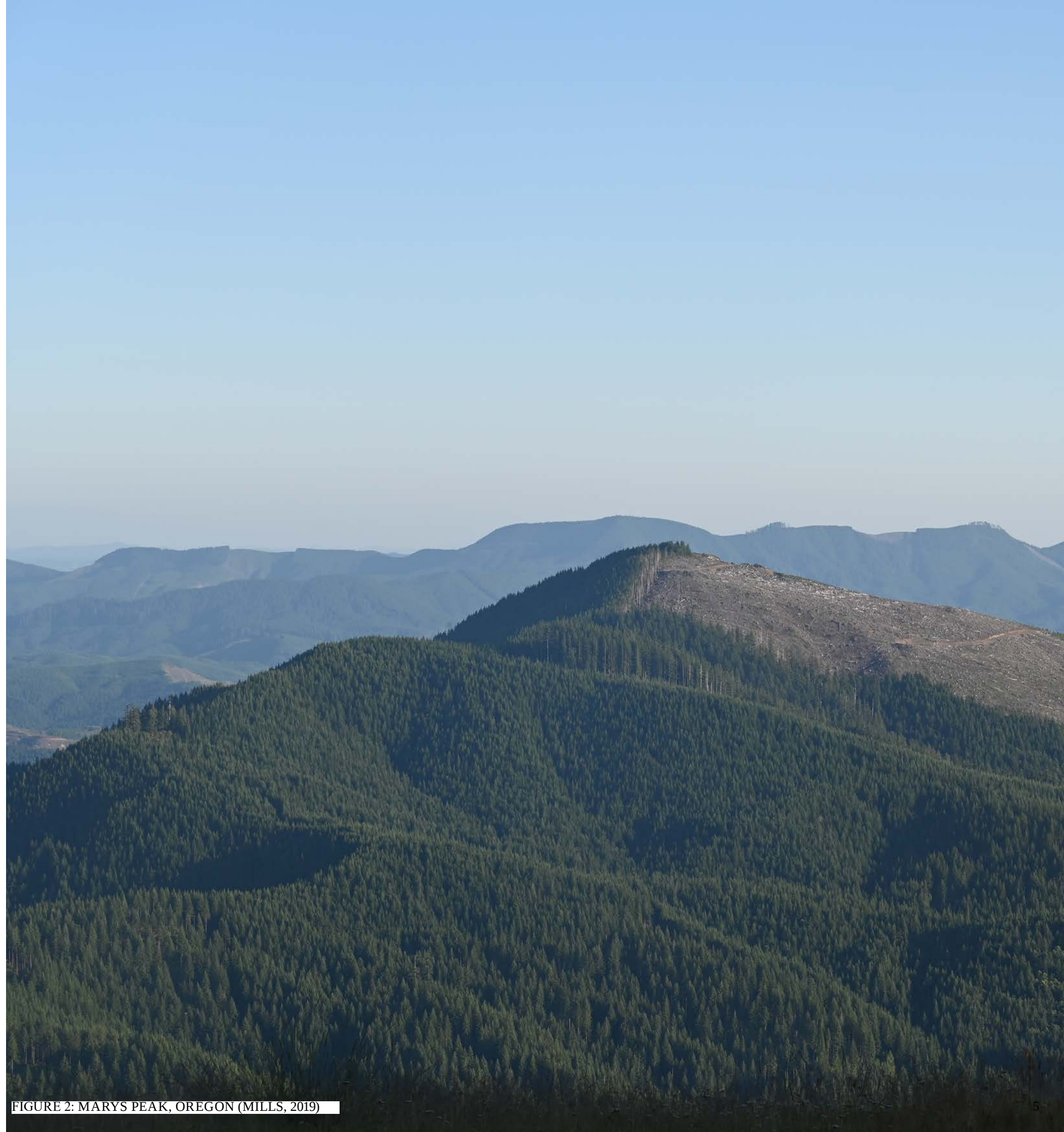


FIGURE 2: MARYS PEAK, OREGON (MILLS, 2019)

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ABBREVIATIONS

CLT	Cross Laminated Timber
DfMA	Design for Manufacture & Assembly
DLT	Dowel Laminated Timber
EWP	Engineered Wood Product
FSC	Forest Stewardship Council
GHG	Greenhouse Gas
MPP	Mass Plywood Panel
MTP	Mass Timber Product
MTC	Mass Timber Construction
NLT	Nail Laminated timber
UT	Utilised timber
UUT	Underutilised timber

EXECUTIVE SUMMARY

This report covers the findings from a research project supported by the Gottstein Fellowship grant, which explored the potential for sustainable design that incorporate underutilised timber (UUT). The project involved travelling to North America and Europe from July to October, 2019, to tour facilities, visit sites, interview and have informal discussions with leading professionals from three categories: (i) forestry & manufacturing, (ii) designers, and (iii) educators & researchers.

The findings from investigation suggest that there is a strong support and acceptance to UUT products for use in the built environment. Engineered wood products like cross laminated timber, and glulam were products identified that could be tweaked to have immediate potential to absorb UUT. Expanding finger-joint manufacturing for residential framing was another area that has strong precedence in North America. Long term, the development of additional products like dowel, and nail laminated timber, brettstapel, lignatur, and mass plywood panels for the veneer market could be beneficial for the Australian context. Circular construction examples were identified in several regions, which was resulting in greater conscious material use and employment opportunities.

Overwhelmingly, the benefits for absorbing UUT range to new products, meeting the demand from the built environment for timber products with local resource, and additional employment opportunities across the timber product supply chain.



FIGURE 3: MOUNT ST. HELENS NATIONAL RESERVE, WASHINGTON (MILLS, 2019)

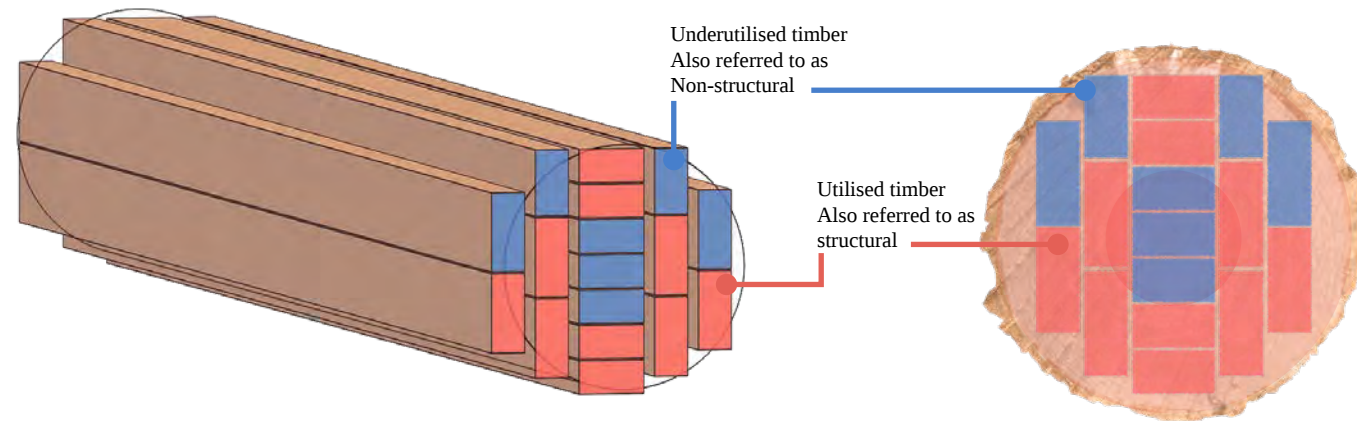


FIGURE 4: RESOURCE BREAKDOWN (MILLS, 2020a)

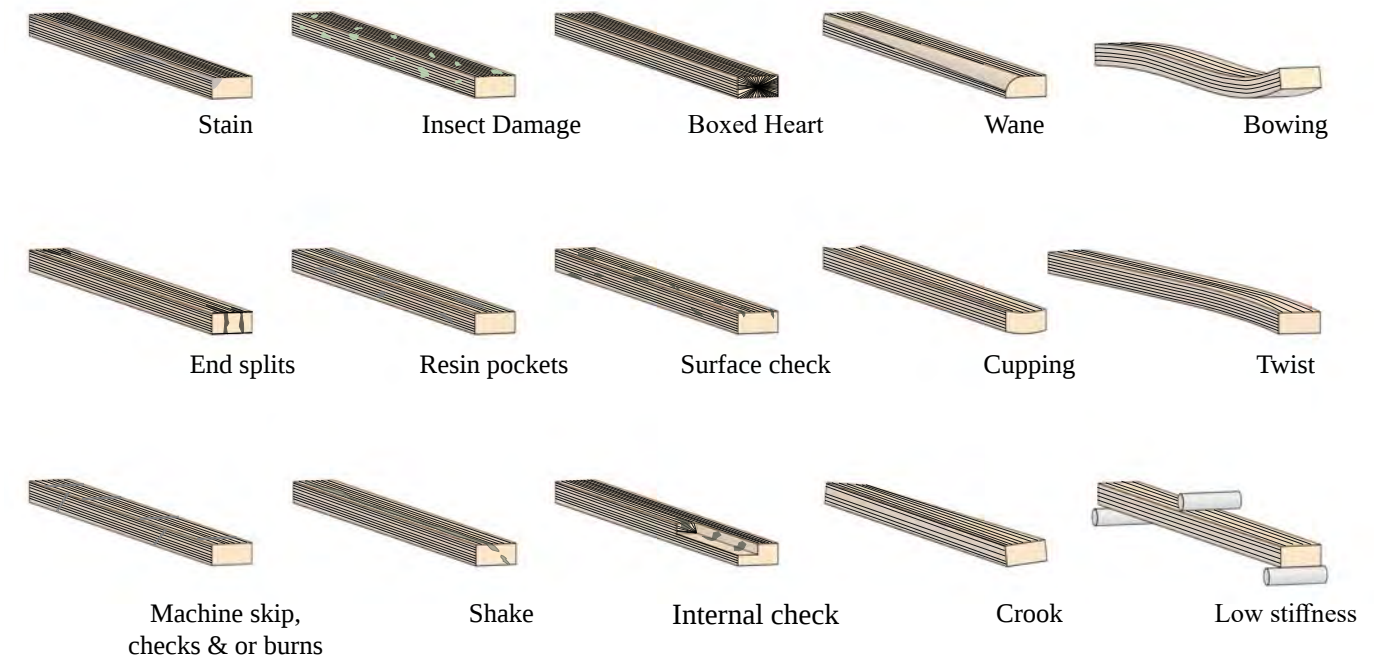


FIGURE 5: UUT GROWTH AND PROCESSING CHARACTERISTICS (MILLS, 2020b)

INTRODUCTION

Softwood milling in Australia is producing a large volume of UUT. Upwards of 40% of softwood milled boards are destined to fail structural grading and for the purposes of this report, can be classed as UUT. This classification also applies to boards with specific growth and processing characteristics that fail to meet market demand due to visual aesthetics. Some of these features, as shown in Figure 5, range from knots, wane, distortion, and colouration through to being low in stiffness. Uncertain climatic conditions, varying log quality, and a surge in interest of timber building products are all varying contributing factors towards UUT. When found together, UUT characteristics, are enough for the material to be classified as low-in-grade and suffer from little consumer acceptance.

While demand for in-grade and high aesthetic timber, or utilised timber (UT) increases, the need for UUT remains low. Furthermore, the onset of a mass timber construction (MTC) boom is expected to increase the demand for UT. For wood growers and manufacturers, through to the consumers of timber products, the potential impacts of this situation are troublesome. MTC can generate an increase in production costs of UT due to covering the financial burden of handling UUT, shortages in domestic tree plantation stocks caused by the rise in demand for products, and a

high volume of market-less UUT product stock. If things remain unchanged, these scenarios can represent a significant volume of resource, which can hinder the addition of value to UUT in the existing product supply chain. Currently, harvested plantation softwood gets processed into four different areas:

- (i) UT as structural products and systems;
- (ii) UUT as non-structural products and systems;
- (iii) UUT processed as pellets for biofuel energy;
- (iv) UUT processed as woodchip and exported.

As the market for UT products in Australia increases, the built environment is becoming increasingly reliant on the import of structural grade softwood products. UUT resource represents an opportunity to create innovative industry solutions for catering to the demand for timber products with the goal of efficiency and economisation.

THE RATIONALE

The research conducted for the Fellowship explored the areas of sustainable design that incorporate UUT for use in the built environment. The study anticipated discovering insight into the different supply chains, gathering an international lens to inform part of a larger project with The Future Timber Hub at The University of Queensland, looking at product design and absorption opportunities for underutilised and marginalised timber for built environment purposes.

The travel for the Gottstein Fellowship research project happened over fourteen weeks, involved travel to seven different countries, 70 meetings, 38 semi structured interviews, and participation in an intensive wood fabrication and research course. The result was a well-rounded inspection of the timber product supply chain of the North-West of North America, an exploration into the Danish Design and academic sectors, a tour of the leading research and manufacturing institutes throughout Central Europe, and a survey of innovations and artisans throughout the South of the UK.

THE PROCESS

The travel for the Fellowship project initiated in July of 2019 on the West coast of North America. It concluded in Dorset of the United Kingdom in October of 2019. The itinerary included:

- four weeks of travel from Oregon, USA to British Columbia, Canada;
- two weeks in Denmark, Germany, Switzerland and Austria;
- six weeks in the United Kingdom.

The time in the United Kingdom included participation in the 2019 Architectural Association Summer Build program in Dorset.

Data was collected through a mixture of photographs, site visits, informal discussions and interviews with entities who had industry experience, and/or were equipped with tooling to handle UUT moving forward. The research involved three sectors along the timber product supply chain:

- (i) forestry & manufacturing;
- (ii) designers;
- (iii) educators & researchers.

The aims of the study were:

- (i) to investigate and document existing practices for how UUT is currently utilised in international markets;
- (ii) to identify and visit leading facilities which are connected to the timber product supply chain;
- (iii) to give a comparative report on the international market scene to Australia.

The table across the next few pages shows a summary of the facilities visited, providing a description of the locality, position on the supply chain and the main findings from the meetings and visits. Following the table is a detailed summary of the regions visited.

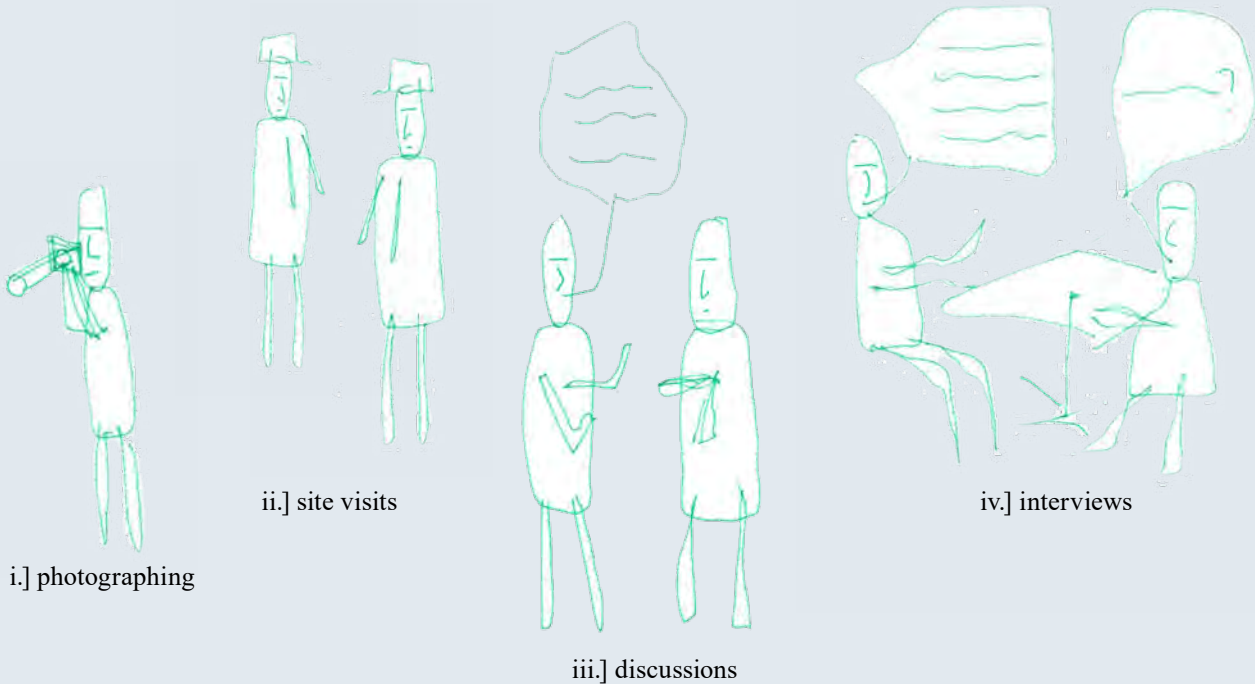


FIGURE 6: METHODS OF RESEARCH, (MILLS, 2019)

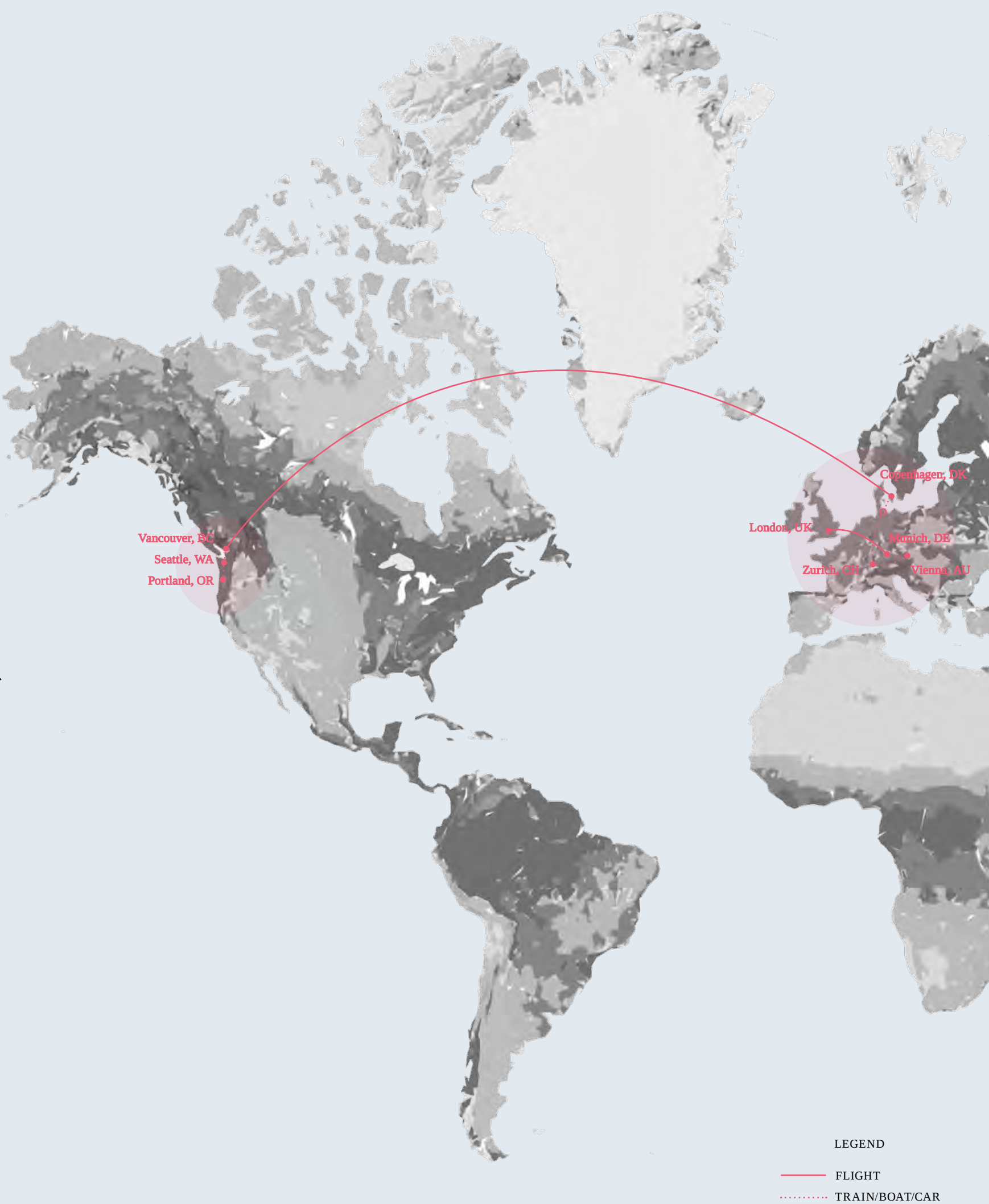


FIGURE 7: OVERVIEW OF DESTINATIONS, (MILLS, 2019)

FELLOWSHIP SUMMRY

 Manufacturers	 Research facility	 Design firms	 Exemplar	
<i>Role/Activity</i>	<i>Organisation/Facility</i>	<i>Region/Country</i>	<i>About</i>	<i>Takeaways</i>
	Tallwood Design Institute	Corvallis, Oregon United States	Collaborative research group encompassing the supply chain. Industry and academic-led	Research looking into reclaimed wood products due to Portland Gov. enforcing a deconstruction policy. Development of mass plywood panel product, in conjunction with Freres Lumber to great success. Learnt of species Pinus Ponderous which is found in surrounding Oregon and considered low in value; potential for use in non-structural capacity in housing.
	Oregon State University Department of wood science and engineering	Corvallis, Oregon United States	Teaching and research focus; understanding the wood properties.	Projects looking at the viability of reclaimed wood for new CLT products, amongst others. Swiss-needle cast fungal disease affecting the growth of Douglas-fir in the North-West NA. Engineered wood products can assist in absorbing UUT, dependent on processing and costs associated.
 	Lucidyne Technologies	Corvallis, Oregon United States	Technology & equipment manufacture supplier	As accessibility to emerging technology opens up, look to engineered wood products to absorb the stock of UUT
 	Pretec	Eugene, Oregon United States	Technology & equipment manufacture supplier	Manual and automated manufacturing need to be carefully situated together. Yield interest will always be a critical driver that needs to be considered for UUT design.
	University of Oregon, Architecture Department	Eugene, Oregon United States	Architectural and research centre; forms part of the Tallwood Design Institute	Educating designers the importance of specifying and building with environmentally conscious materials like timber. Being able to <i>activate</i> the designer to create and showcase UUT potential.
	Weyerhaeuser	Salem, Oregon United States	National timber product manufacturer and supplier	Milling Douglas Fir, which produces a low volume of UUT. This wood is milled green and primarily results in premium structural contract grade UT.
	SRG Partnership	Portland, Oregon United States	Architectural firm; experienced with MTC	Engineered wood products can absorb UUT. In addition, built examples of UUT will help develop the confidence of the success and viability of different products.
	LEVER	Portland, Oregon United States	Architectural firm; experienced with MTC	Some opportunities for integrating UUT into projects. Establishing a process for procurement and specification important.
	Cut my timber	Portland, Oregon United States	Advanced timber product manufacturer	Possible to add value to UUT with advanced manufacturing. Important to showcase built examples of UUT. Designers need to be aware of where and how a product is created, and the benefits for working with UUT; i.e. Responsible use of resource, cheaper etc.
	Tillamook Air Museum	Tillamook, Oregon United States	Historic building example	Large scale WWII blimp hangar on the coast of Oregon. Operating as both an air museum and sawmill. Impressive structure made of short length truss work.

<i>Role/Activity</i>	<i>Organisation/Facility</i>	<i>Region/Country</i>	<i>About</i>	<i>Takeaways</i>
	USNR	Woodland, Washington United States	Technology & equipment manufacture supplier	One of the leading technologies and tooling suppliers globally. Have been working with Kattera's new Spokane CLT mill. Southern Pinus grown in the South-East of the US sharing similarities to resource grown back in Australia; fast-growth with large growth rings. Look to EWP's for UUT uptake.
	Kattera	Seattle, Washington United States	Timber product manufacturer & developer	Kattera's new Spokane CLT mill is hoping to foresee opportunities along the production line to absorb wood when quality is varying. Kattera purchases graded wood and re-grades in house before milling. Striving for mass design, perfection and standardisation.
	Miller & Hull Partnership	Seattle, Washington United States	Architectural firm; experienced with MTC	Collaborating with universities to turn underutilised and unregulated whole wood resource into building products and systems. Questions arose during the interview, what is value? What could be a different partnership to initiate the uptake of marginalised resources?
	Bullitt Center	Seattle, Washington United States	Building example	Mass timber example, carbon-neutral energy and net-zero water building; lifecycle of 250 years.
	Michael Green Architecture MGA	Vancouver, British Columbia Canada	Architectural firm; experienced with MTC Partnered with Kattera Group, design & construct	Partnership with Kattera allows for direct access to manufacturing and material locally. The firm would like a greater emphasis on tracking where the resource comes from. Research led design
	Equilibrium	Vancouver, British Columbia Canada	Engineering firm; experienced with MTC Partnered with Kattera Group, design & construct	Engineered wood products and adhesives can assist in value-adding to UUT in both existing and novel products and systems
	Fast & Epp	Vancouver, British Columbia Canada	Engineering firm; experienced with MTC	Beetle infested wood/blue stained product specified as a feature element in projects. Engineered wood products like CLT, DLT, and NLT can play a role in absorbing UUT resource.
	LWPAC & Intelligent City	Vancouver, British Columbia Canada	Design & Developer. Focus on mass timber	Incremental innovation cycle; creating a product which looks the same but utilises lower quality material and cheaper to produce. Spoke of the importance to explore and market different visual qualities.
	HILO LAB, University of British Columbia	Vancouver, British Columbia Canada	Teaching & research architectural focus looking at the reuse of material waste from construction	Zippered wood project; generating a system that is robust enough to adapt to changing resource quality and quantity. Establishing the constraints of the resource.
	Center for Advanced Wood Processing CAWP	Vancouver, British Columbia Canada	Advanced fabrication facility which engages in research with industry and other departments at UBC	Research industry focus allows for collaboration with broader disciplines and stakeholders along the supply chain. Rapidly evolving technology can assist in incorporating UUT for building products.
	FPInnovations	Vancouver, British Columbia Canada	National research institute conducting research across the whole timber processing supply chain	Spoke of evolving markets in Canada and provided a thorough overview of the timber industry. For UUT, sees potential for absorbing different species and the ability to adapt to changing resource.
	British Columbia Institute of Technology BCIT	Vancouver, British Columbia Canada	Trade focus institute teaching industry wood processing certificate; upskilling mature employees	Importance of raising the awareness right across the supply chain, at institutes and trade training facilities like BCIT. Communicating the difference of defects; two types – growth, and processing.

<i>Role/Activity</i>	<i>Organisation/Facility</i>	<i>Region/Country</i>	<i>About</i>	<i>Takeaways</i>
	Chopvalue	Vancouver, British Columbia Canada	Product example	Upcycling used chopsticks into products; uptake has been highly successful. Manufacture home décor to furniture.
	Richmond Olympic Oval	Richmond, British Columbia Canada	Building example	Beetle-killed Pine utilised in Beams and cladding; use of low-aesthetic resource for high exposure event, the Olympics.
 	3XN/GXN	Copenhagen, Denmark	Architectural & research firm pursuing work in the field of circular futures. Experienced with MTC	Essential to understanding the visual performances of potential UUT products. Circular Futures provides examples of upcycling and value-adding to marginalised resources
	Centre for Industrialised Architecture KADK	Copenhagen, Denmark	Collaborative group working internationally with developing nations to initiate sustainability concepts in Architecture	Important to showcase the qualities, and back story to the UUT resource for end users to engage.
	Circle House	Copenhagen, Denmark	Building example	Scalable building solution by Lendager Group, Vandkunsten, and 3XN Architects. Aims that 90% of the materials used in the project can be recycled and reused later without losing significant value.
	Gramazio Kohler Research ETH	Zurich, Switzerland	Leading research group looking into numerous materials with additive manufacturing	Looking at paths & processes which welcome inclusiveness. Projects presented were of a high level; simplifying material, generating, and solving complex solutions through design.
	Chäserrugg Building	St. Gallen Switzerland	Building example	A Mass timber example. The building has a high level of detailing and joinery.
 	The Lehmann Group	Gossau, Switzerland	Leading timber sawmill, timber supplier and advanced timber manufacturer	The importance for designers to learn and be aware of the manufacturing process. Adhesives can be utilised to assist in upcycling UUT for products and systems
	Stora Enso YBBS	Donau, Austria	Timber manufacturer. I visited the CLT manufacturing line	Spoke of the history of CLT and how it was generated to absorb lower quality wood resource. UUT-like resource at Stora Enso typically exported to the Levante Market.
	Wiehag Timber	Altheim Austria	Leading glulam manufacturing and engineering group working on major architectural projects globally	UUT resource can be absorbed in glulam products; the factor to consider is manufacturing; how dealing with this resource will impact the processing line with time and costs associated.
	Architecture Department, TUMwood, Technical University of Munich	Munich, Germany	Architecture school and research group working with wood for mass timber construction. Form part of a larger group TUMwood.	Optimising the opportunities for wood and keeping it a negative carbon emitter. Working with regulations to get UUT like-resource to product and to market.
	Centre for Natural Material Innovation Cambridge University	Cambridge, The United Kingdom	Leading material researchers, specialists in timber design. Position themselves as forward-thinkers advocating the use of wood	Plenty of opportunities for absorbing UUT through engineered wood products. Limitations would be the processing/handling and budget.

<i>Role/Activity</i>	<i>Organisation/Facility</i>	<i>Region/Country</i>	<i>About</i>	<i>Takeaways</i>
	Civil Engineering Department Cambridge University	Cambridge, The United Kingdom	Department of Civil Engineering, which collaborates with Natural Material Innovation for timber design research	How can market perception and desires shape the uptake of UUT? UUT has value, it just hasn't been identified yet.
	Cambridge Mosque	Cambridge, The United Kingdom	Building example	Mass timber example, Timber design and manufactured by The Lehmann Group
	Eurban	London, The United Kingdom	Design & construct/engineers; integrated supply chain partner	Education is vital for reform. High importance for UUT built examples, prototype or in a broader project to act as an exemplar.
	Waugh Thisleton Architects WTA	London, The United Kingdom	Architectural firm; experienced with MTC	The area of procurement an important consideration for any potential UUT. Given the inhomogeneous nature, critical to inform designers and end users of growth and processing characteristics of UUT.
   	Hooke Park, Architectural Association AA	Hooke, The United Kingdom	Architectural Association satellite campus. The site acts as a wood supply chain for the students and a broader community of Dorset	UUT examples in the form of buildings, art pieces and furniture design. Importance of instilling a different mindset and philosophy in how the material is consumed.
  	Timber Strategies	Dartington, The United Kingdom	Timber consultancy working across the supply chain with all parties.	Spoke of the need for the timber industry to be looking towards other fields for influence. Production will need to diversify in terms of wood species being utilised and be adapt for change.

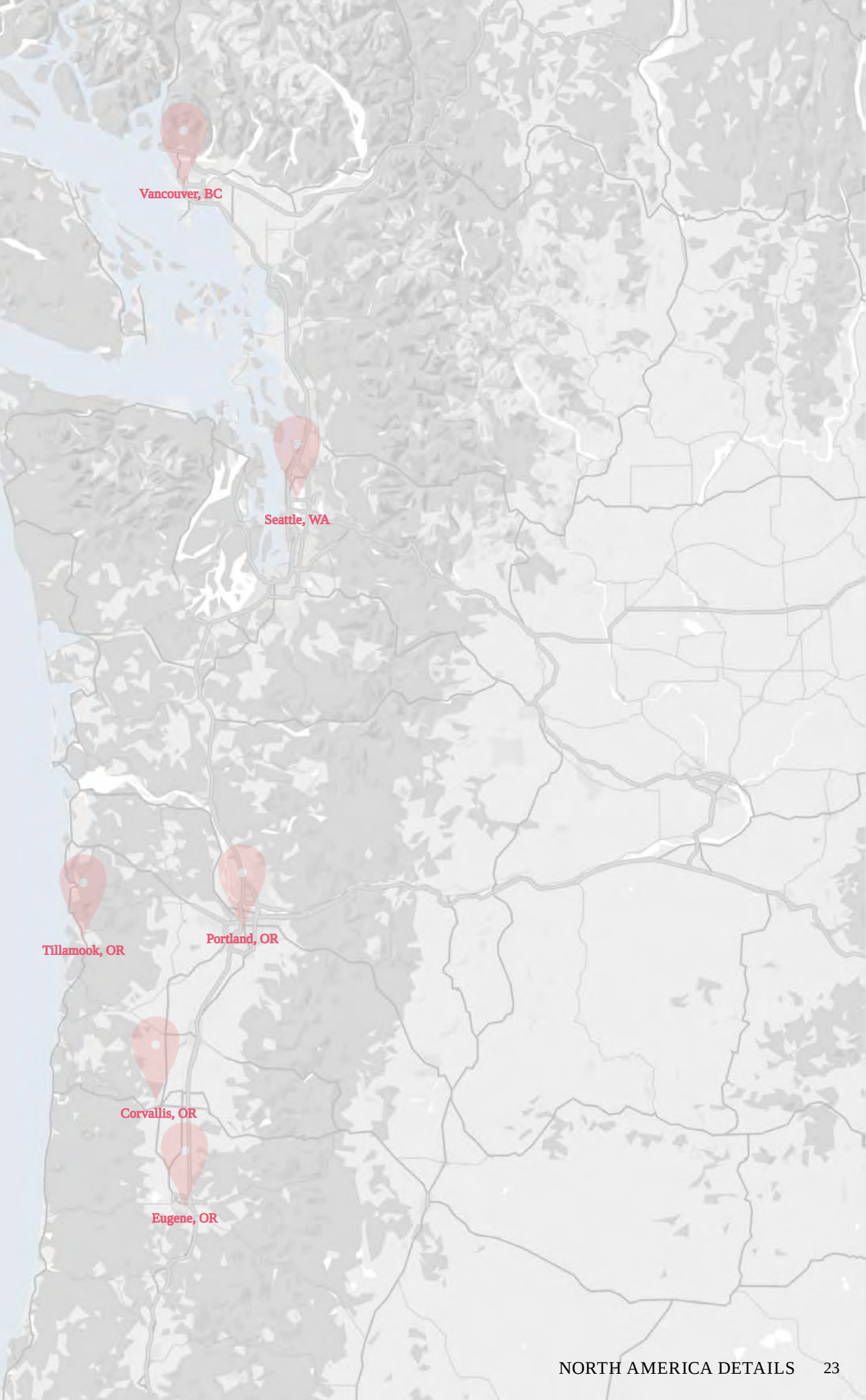
NORTH AMERICA

BACKGROUND

The North America section of the trip commenced in the United States of America in the North-West States of Oregon and Washington, and concluded in British Columbia, Canada. The regions visited are, historically and presently, heavily invested in timber processing. The milling sector in the North-West contributes to the largest market in the world for traditional wood-framed buildings. In this region, there is significant research and excitement for MTC in the built environment because the interest in wood is significant. Advancing technologies coupled with wood’s environmental credentials and the ability for off-site fabrication, is another factor resulting in more projects.

During this leg of the trip, over thirty meetings took place with forest estates owners, sawmill and manufacture operatives, service providers, designers, educators, and researchers. These meetings provided an insight to each facility’s role within the timber product supply chain, their respective backgrounds, and their experience dealing with UUT.

FIGURE 8: NORTH AMERICA
DESTINATIONS, (MILLS, 2019)



OREGON, USA

In Corvallis, Oregon, the Tallwood Design Institute (TDI) is connecting, collaborating, and researching with various stakeholders across the supply chain with a focus on advanced structural timber outputs (Dalheim, 2019). TDI is a collaboration between Oregon State University's College of Forestry and Engineering, in Corvallis, and The University of Oregon's College of Design, in Eugene. The A.A. Red Emmerson Advanced Wood Products Laboratory, as seen in Figures 11 and 12, where TDI is based, exemplifies this collaboration and forms part of Oregon State University's wider program, hosted in their Oregon Forest Science Complex. This dedicated timber research centre is constructed and designed with a local product, mass plywood panels (MPP) produced by Freres Lumber Co.

MPP is a new product for the timber industry in Oregon and, through ongoing research and development, is being marketed for the built environment as an alternate, and competent, mass timber product (Freres Lumber Co., 2020). The advantage of MPP is that it doesn't suffer from differential shrinkage, cracking, and movement within the panel, a common problem with other engineered wood products (EWP). The trade-off though, is that the amount of adhesive used to form a panel is significantly higher compared with other EWPs. A Portland-based architectural design practice, LEVER, has conducted experiments with Freres and TDI looking into linear expansion with panels. While product refinement is still ongoing, MPP has recently been approved for construction projects of up to 18-stories in the Oregon Area (Zeiba, 2019).

The Oregon State University (OSU) College of Forestry is considered to be world leaders in the field of wood science and forestry. The recent expansion of the college has seen the development and construction of another MTC project in the redevelopment of the College of Forestry, shown in Figures 13 and 14. Designed by Michael Green Architects and StructureCraft, the project sourced locally produced CLT panels which were manufactured South of Corvallis by DR Johnson Wood Innovations.

A research project from OSU's College of Forestry is providing outlets for salvaged timber with EWPs, in the form of cross laminated timber (CLT) and glulam products. Raphael E. Arbalaez recently tested the opportunities for upcycling salvaged beams into CLT in his Master's [Thesis](#) (Arbalaez, 2020), supervised by Dr Laurence Schimleck. By establishing a potential supply of salvaged timber for CLT, testing was done

looking into the structural capacities of panels. The project arose from a City of Portland Metro mandate, which enforces the reuse of wood from buildings that are being demolished and over 100 years old. In the current market, this wood typically ends up being reused as woodchip or biofuel. However, the project team argued that the reclaimed wood is often of high structural integrity and offers unique aesthetic characteristics.

The OSU's CLT product, shares similarities with other potential UUT products in that there are added costs associated with handling and processing the resource. This body of work forms part of a growing movement in the North-West, looking at the opportunities for the reuse of salvaged timber. At TDI and OSU, all meetings' participants spoke positively, and eagerly for the potential and benefit for using resource like UUT. Local examples of wood resources such as Juniper and Ponderosa Pine or Poplar were mentioned, that are underutilised in the Oregon and California contexts. Participants suggested that these species of wood act as fuel for the summer fires, which are causing significant damage to the Western States in the summer months. Both TDI and OSU professors suggested that using underutilised tree species for standardised, prefabricated, no-load bearing building products could have benefits for construction. For instance, it would help reduce the amount of fuel in fire-prone regions, provide new forms of employment, and assist in meeting the demand of mass timber products for developments such as those being proposed by [Katerra](#) or Airbnb's [Samara](#). Additionally, there are similar [projects](#), funded by the likes of Apple, Facebook, Google and Microsoft, aiming at addressing housing affordability and homelessness are other potential markets for UUT resources (Wilson, 2020).

Another area of research at the College of Forestry is on Swiss Needle Cast (SNC). SNC is a native fungal disease affecting the growth of Douglas Fir trees in certain areas of Oregon, and across the world. The disease causes premature needle loss and, ultimately, a thinning of the crowns of the trees. SNC is typically found in Fir on the Western region of Oregon, in areas which have higher rainfall and milder winters (Shaw, 2008). While the fungal pathogen is of concern to foresters, it has been known since the 20th century. It typically comes in 30-year waves (Withrowb, 2015).

Both research examples of underutilised forest resource and SNC disease highlight the importance of being able to rapidly identify and measure wood properties. Increasingly, systems that monitor and capture relevant



FIGURE 9: OSU CORVALLIS (MILLS, 2019)



FIGURE 10: OSU CORVALLIS (MILLS, 2019)



FIGURE 11: TDI (MILLS, 2019)



FIGURE 12: TDI (MILLS, 2019)



FIGURE 13: PEAVY HALL (MILLS, 2019)



FIGURE 14: PEAVY HALL (MILLS, 2019)



FIGURE 16: WEYERHAEUSER SAWMILL SANTIAM (MILLS, 2019)



FIGURE 15: WEYERHAEUSER SAWMILL SANTIAM (MILLS, 2019)



FIGURE 17: WEYERHAEUSER SAWMILL SANTIAM (MILLS, 2019)



FIGURE 18: WEYERHAEUSER SAWMILL SANTIAM (MILLS, 2019)



FIGURE 20: WEYERHAEUSER SAWMILL SANTIAM (MILLS, 2019)



FIGURE 19: WEYERHAEUSER SAWMILL SANTIAM (MILLS, 2019)



FIGURE 21: WEYERHAEUSER SAWMILL SANTIAM (MILLS, 2019)

tree data are evolving, and technology is becoming more accessible and enabling faster processing time. Light detection and ranging (LiDAR) scanning enables foresters, millers, designers, and end-users opportunities to scan and identify growth characteristics, along with potential resource issues of a tree before felling. This process means that the resource can be matched to end applications based upon its inherent characteristics before felling, which will ultimately assist in minimising resource marginalisation.

At the University of Oregon (UO), in the College of Design, architectural studios that have a mass timber focus have a high level of exposure to surrounding industry partners and the supply chain in general. The studios enable design students to learn of timber products and mass timber structures while providing examples of feasibility for the broader community of Oregon and beyond (TDI, 2020). Projects explored in the studio format have resulted in several real-world proposals being conceptualised and constructed. Lane County Courthouse [Studio](#), Hayward Field West Grandstands [Studio](#), and Glenwood Parking Garage

[Studio](#) were all projects which have resulted in direct uptake within the community. The showcasing of the students work through booklets provided extensive exposure not only of the students' body of work and skillset but also of the projects and ideas of mass timber. The Glenwood CLT parking garage was initiated as university architectural studio project and received a great deal of exposure from the community throughout the semester, and helped instigate a collaborative project between SRG Partnership as the architects (SRG Partnership, 2020).

While travelling through the area of Corvallis and Eugene, visits were arranged to several manufacturers and machinist specialists. Weyerhaeuser in Santiam Oregon provided a full tour of the mill and discussed operations and their procedures regarding UUT. The mill operates and utilises their own forests, maximising efficiency and profit per acre. Other sawmills and manufacturing plants of Weyerhaeuser produce EWPs, the one in Santiam, however, primarily focuses on board and plank products for home improvements outlet Home Depot. The resource processed at Santiam is typically Douglas

Fir, which is run through a highly automated plant, as seen in Figures 15 to 21. Participants explained that the Douglas Fir strand cycle is in the order of 50-70 years, which produces characteristically stable wood, allowing for processing while still green. A structural product extract of 90% or higher per log is typical for the mill. The remaining UUT resource that is generated, typically ends up as one of the following: (i) short length boards that are bought up by a local roof frame manufacturer for truss products, (ii) chipped for strand products, (iii) pellets for biofuel, (iv) or firewood. While the structural product extraction rate is considerably higher than that of softwood mills in Australia, the pathways for UUT share some similarities to the Australian supply chain.

Lucidyne Technologies is another leader in the industry who provided a tour and showcased their work undertaken at the Corvallis office and workshop. The team presented the applications of their services and ways in which they add value along the sawmilling process; a standout example was their scanning technologies. Using this equipment, growth

and processing characteristics can be identified and grouped accordingly for their suitable application. On a pack of boards, processes can pinpoint a board which may have UUT characteristics and highlight the end product suitability for EWPs, such as CLT, DLT, NLT, and Glulam. In discussing potential UUT uptake, participants pointed out that one major limitation is in sorting and distributing the boards. Traditionally, there is perhaps three or four different structural and one non-structural grade at a sawmill. Each different grade requires its own number of feedstock bins; the more bins you have, the more floor space and processing line is needed. The interviewees suggested that the costs associated with having more bins, with sorting UUT boards in the current market, may not add value for millers. Opportunities lie through the modification of existing products or the development of novel EWPs, which can either finger joint together UUT boards and planks or be chipped and reassembled through adhesives. The process and assembly require modification, though, and what could initiate this remains to be seen.

Following the time spent in central Oregon, the



FIGURE 22: CUT MY TIMBER, PORTLAND, (MILLS, 2019)



FIGURE 23: CUT MY TIMBER, PORTLAND, (MILLS, 2019)



FIGURE 24: CUT MY TIMBER, PORTLAND, (MILLS, 2019)



FIGURE 25: CUT MY TIMBER, PORTLAND, (MILLS, 2019)

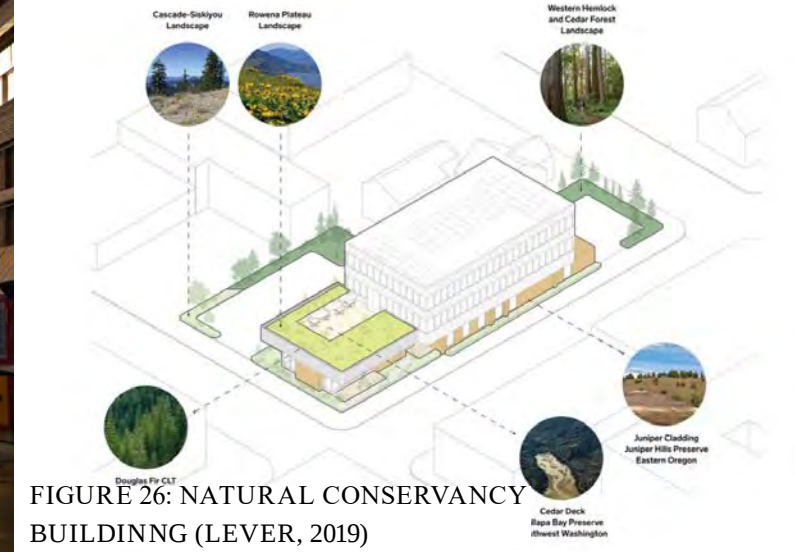


FIGURE 26: NATURAL CONSERVANCY BUILDING (LEVER, 2019)



FIGURE 27: NATURAL CONSERVANCY BUILDING (MILLS, 2019)



FIGURE 28: MTC SITE, PORTLAND (MILLS, 2019)



FIGURE 29: MTC SITE, SEATTLE (MILLS, 2019)

travel continued North to Portland city, where visits were arranged with leading architecture firms and advanced manufacturers. Also, some exemplar buildings were visited and documented.

Cut My Timber (CMT) are an advanced timber manufacturer situated just North-West of Portland City, based in a converted timber framed Tram shed. CMT's setup, shown in Figures 22 to 25, has two Hundegger machines, a K2 beam processor, and a Speed-Cut version. They fabricate using high-grade wood from Douglas-Fir, Western Red Cedar, and Alaskan Yellow Cedar. The process adds value to the wood resource through advanced machining and creating highly detailed, and often, highly complex geometry. CMT showed enthusiasm for working with UUT and expected that with an evolving climactic situation, UUT resource will have to be used in higher volume moving forward. The limiting factor is the current market demand and values associated with UUT and UT make it hard for CMT to justify using UUT. Other limitations for UUT are the technical aspects of processing the wood resource. Machinery is reliant on true form and size and operates best

processing straight pieces. If the board is not linear, the laser eye will not read the board correctly, impacting the roller feed which, subsequently, will not supply the wood correctly. The way wood is classified based on defects was a topic raised in the interviews at CMT. They suggested that grading should occur in three forms: (i) structural, (ii) visual, and (iii) form and truth to form. Doing so, they argued, would enable additional pathways for UUT to be absorbed into the advanced manufacturing of products.

SRG Partnership and LEVER architects in Portland were met with following CMT. Both offices were toured, where examples of the firms' works were showcased and discussed. SRG Partnership positions themselves as timber advocates and prides themselves on having an inventive outlook. Glenwood parking Garage [project](#)—a collaborative outcome with the Mass Timber studios at the University of Oregon—was a project which implemented post-tensioned mass CLT shear walls. An interesting aspect to this is that it's a multi-level, open-air car park constructed out of mass timber - believed to be the first for North America. SRG Partnership collaborated with the

Energy Studies in Buildings Lab at UO to analyse the climatic situations the building would face. The analysis led to a steel frame solution that provides a two and a half meter overhang ensuring cover for the perimeter mass timber columns.

LEVER Architecture highlighted their use of UUT in façade treatments on numerous projects. Juniper Pine, considered an invasive species, which is found in the Rockies and Easter Oregon, was specified and up-marketed as cladding for the Natural Conservancy building, as shown in Figures 26 and 27. Further, Poplar Pacific Albus was implemented on the Union Way walkway project, utilising a resource from an FSC-certified plantation in Oregon (Collins wood, 2015). Both examples highlighted the importance of ascertaining the appearance qualities of the products before specification. Participants noted that a designer can add value to UUT; however, it is ultimately dependent on the project's requirements and the outlooks of the client undertaking the development. It, therefore, becomes critical to be able to convey how the product will perform, react, and add or subtract to areas of the building. Being able to specify a product

on its properties is vitally important, a situation which creates difficulties when it comes to UUT as the resource is often inhomogeneous. As shown by both sets of architects, well thought out planning can circumvent these issues.

In addition to the mass timber projects visited in Portland, a historic exemplar was seen in Tillamook, on the Western seaboard of Oregon. Tillamook Hangar B, now the Tillamook Air Museum, is referred to as the largest clear-span wood structure in the world (Robinson, 2020). As pictured in Figures 30 to 33, the building was originally one of two hangars built in Tillamook during World War II, originally as blimp hangars. Hangar A, which burnt down in the early 1990s, was built in under 30 days. The vast and impressive structure showcases the possibilities for short-length truss work. The building now operates as a sawmill, in addition to an air museum.



FIGURE 30: AIR MUSEUM, TILLAMOOK (MILLS, 2019)



FIGURE 31: AIR MUSEUM, TILLAMOOK (MILLS, 2019)



FIGURE 34: PARADISE INN BUILDING, MT RAINER, (MILLS, 2019)



FIGURE 32: AIR MUSEUM, TILLAMOOK (MILLS, 2019)



FIGURE 33: AIR MUSEUM, TILLAMOOK (MILLS, 2019)



FIGURE 35: PARADISE INN BUILDING, MT RAINER, (MILLS, 2019)



FIGURE 36: PARADISE INN BUILDING, MT RAINER, (MILLS, 2019)

WASHINGTON, USA

USNR, based in Woodland, just north of the Oregon border was visited first. USNR is one of the largest world-leading supplier of equipment and technologies for wood processing (USNR, 2020). Specialising in providing industrial machinery throughout the timber processing chain, USNR recently provided a turn-key package in setting up the Spokane CLT Factory for Kattera. One area discussed with members of their mass timber sales team was UUT absorption in the form of engineered timber. The United States has a large strand manufacturing sector; laminated strand lumber (LSL), structural composite lumber (SCL), parallel strand lumber (PSL), and oriented strand lumber (OSL), and it was noted in the visit that these products can absorb UUT when chipped (Weyerhaeuser, 2020). Similar to TDI in Oregon, USNR is exploring opportunities for prefabricated products which can absorb underutilised wood, through broken-down free fibre for mass-built assemblies for affordable housing projects.

USNR has worked with customers to process UUT resources before, and believe that this material can be utilised well in GLT or laminated beams. Beetle kill pine, or mountain pine beetle (MPB) also referred to as denim pine is a local type of wood resource which would fall into the UUT category. Extensive research has been undertaken looking at the possibilities for the use of this resource, and USNR collaborates with numerous manufacturers and universities in the region to trial new products and systems. In conjunction with Oregon State University, DR Johnson Wood Innovations and Collins Pine, there is work conducted looking at mixing blue stain with ponderosa pine as a CLT product.

For UUT board resource, participants suggested that by adjusting the layers of CLT, panels could have some absorption benefits. By layering up in odd or randomised sizes, this enables the use of shorter length boards and offcuts. A second area discussed was on advanced technologies and what they mean for the timber industry. With manufacturing becoming more accessible and automated, employment opportunities are changing and often reducing. The importance

of adapting the existing workforce for this change is a significant issue the timber industry will need to monitor moving into the age of MTC. How can digital fabrication and, more broadly, mass timber be inclusive to re-education, reskilling, or upskilling?

Miller Hull Partnership was visited next in Seattle, where local architect Glen Stellmacher. Glen trained at The University of Washington and at the Architectural Association's Hooke Park woodland campus shared his views. At the time of this visit, Stellmacher was researching sustainable forestry practices and novel forms of partnerships across the timber product supply chain with The University of Washington and Miller Hull Partnership. This body of work is looking at engaging designers with forestry and upscaling the use of whole wood as a mass building product. Glen spoke passionately that design and value stem from the triumvirate of economic, environmental, and social spheres. The concept of value is reflected by the association's designers, and end-users have with wood. Glen argued that wood in an architectural sense does not benefit from the same appreciation or cultural associations which have been invested

in other products.

An example was given of a pair of high-end American sneakers, which are highly valued not because of the manufacturing, processing costs, or quality, but instead, they are valued because the brand is recognised globally as being appropriate, cool, or as being the only option. In local clusters and regions, there is undoubtedly a sense of belonging or positive association with wood products as there is in Queensland, Australia with the typical Queensland House on stumps. However, Glen proposes that globally, timber is yet to have those associations, or indeed any other building product, which has the same drawbacks as the sneakers. New partnerships across the supply chain which value responsible use of resource and quality manufacturing will go some way to establishing modern timber appreciation.

Kattera was visited next in Seattle. Kattera is a vertically integrated company, that aims to optimise all areas of the building supply chain. In Spokane, Washington, Kattera now has the world's largest CLT manufacturing plant, able to produce over 11 million



FIGURE 37: CLT MANUFACTURING PLANT SPOKANE KATERRA, (DEWIT, 2019)



FIGURE 38: CLT MANUFACTURING PLANT SPOKANE KATERRA, (DEWIT, 2019)



FIGURE 39: CATALYST BUILDING SECTION PERSPECTIVE, (KATERRA, 2020)

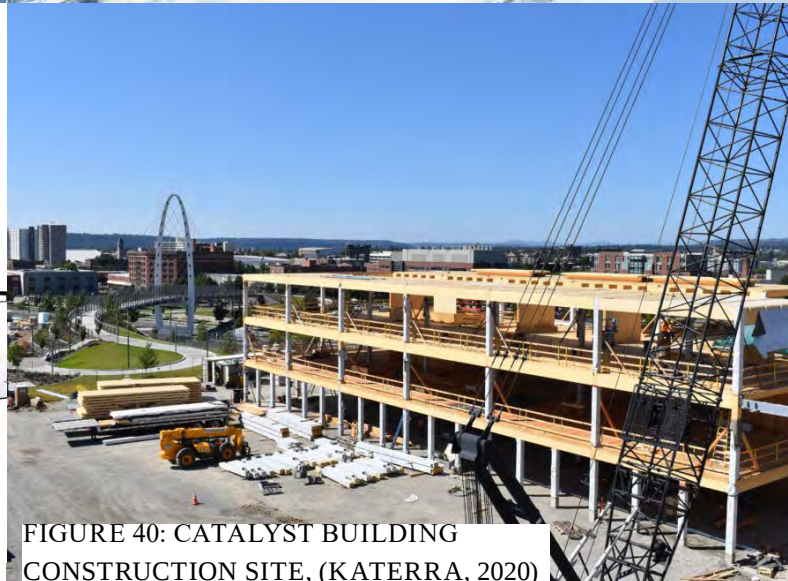


FIGURE 40: CATALYST BUILDING CONSTRUCTION SITE, (KATERRA, 2020)



FIGURE 42: MT RAINER NATURE RESERVE (MILLS, 2019)



FIGURE 41: KELLER CENTER CHICAGO, (FARR, 2019)



FIGURE 43: SEATTLE PUBLIC LIBRARY (MILLS, 2019)

square feet of CLT per year (Katerra, 2019). Their state-of-the-art factory, shown in Figures 37 and 38, gives Katerra the ability to manage demand for material on their own developments, as well as act in a broader capacity for the North West and abroad as a material supplier. Katerra has recently opened up the Catalyst building, which has been built using a specialised rib CLT panel structure, as seen in Figures 39 and 40 (Katerra, 2020).

At Katerra's Headquarters, interviews were undertaken with both a senior engineer and project lead architect. Both suggested that absorbing UUT through EWP's like CLT can become, and should be the norm. By having low strength boards in the middle lamella, CLT panels can begin to incorporate higher levels of UUT. Already in the US, there is a market for low-grade CLT panels for vehicular access mats, which are typically used on mining sites for heavy-machinery access. An area raised in the meetings with Katerra was the fact that timber has such a rich and diverse timber history in the North West. Communication of this story and the role timber can play going forward is essential. Transparency along the supply chain was another aspect raised which could benefit from improvement. It is difficult at present to say accurately where the timber product originate, which plantation stand or tree the wood came from. The interviewees believed that it will be a valuable marketing tool to know where the wood resource actually comes from. Designers and ultimately specifiers struggle to communicate the full carbon footprint of a product if there is no information on where the product originated. This information was deemed vital for providing an accurate picture to a potential client or end-user.

BRITISH COLUMBIA, CANADA

Katerra's views were echoed at Michael Green Architecture (MGA), in Vancouver of British Columbia. MGA is a leading mass timber architecture firm advocating for tall timber buildings, who became a part of the Katerra Partnership in 2019. This relationship aims to form part of a growing movement to make timber buildings beautiful, simple, and repeatable. Paul McBride of MGA was interviewed and spoke of this drive that ultimately intends to initiate change throughout the entire industry.

The topic of supply chain transparency was also of

high importance for MGA. High value is placed on the ability to purchase and specify sustainably sourced timber products which are FSC rated. Currently, the FSC rated timber that MGA specifies comes from local and international suppliers. The carbon dioxide (CO₂) footprint associated with importing and selecting these products is somewhat unclear. Limiting factors arise when attempting to specify local wood products are their scale, and the fact that local plantations are often not FSC rated. This situation usually results in a foreign imported product being selected to meet environmental criteria. This was described as an ever increasing issue, wherein local products are better suited for all the other specification criteria.

The nature of finding contractors that are willing to cost and install novel products can be challenging, requiring a lot of time and coordination. Specifiers generally stick to tried and tested existing EWPs, such as CLT, NLT, and BCLT (Blue Cross Laminated Timber). The general consensus espoused by MGA is that it would take a unique project, or indeed built examples, for industry uptake of new, locally produced, UUT products. Paul spoke of having built UUT prototypes as a way to provide specifiers and end-users a chance to see what the product looks, feels, and even smells like.

The Keller Centre was mentioned as an example at the University of Chicago. The building showcases the use of locally sourced materials and was refurbished utilising a locally-sourced ash tree which was felled due to emerald ash borer damage (Chicago Botanic Garden, 2020). The renovation saw the use of the ash wood in the central auditorium and staircase, bringing a warm honey-like tone to the 1960's limestone-clad concrete structure, as seen in Figure 41. Renowned Chicago artist, Theaster Gates initiated the reclaiming of the ash trees, which were donated to the project from local authorities in Chicago. Through a grant funded scheme, a local mill was purchased and used to process the logs (Bertagnoli, 2019).

Another company visited in Canada was Intelligent City, in Vancouver. They specify and use timber products for the built environment, and design the manufacturing and processes for an assembly of timber products produced for MTC. Oliver David Krieg, formerly of ICD in Stuttgart, Germany and now with Intelligent City as Chief Technology Officer, discussed the firm's projects and current research streams. At the time of this visit, the firm was looking into novel manufacturing processes for working with timber materials. Intelligent City works with



FIGURE 44: SEATTLE WATERFRONT (MILLS, 2019)



FIGURE 45: CHOPVALUE ENGINEER RECYCLED CHOPSTICKS, (CHOPVALUE, 2019)



FIGURE 46: CITIES OF THE FUTURE, MASS TIMBER VANCOUVER (INTELLIGENT CITY, 2019)



FIGURE 47: RICHMOND OLYMPIC OVAL STRUCTURE, (MILLS, 2019)



FIGURE 48: RICHMOND OLYMPIC OVAL STRUCTURE, (MILLS, 2019)



FIGURE 49: RICHMOND OLYMPIC OVAL STRUCTURE, (MILLS, 2019)

high grade, high-value wood. Oliver spoke of the importance of marketing to consumers, to provide a greater understanding of how UUT products function, alongside having standardised properties to generate a workable level of demand. Incremental innovation was suggested as a possible method for UUT uptake. The process allows for a series of improvements to existing EWPs such as CLT or glulam. In the case of novel UUT systems, having a product that resembles an existing UT product but is made from UUT, is considered a valuable and marketable aspect. To create products using UUT, that is cheaper to acquire and manufacture, but ultimately does not impact the end-use or aesthetical characteristics was described as an ideal outcome.

ChopValue, a local company, collects old chopsticks and create glue laminated chopstick plywood bamboo material, shown in Figure 45 (ChopValue, 2020). The result is a product made from upcycled chopsticks used to create homeware and décor products. The company is expanding, with multiple outlets opening across North America. Echoing MGA, Oliver argued that, for UUT success, there needed to be examples, built forms, to show off the possible aesthetics and structural capabilities. Once this occurs, he suggested that it will be an easier task convincing designers to engage with a product and generate more acceptance for the merits of UUT.

Equilibrium, another company who are part of the Kattera group, are an engineering consultancy firm involved with timber design based in Vancouver. The firm has recently shifted away from only providing structure and engineering services to being heavily involved in timber prefabrication with Kattera. Equilibrium is now developing new products and producing incremental innovation of existing ones to streamline and standardise product manufacturing, and to create a more efficient construction industry.

For Equilibrium, the opportunities for UUT are with EWPs and the mass timber movement, particularly CLT. As long as the CLT panel is one-way spanning, it is an effective UUT absorber. The external fibres can be specified as UT, but the internal lamellas can be UUT. Johannes Schneider of Equilibrium noted that this was the original intention for CLT. To select UT, high stiffness lamellas in situations where it's not structurally required is wasteful. If UUT were to be included in CLT products, there are potential savings in costs and resource volume. Other opportunities for UUT exist with DLT, which is quite common in British Columbia and Canada. Wood fibre insulation

was also mentioned as another suitable application for UUT, and one which has quite a large market in Europe.

A regional example of underutilised tree species was raised, where Birchwood was selected for a mass timber project. This project was a collaboration between the designers, the architect and engineer, and sawmill, partnering up to get the community involved in milling the Birchwood. This was of great benefit to the local community who, at the time, was suffering from high levels of unemployment. Johannes suggested that this example shows how non-traditional partnerships allow instigation for working with UUT. In a conventional framework, code and regulation are very stringent. They can often be very limiting for novel products and systems. The engineer has to stamp and make sure the project and products comply with the given standards. Legislation, he argued, and possibly grading needs to adapt if UUT is going to be used in a greater capacity. Millers and manufacturers need to come together and acknowledge there is a serious quantity of UUT being produced. There are higher-value uses that it can be utilised for aside from burning which releases the sequestered CO2 back into the air or exporting overseas. Johannes posed the questions, do new grades need to be even created? Or is reengineering to develop new product a necessity?

Following Equilibrium, Fast & Epp Engineers were visited. Fast & Epp, who were attached with Structurecraft until recent years, are similar to Equilibrium in that they are leading timber engineers who work throughout North America and around the world. Grandview Pool and the Mannheim Renewal are some recent exemplar projects the firm has been involved in. Carla Dickof, who is a senior engineer with Fast & Epp participated in an interview. Carla talked about the work the firm has done with UUT. Resource like beetle-killed wood was one example, where it was quite successfully turned in numerous products both structurally and non-structurally with market acceptance. Richmond Olympic Oval was given as an example which used beetle-killed wood, as seen in Figures 47 to 49. The wood was used in both structural and non-structural capacities and represents UUT being used in high exposure public amenity building. Carla spoke of the high level of excitement when the blue stain beetlekilled wood was incorporated into products and first marketed to designers. It posed something quite unique for MTC. Research showed that blue staining mountain pine was purely an aesthetic change and did not impact the structural properties of the wood. Subsequently,



FIGURE 50: WANDER WOOD PAVILION
UBC, (MEYBOOM ET AL., 2018)



FIGURE 51: WANDER WOOD PAVILION
UBC, (MEYBOOM ET AL., 2018)



FIGURE 56: COLLEGE OF
FORESTRY UBC, (MILLS, 2019)



FIGURES 52, 53, 54 & 55: HILO LAB
ZIPPERED WOOD PROJECT (SALA 2019)

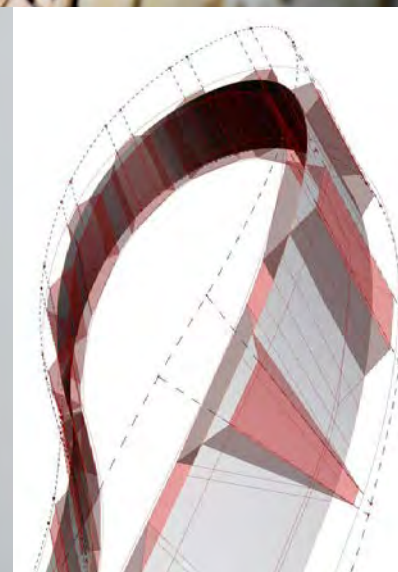


FIGURE 57: THE LONG HOUSE
UBC, (MILLS, 2019)



FIGURE 58: COLLEGE OF
FORESTRY UBC, (MILLS, 2019)

blue-stained mountain pine has seen uptake for CLT and other engineered wood systems.

At the University of British Columbia (UBC) campus, multiple faculties and research groups were interviewed, and the facilities toured. Numerous timber pavilions are scattered around the campus, which provides good exposure for the different timber research and design for groups. One pavilion viewed was the third annual Wander Wood Pavilion. The structure was created between UBC's School of Architecture and Landscape Architecture (SALA), Centre for Advanced Wood Processing (CAWP) and Intelligent City during the Robot Made workshop build. Shown in Figures 50 and 51, the project was led by Professor David Correa of University of Waterloo, Associate Professor AnnaLisa Meyboom of SALA, and Oliver David Kreig of Intelligent City. The pavilion is a latticed and curving timber structure that consists of totally unique pieces of wood. Fabrication was done using CNC and multi-axis robotic equipment and constructed over three days. The project attempts to show students the opportunities for integrating

digital and physical fabrication strategies in their approach to design (Gibson, 2018).

The [HILO Lab](#) was visited next, which is run by Associate Professor and Chair, Architecture Blair Satterfield, and associated with SALA. The group is interested in timber as a waste stream generated by the construction industry and is doing research into upcycling and repurposing this waste and extending the life of the wood. They aim to make their repurposing and redeployment more responsible and meaningful, rather than just consuming the resource. This design ethic is portrayed elegantly in the Zippered Wood project, shown in Figures 52 to 55. The project tackles the abundant and growing quantity of wood being wasted by Vancouver and the wider British Columbia construction sector (Burry et al., 2020). Timber boards typically of 2x4 (50x100mm) dimension were strategically designed and cut in specific sections, and paired with mate boards to generate bent and curved geometry. The project upcycles timber offcuts into curved, long column and beam structures (SALA UBC, 2018).

The concept of the Zippered Wood project shows ways in which advancing technologies and fabrication methods can be designed to be inclusive and accessible in nature. The team behind the project believes that by flattening access to the digital workflows, access to tools, fabrication, and ideas can come readily. This was an interesting theme from the group, and one in which was spoken similarly across the region. How can advancing technologies and fabrication methods be accessible on mass? And shows research opening up and providing opportunities which were not available a decade or more ago.

FPInnovations, a not-for-profit forest research group assisting the Canadian forest industry was visited following the HILO Lab. Researchers explained that the region of British Columbia is divided into coastal and internal regional areas where the primary of forestry milling occurs. The coastal areas are made up of mills that are dated, and with little investment, while the internal regions are made up of state-of-the-art mills. In British Columbia, transport can often mean shipping raw logs quite a long way from one

facility to another, making for prohibitive costs.

At the time of visiting Vancouver, interview participants explained that a lot of mills in British Columbia were operating at a loss, and either had to close down or were forecasting to shut down. This was due to many reasons as such ongoing drops in timber prices, wood supply running tight, bug attacks, US import duties, stumpage rates, and transportations costs rising. Since then, in March 2020, the World Health Organisation declared COVID-19 a pandemic, which has resulted in North America experiencing record-high prices for dimension timber. While the export market to the US is still down, mills are in a far better financial position.

The type of wood species milled and manufactured in British Columbia are commonly Spruce Pine Fir (SPF). SPF typically is a mix of species like White, Black, Red, and Engelmann Spruces, Balsam Fir, Jack, and Lodgepole Pine (WoodSolutions, 2020). The strength factor in SPF has been dropping and species evolving with more Balsam Fir and less of the

Ponderosa and Lodgepole Pines. The coastal region processes mainly Western Red Cedar, Douglas Fir and Hemlock. Western Hemlock is considered a high commodity resource, that often is exported to the Asian markets such as Japan and China.

SUMMARY

These different species result in different structural product extracts. In the North-West regions, there are different EWP’s alongside a larger fingerjointing of short length boards which absorb UUT volume. MPP, D LT and NLT were EWP’s which could have a direct benefit in absorbing UUT for the Australian context. The Historical example of Tillamook Hanger shows a terrific exemplar of what can be achieved with short length pieces of timber, in an incredibly short amount of time. The Tillamook hanger shares similarities, albeit on a much smaller scale with some of the aircraft hangers scattered around the city of Brisbane, Australia. At a similar time during World War II, a series of aircraft shelters were built in a matter of days with short length pieces of timber, and the structures are still standing and operating nearly 80 years later. UUT often has a portion of boards which is structurally high grade and stable. These areas can be extracted and either finger-jointed for use in EWPs or used in board format to create framing and truss structures similar to those found in the aircraft hangers.

Another takeaway from North America was the disconnect and fragmentation across the supply chain. Similar to Australia, and aside from a handful of firms, designers are generally not engaged with the sawmills and forestry at the beginning of the supply chain, and vice versa. Concerns were raised regularly about the gap in knowledge of what it means to be sustainable in manufacturing products. This is with both in certified forests, and knowing where the material comes from in the first place. Right across the region there was enthusiasm for the prospects of UUT and recognition of the potential it represented with the coming demand for mass timber products in the built environment. The impact of climate change could easily mean higher rates of SNC and diseases effecting tree stock, resulting in lower quality of the wood resource. The need to think ahead and plan long-term for potential UUT products is paramount with changing environmental conditions.

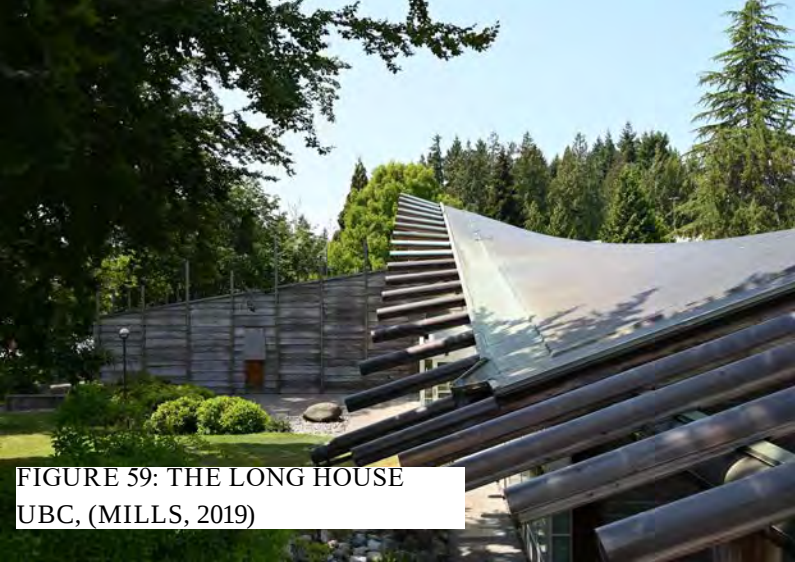


FIGURE 59: THE LONG HOUSE
UBC, (MILLS, 2019)



FIGURE 60: THE LONG HOUSE
UBC, (MILLS, 2019)



FIGURE 61: BROCK COMMONS
TALLWOOD HOUSE UBC, (MILLS, 2019)

EUROPE

BACKGROUND

Travelling over the Atlantic, the journey continued to Europe. Commencing in Copenhagen, Denmark, continuing onto Zurich and Gossau in Switzerland, Vienna, Althiem and Donau in Austria, Munich in Germany, and finishing in the UK. The research project for the Fellowship concluded with an intensive wood fabrication placement at the Architectural Association Hooke Park campus.

FIGURE 62: EUROPE
DESTINATIONS, (MILLS, 2019)



FIGURE 63: T3 BAYSIDE ILLUSTRATION, (3XN, 2019)



FIGURE 64: T3 BAYSIDE ILLUSTRATION, (3XN, 2019)

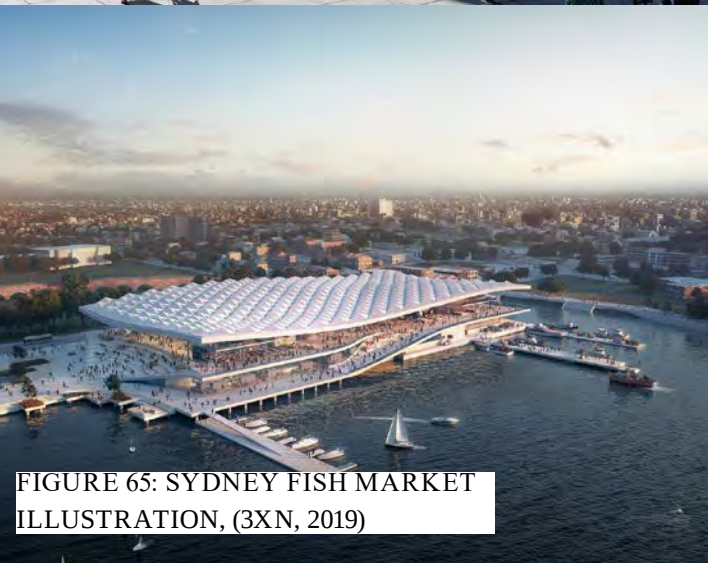


FIGURE 65: SYDNEY FISH MARKET ILLUSTRATION, (3XN, 2019)



FIGURE 66: SYDNEY FISH MARKET ILLUSTRATION, (3XN, 2019)

DENMARK

Copenhagen in Denmark is home some of the world leading designers delving into the idea of a circular future. A concept that encompasses design for disassembly and material passports for supply chain transparency, as the industry works towards the United Nations' 17 sustainable development goals (see Figure 71). Denmark, however, has very few timber buildings being constructed in the modern age. Similar to other European nations, which were all once covered with structures that incorporated timber design, Denmark has transitioned to masonry, stone, concrete, and steel construction materials, with timber becoming a minor resource for built environment use (Jensen, et al. 2019).

In recent years, as society moves towards environmental action and the use of renewable materials, timber has had something of a resurgence in the wider Scandinavian region. Timber in the form of engineered wood products, such as CLT, LVL, and Glulam are being specified and attracting more significant interest. Mjøstårnet in Norway (Block, 2019), the world's tallest timber building, and Kajstaden in Sweden (Walsh, 2019), are recent examples. However, legislation, logistics, and end-user desire mean that mass timber buildings as a norm are still some way off in the region. Internationally, this is a different story, with Denmark based architects like 3XN and C. F. Møller Architects being responsible for several timber-based designs in Scandinavia, the UK, North America, and Australia.

One of the many exemplary buildings visited whilst in Copenhagen was the Sports & Community Hall project completed in 2006 by architects Dorte Mandrup. The building was constructed with glulam beam and trusses and clad in polycarbonate, as seen in Figures 67 to 70. The figures show the use of warm, golden tones of timber structure popping against the green vinyl flooring, further highlighted by the filtered natural light from the polycarbonate utilised on the wall and roof. The use of these materials came together to create an affordable and sustainably produced project. The building has high community exposure and gives a great example of how timber, and indeed UUT products, could attract attention when used in community-based facilities.

The architectural firm 3XN, located in Copenhagen was visited. They have international offices scattered around the globe. At present, they have two notable international projects in T3 Bayside of Toronto, Canada, and the new Sydney Fish Markets done in conjunction with BVN in Australia, both being constructed with EWPs. The group has been evolving over three decades,



FIGURE 67: SPORTS & COMMUNITY HALL COPENHAGEN, (MILLS, 2019)



FIGURE 69: SPORTS & COMMUNITY HALL COPENHAGEN, (MILLS, 2019)



FIGURE 68: SPORTS & COMMUNITY HALL COPENHAGEN, (MILLS, 2019)



FIGURE 70: SPORTS & COMMUNITY HALL COPENHAGEN, (MILLS, 2019)



FIGURE 71: UN SUSTAINABLE DEVELOPMENT GOALS; ADAPTED (MILLS, 2019)

and places emphasis on people and innovation as part of the projects they undertake. Their research wing, GXN, comprises of a handful of staff researching and advocating for circular-future outcomes for the built environment.

Circular futures is a vision where waste is designed out, and the focus of construction turns to people and the environments. Circular future, as outlined in the publication “[Building a Circular Future](#)” by Kasper Guldager Jensen and John Sommer, 2018 encompasses design for disassembly, material passports, and a circular economy. Unpacking these terms: design for disassembly aims to make all joints visible, mechanical, dissolvable, similar, and common; material passports aim to establish functionality information at the component level; and with circular economy aims is to implement business models that support a sustainable future for the entire industry (Jensen, et al. 2019). GXN has experience in creating and implementing sustainable initiatives with resources, some utilised and underutilised.

The 3XN headquarters, situated in a series of retrofitted heritage-listed Cannon Boat Sheds, is an example of the circular agenda advocated by the company. Over-looking the waterfront, the open-plan office allows natural light to bring out the warmth of the exposed timber structure. GXN’s projects use a range of different materials, and the group has been looking into the opportunities allowed by new and novel designs. The [Circle House project](#) is designed as a scalable building solution by Lendager Group, Vandkunsten, and 3XN. The project aims for 90% of the materials used in the project to be recycled and reused without losing significant value. Marginalised and underutilised materials like reclaimed burnt wood, demountable clay tiles, cork panels, and plastic shingles are some of the façade treatments implemented. This innovation was inspired through research undertaken into resource scarcity and bases itself on the need to rethink the way society consumes and discards resources.

For UUT the role of any potential the product and the aesthetic presentation was raised as an essential consideration. Being able to control the way a UUT product performs structurally is one thing. How it looks, its sensory value, the feeling it emits, are just as important things to consider. This is especially a problem when designers may not be able to reliably specify the aesthetics of the product. How can designers provide accurate descriptions and portrayals of a resource which isn’t uniform and has changing

characteristics? The second factor raised was that any of the growth and processing characteristics which define UUT could quite easily be marketed as features and aesthetically important. Products like reclaimed wood and plastic shingles in the Circle House are an example of this process. An Australian example of this is the eucalyptus acoustic panel developed by the CSAW group with the University of Tasmania.

A third takeaway from the meeting was the concept of lunch n learns; the period during the week when designers meet with sales representatives. Novel products, systems and recommendations for specifications on projects are pitched. The role of learning, investigating, and researching products is often marginalised and not given the importance that it should. This was partially the basis for the establishment of GXN; to inform, innovate, and assist 3XN’s projects and the wider community, and ultimately beg the question, “what’s on the shelf?” The research wing GXN of 3XN is quite a common aspect for architecture firms in Denmark. Architectural firms usually have a research department, and indeed large offices have access to PhD students to research topics of benefit to the project and broader community. At KADK, The Royal Academy of Arts frequently competes and collaborates with firms on research; enabling the industry to research opportunities and collaboration with academia.



FIGURE 72: Inderhavnsbroen
Copenhagen, (Mills, 2019)



FIGURE 73: FACADE DETAIL 01
SWITZERLAND (MILLS, 2019)



FIGURE 74: FACADE DETAIL 02
SWITZERLAND (MILLS, 2019)



FIGURE 75: FACADE DETAIL 03
SWITZERLAND (MILLS, 2019)



FIGURE 76: FACADE DETAIL 04
SWITZERLAND (MILLS, 2019)



FIGURE 77: LAUSANNE BRIDGE
STRUCTURE DETAIL (MILLS, 2019)



FIGURE 78: TAMEDIA HOUSE
STRUCTURE DETAIL (MILLS, 2019)



FIGURE 79: CHASERRUGG
FACADE DETAIL, (MILLS, 2019)



FIGURE 80: ARCH_TECH_LAB
SEQUENTIAL ROOF (MILLS, 2019)

SWITZERLAND

The Grazmazio Kohler Research Lab at ETH, on the North-East of Zurich, Switzerland was the first place visited after Copenhagen. At the time, the Lab was conducting investigations into digital processes in manufacturing and the resulting implications for architectural design. Recent work from the Lab has resulted in complex geometry being produced, often achieved using inexpensive and often marginalised materials.

The Arch_Tech_Lab Sequential Roof, completed in 2017, highlights the potential for long-span roof trusses generated with digital and advanced fabrication processes, as seen in Figure 80. Over 160 single trusses make up the 2,300 square meters organic roof design produced with a robotic-assembly process, which analysed and selected from over 48,000 pieces of timber to form the trusses (Gramazio Kohler Research, 2016). This project is one of numerous from the Lab, which teams digital fabrication techniques with novel material

responsible practices.

The specialist researchers behind the Group's recent project, [Augmented Acoustics](#) were interviewed. They explained that the project utilises camera control units to help carpenters assemble bespoke acoustic timber walls. The cameras provide feedback and guide users to place the material in exact positions within the model (Gramazio Kohler Research, 2019). This accessibility, and flattened technology provides employment opportunities for operating advanced technologies for anyone.

Discussing the initiatives for UUT uptake, the importance of the material's tolerances was suggested. Grain direction and the fibre strength of a piece of wood, for instance, both play critical roles in the way digital processes analysed and fabricated the material in both the Augmented Acoustics and Sequential Roof projects.

Following my time in Zurich, the trip continued to Gossau, where the Lehmann Group's sawmill and other facilities were toured. The Lehmann family has



FIGURE 81: CHASERRUGG INTERNAL
PERSPECTIVE (MILLS, 2019)



FIGURE 82: CHASERRUGG INTERNAL
PERSPECTIVE (MILLS, 2019)

been associated with timber for more than 140 years and has grown into a group of three companies employing over 300 people. The first company is Blumer-Lehmann AG. A consultancy, design, product, erection and project management entity considered an internationally leading company for its digital production of freeform timber structures. The company collaborates with architects such as Herzog & de Meuron, Shigeru Ban Architects and Foster + Partners, to name a few. Recent projects like the [Chäserrugg building](#), as seen in Figures 79, 81, 82 and 86, and the [Kulum Eis Pavilion](#), in Figure 83, show some examples of the results of these collaborations.

The second company for the Group is Lehmann Holzwerk AG; the saw and planning mill operations. A state-of-the-art setup, the mill processes in the order of 110,000 cubic meters of logs annually and generates products such as dimensioned board and plank for structural framing, cladding, facades and floor elements. By-products are processed to pellets, animal litter, and briquettes. The biomass from the sawmill is enough to power the operations at the mill, in addition to powering electricity for a further 1,500 surrounding households.

The third company of the Group is BL Silobau AG; silo and construction specialists focusing on automation and modern conveyor technology for bespoke, and economical solutions for silo and grit storage.

In 2017-2018, the sawn wood market in Switzerland comprised of approximately 96% softwood, and 4% (FOEN Forest Division, 2019). It was with this context that The Lehmann Group spoke of the need for flexibility and adaptability, with the belief that these capacities will be critical to the success of any sawmill in the next 20-30 years. In Switzerland and, further, across Central Europe, manufacturers are faced with changing resource and qualities with softwoods. Ongoing uncertainty with climatic conditions, insect infestations such as beetle bark, and a general over-reliance on conifers are resulting in both renewed interest in opportunities for hardwoods. Millers and manufactures like The Lehmann Group, are looking at how they can absorb and make use of UUT resources through adhesive lamination techniques.

Over the last decade, the Group has become a leading manufacturer and supplier, collaborating



FIGURE 83: KULUM EISPAVILION
ST MORITZ; (YOUNG, 2017)



FIGURE 84: THE LEHMANN GROUP
SAWMILL GOSSAU (MILLS, 2019)

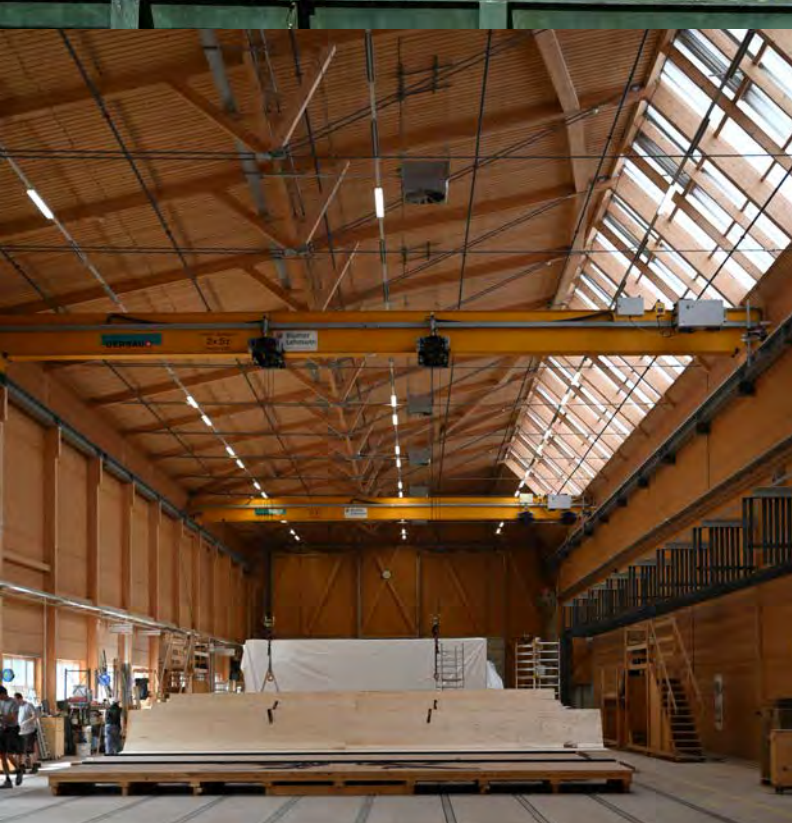


FIGURE 85: THE LEHMANN GROUP
SAWMILL GOSSAU (MILLS, 2019)



FIGURE 86: CHASERRUGG
PERSPECTIVE (MILLS, 2019)

with architectural firms across the world to produce engineered wood products. The Lehmann Group’s freeform division, displays an array of prototypes from previous and ongoing projects. The example of the [Urbach Tower](#) project was shown as a successful collaboration, done in conjunction with ICD and ITKE at the University of Stuttgart. The project looks at novel natural curvature techniques for self-shaping engineered wood panels. The approach takes advantage of the resource’s natural characteristics and provides terrific exposure for the properties of wood. This work was recently published in [Fabricate](#) Bury et al., 2020.



FIGURE 87: SWISS VERNACULAR
(MILLS, 2019)

AUSTRIA

The first visit in Austria was to the Technical University of Vienna, where meetings were held with researchers at the Department of Architecture and Sustainable Design and Planning (DASDP). Work is underway to bring timber construction back into cities in Austria. One project, such as DASDP's [Vivihouse](#) aims to use mass timber at bringing accessible, environmentally focused design to communities. Although Austria is a major timber manufacturer and supplier, most products are destined for export to other regions of European nations along with the UK, North America, Asia, and Oceania. Within Austria specifically, timber construction is still relatively small in comparison to other conventional construction materials. The Vivihouse project is attempt to remedy this by providing viable, adaptable, and sustainable alternatives for developments in cities, through the specific use of ecological materials (TU Vienna, 2020).

Stora Enso's Ybbs Sawmill was another placed visited in Northern Austria, in Donau. The sawmill produces board and plank product and has an advanced manufacturing wing to the facility which produces many EWPs, such as CLT and Glulam. The mill has a rough turnover of 550,000 m³ of sawn timber and 430,000 m³ of processed wood per year. Globally, Stora Enso has several other sawmills and additional processing units and produces other products such as pulp, paper, and packaging.

Stora Enso has two avenue streams for UUT. Primarily, UUT is exported to the Levant Market, i.e. North African and Middle Eastern countries, as well as to Asian countries. UUT is value-added through finger jointing, re-cutted, laminated or used as board or plank product for structural purposes. Often the structural grade requirements are not as stringent as in Europe. The second avenue is through EWP'S like CLT, GLT and KVH products.

EWP CLT was suggested as a quick way to initiate absorption of UUT product. Gernot Weiß, Head of the CLT Business Line for Stora Enso, gave a tour of the CLT facility and talked about UUT. Gernot pointed out that CLT was created within the region several decades ago to absorb UUT produced during the milling process. At the Stora Enso Ybbs facility, the sawmill operation is across the road to the EWP line, allowing for efficient operations to occur. Visits to many other sawmills and advanced manufacturing facilities have shown that timber often has to be transported some distance to be value-added. At Ybbs, value-adding operations

are a simple process, and the CLT manufactured by Stora Enso can absorb portions of UUT. Discolouration from beetle-infestation, knotty boards, minor wane and distortion are UUT characteristics that can be absorbed in EWPs, either as a feature or non-visible. A majority of CLT panels used are non-visual and are clad or wrapped in other third-party products. As was the case with advanced manufacturers in North America, however, labour and machining costs arise and can become a limiting aspect for dealing with UUT.

Another example of one product which utilises UUT was KVH. KVH absorbs larger pieces of UUT that have characteristics like knots. The knots are cut out, and the remaining board is finger-jointed together for use in solid wood products. In one method being trialled, UUT board and plank products are laminated like glulam. Disconnect in the supply chain between the harvesting and manufacturing phase was a concern raised during discussions at Stora Enso and were similar to the ones presented in discussions with The Lehmann Group. It is often difficult to obtain the full background information on where the logs are acquired. For the EWP line, knowing where the log is grown and how far it has been transported would be useful information to be able to convey to the client for a particular product.

Wiehag Gmbh, based in Altheim the North-West of Austria, were the last stop in Austria before Munich. Wiehag Gmbh is a group of facilities including, Timber Construction, Timber and Partner, and Industrial Construction, all located in the North-West of Austria. Wiehag Timber construction plant was toured with senior sales representative Markus Frixeder. Wiehag's work spans the globe, collaborating with leading architectural firms in producing highly resolved timber projects. The UK projects The Canary Wharf subway station, and the whiskey distillery The Macallan are some recent glulam projects supplied by Wiehag.

Wiehag, unlike the Ybbs setup of Stora Enso, is primarily an advanced manufacturer focused on EWP glulam. Being a glulam manufacturer of board and plank product, they typically use high to premium grade UT, which is purchased sawn and ready for manufacturing. In terms of UUT, small portions of wood are generated from offcuts in the manufacturing line. This resource is of high to premium grade but is typically small in quantity. At present, this quantity is being pushed towards pellets for bioenergy. There was previously a sawmill attached to the operations, which was destroyed in a fire. Prior to this though, the UUT produced during sawmill operations was being



FIGURE 88: STORA ENSO YBBS SAWMILL, (MILLS, 2019)

absorbed into glulam product. Markus believed that opportunity for absorbing UUT could be with both non-structural and structural GLT and laminated beams. At present, Wiehag does not have a market for this, but moving forward with an evolving and varying resource, this could change.

GERMANY

Munich, Germany was the final stop in Central Europe before heading across to the UK. At the Technical University of Munich (TUM), the Department of Architecture was visited and Professor Hermann Kaufmann and architect Sandra Schuster, who are also a part of [TUMwood](#) were interviewed. The group engages with the industry to identify pressing issues as well as foreseeable ones to create projects to solve them. In the field of research, TUMwood collaborates with industry, among others, to identify both urgent and foreseeable problems, intending to create projects to solve them.

TUMwood is researching several areas: ways for carbon sequestration through wood construction; novel opportunities for utilising hardwood; the reuse and upcycling of wood waste; and ultimately, optimising timber to keep it as a negative carbon emitter (TUMwood, 2020a). Professor Hermann Kaufmann's discussed he's latest publication "[Manual of Multi-Storey Timber Structures](#)", where several EWP's were suggested as UUT absorption methods. In particular, stapled load-bearing dowel laminated boards were an example of upscaling a UUT resource quite effectively in Europe, and essentially are a combination of an NLT and DLT product. There were similarities with the work being produced at TUMwood to that of in Denmark and the North-West of North America; the reuse of wood in terms of circularity, raising awareness for the opportunities for upcycling wood from demolished buildings; beetle-infested wood opportunities; hardwood resource opportunities in EWP's, among many others.

In Germany, one limiting factor prohibiting novel UUT products and other marginalised resources is the regulations and quality control placed on construction products. Having built and tested prototypes of UUT systems will assist in making UUT more accessible for industry use. While the policy may be challenging to overcome initially, there are industry accessible platforms available which help raise awareness of timber construction. Website [dataholz](#), provides a detailed list of products which have been approved and

are ready for specification and example applications. This level of accessible communication is a terrific exemplar of fixing fragmentation across the supply chain, especially of informing designers of a total understanding of timber design.



FIGURE 89: MUNICH
STREETSCAPE, (MILLS, 2019)



FIGURE 90: OLYMPIAPARK
MUNICH, (MILLS, 2019)



FIGURE 91: WOOD HUB PAVILION
(TUMWOOD, 2019)



FIGURE 92: WOOD HUB PAVILION
(TUMWOOD, 2019)

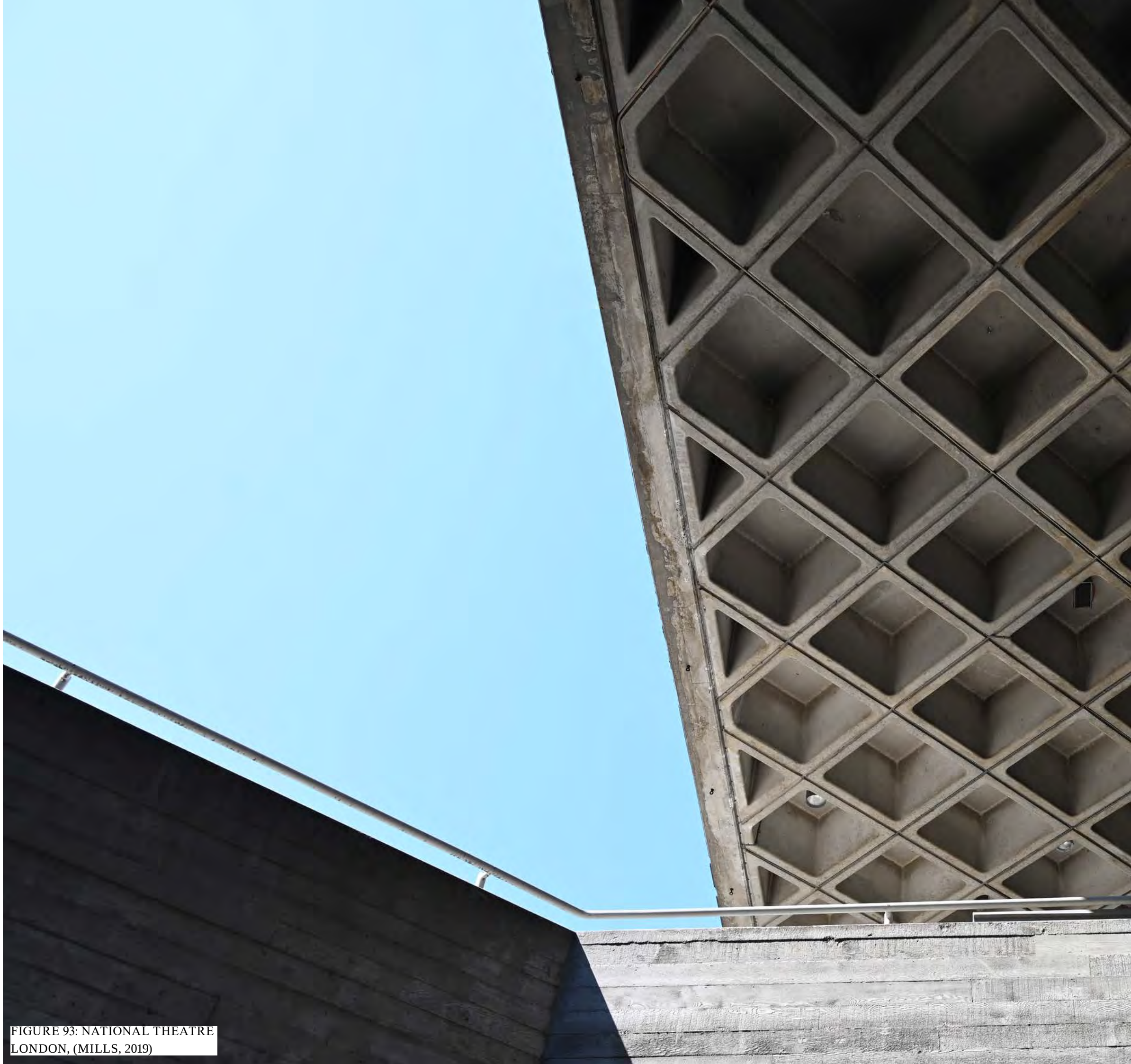


FIGURE 93: NATIONAL THEATRE
LONDON, (MILLS, 2019)



FIGURE 94: CAMBRIDGE MOSQUE
INTERNAL PERSPECTIVE, (MILLS, 2019)



FIGURE 95: CAMBRIDGE MOSQUE
INTERNAL PERSPECTIVE, (MILLS, 2019)

THE UNITED KINGDOM

In the last phase of the trip, several educators, researchers and designers were interviewed. Cambridge, Northeast of London, was the first place visited. The first stop was at the Cambridge Mosque, seen in Figures 94 and 95. The mosque uses a timber column tree-like structure, designed by Marks Barfield Architects, in conjunction with The Lehmann Group who produced the timber structure. This project highlights the opportunities for freeform timber moving forward.

Cambridge University was visited next, where time was spent with the Department of Civil Engineering, and [The Natural Material Innovation Group](#) (NatMat) affiliated with the Department of Architecture. The collaborations and work undertaken between these three groups all advocate timber projects for large scale high-rise construction, with a variety of projects receiving extensive attention.

The Department of Engineering represents Cambridge University's largest department, and Dr Robert Foster provided a tour of their facilities. He is a lecturer and

researcher within the field of timber design investigating the potential scope for tall timber buildings, society's need for them, and what is needed to construct them. Work is also being done into identifying opportunities for large pieces of structural wood products, arguing that there is a lot of literature and industry activity in small to medium size timber products, but for larger-scale endeavours, particularly for the products that would be needed to erect super tall timber buildings, there is little activity other than imaginary renders and ideas. With this work, Foster hopes to contribute to the understanding of large-scale timber products performance.

Discussing potential opportunities for UUT, the case for EWP was again suggested as being a viable absorber of UUT. Robert suggested that by breaking down and reconstituting UUT for an EWP produces value. By doing so, full knowledge of properties, process and output are homogenised and can be tested and specified accordingly. Growth and processing characteristics are removed and cut out, leaving the desired material to be reassembled into a structurally viable product. Such processes exist with strand products like LVL

and OSB, to name a few. In Australia, there is scope for additional strand systems, as previously written in the North America section of this report. With strand systems, however, it should be noted that the presence of smaller pieces of wood, more adhesive, and glue lines entails flammability considerations. UUT represents a catch 22; its selling point is that it's unrealised and underutilised. However, if this gives the consumer the impression that UUT is low grade or quality product than its selling point becomes problematic. As such, how UUT is portrayed needs a careful marketing campaign.

Another aspect raised was the way timber is taught in University courses like engineering or architecture. While educators should remain agnostic when teaching materials, there is an opportunity for UUT to be incorporated into teaching timber and its breakdowns. Robert suggested that the key is to provide students with all the information without privileging any one methodology. To let the content being taught speak for itself as to what the best material is for specific projects. The example of reinforced concrete was put forward as material which has had tremendous

success and acceptance in the built environment. Concrete has limited use structurally without reinforcement due to its compression-only design. However, once coupled with steel, it becomes a high value and versatile product. Resource and products being labelled low-in-value are only so because there has yet to be a purpose assigned to it, which can enable it to become high value.

NatMat's Principal Investigator Michael Ramage also participated in the research. With several diverse projects on the go across the fields of architecture and engineering, NatMat is looking into what can be done with timber over the coming decades. One recent project from NatMat, is Oakwood Tower, shown in Figure 96. A hypothetical example of a London timber skyscraper done in conjunction with PLP Architects. The project has received extensive coverage, and serves as a speculative exemplar to what is still to be achieved with modern timber design. NatMat are identifying opportunities for timber as a construction material to assist in tackling many of the housing crises around the world. By positioning themselves pragmatically in the middle of the supply chain, the



FIGURE 96: OAKWOOD TIMBER TOWER
PROPOSAL LONDON, (PLP ARCHITECTS, 2020)

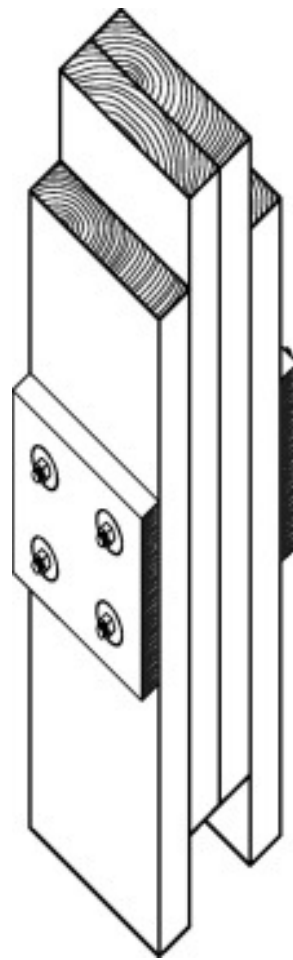


FIGURE 97: STRESS LAMINATED
COLUMNS (FLEMMING, 2019)

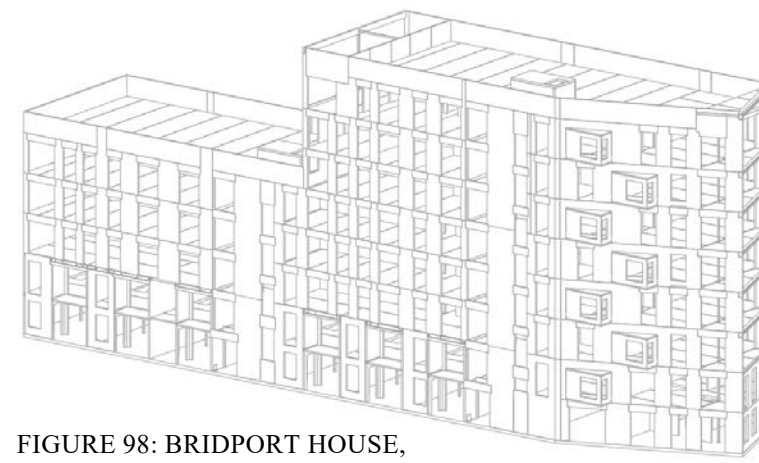


FIGURE 98: BRIDPORT HOUSE,
EAST LONDON, (EURBAN, 2020)

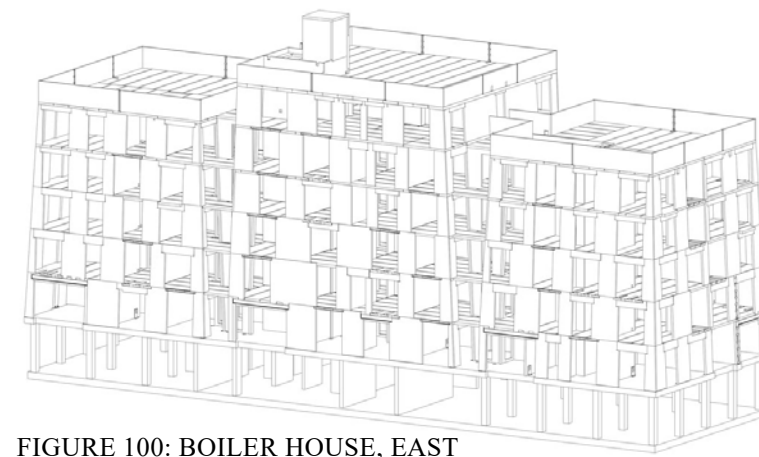


FIGURE 100: BOILER HOUSE, EAST
LONDON, (EURBAN, 2020)



FIGURE 99: BRIDPORT HOUSE,
EAST LONDON, (EURBAN, 2020)



FIGURE 101: BOILER HOUSE, EAST
LONDON, (EURBAN, 2020)

group can undertake research which is valuable from both an academic and industry perspective. NatMat's collaboration within the industry is strong, with informal modes of communication regularly occurring with architects, engineers, and manufacturing facilities.

Examples of EWP's like chipboard or, again, CLT, were raised as effective UUT absorbing products. A recent PhD [project](#) with the group, undertaken by Patrick Fleming, looked at stress-laminated columns made with low-grade wood, as seen in Figure 97. The moisture content of the resource was too high for production as an adhesive formed product. However, the resource still worked effectively as a stress laminated product. As is the case with similar UUT initiatives, because of the success and demand for UT products, high-grade virgin wood is being used in most manufacturing lines to meet consumer demand. Echoing the feedback from the North American meetings, NatMat spoke of the added time and costs in processing UUT, and when compared with the production of UT products, financially doesn't add up. The group provided insight to laterally thinking about

wood as a resource. Rather than using large portions of log in chipping and burning for energy, instead, look at how designers can maximise the usage of the available resource of each log. The benefits range from the continued storage of carbon, through to the use of fewer trees.

Another topic raised was inefficiency within project development to construction. Michael explained that typically buildings are designed before the material is chosen. In timber design, it is critical to be making the decision for working with timber as early as possible. By doing so, greater efficiency can be achieved, and a higher level of architectural input can result in more expansive timber projects. Michael believed that this can be assisted with the emerging field like design for manufacturing and assembly (DFMA). He predicts it will herald greater integration between fabrication, design, construction, and the operation of timber buildings.

From Cambridge, the next stop was in London visiting Mass Timber exemplars as well as meeting with two highly acclaimed timber advocates. Eurban, who

are specialists in solid timber construction and have completed over 300 solid wood constructions, was visited. The company was initially established to introduce CLT and other EWPs to the UK market, and now works across Europe, North America, Asia, and Oceania. Eurban operates as an integrated supply chain partner, providing engineering and installation for housing projects (Eurban, 2020c). Strong and trusted partners upstream of the supply chain allow Eurban to control the direction and selection of timber products for designers and architects.

UUT and the background of Eurban was discussed with Director Philipp Zumbrunnen, who trained as a carpenter and studied timber engineering. The concept of fragmentation across the timber product supply chain was raised again and that it is hindering the development of certain aspects of the industry. At present, European CLT manufacturers produce a product which is high in aesthetics, which even the non-visual panel has a high aesthetic. UUT is often exported to other regions like the Levante Market. For CLT, the timing of the purchase can play an important role in the aesthetics of the panel. Panels purchased

in spring are fresher and have a higher aesthetic in comparison to the ones purchased in autumn. Philipp suggested that CLT needs to return to what it was conceived initially; a mass option which absorbs UUT. A smaller producer or manufacturer near a sawmill that can access UUT for a low cost and have minimal transportation requirements would be an ideal situation for UUT production. Timber systems like [brettstapel](#) and [lignatur](#) were given as examples of construction products which could provide direct absorption of UUT.

Education was put forward as a critical aspect to inform and educate both designers and customers about timber being a natural and sustainable material. Raising awareness of the characteristics like some found in UUT which are adequate for construction purposes. The example of concrete was introduced; surface cracking or stains, for example, do not affect the integrity of the product, such is also the timber case. However, cracking in timber panels has been a concern for some of the earlier clients of Eurban. Built exemplars were again suggested as necessary for raising awareness of the possibilities of various

products. The example of Lendlease in Australia was given, who built three mid-rises towers with CLT before anyone else, paving the way for a greater demand for timber construction in the region.

Following Eurban, Waugh Thistleton Architects (WTA) was visited. WTA are passionate designers for the use of engineered timber as a means of addressing global warming and the environmental crisis. The firms' work looks at how wood can replace concrete and steel as a primary material for construction. Their projects play an important role in showcasing the benefits of using engineered timber in construction. WTA has built a reputation for sustainable design across the construction sector and can highlight and advocate the benefits of designing with engineered timber. EWP construction provides a viable and robust alternative to concrete frame and traditional building methodologies, according to WTA. Associate Kieran Walker participated in an interview and talked about the state of MTC affairs and his thoughts on UUT uptake.

Advancements in prefabrication and the digitisation of the construction process presents new pathways for UUT with EWP designs. One consideration raised of potential UUT products was the current lack of standardisation across the industry; most manufacturers have different production techniques and sizes in Europe. Additionally, while one manufacturer may be generating a lot of UUT, others will produce very little. Suppose one miller who is producing UUT starts to value-add and manufacture a product from it. In that case, the designer is in a position where they need to suggest such options without boxing the client into a choice-less scenario. Architects, he told, need to be careful not to be too specific about what they are specifying, to ensure client procurement options are not limited.

This consideration raised an interesting aspect of UUT. Sawmills and manufacturers who have UUT stock are typically going to be the large-scale operatives. Large-scale mills are the ones who are going to have the finances and relationships to initiate different strategies for absorbing UUT. While in Europe this might mean a handful of sawmills, in Australia this could be limited to one or two. If sawmills in Australia could divert UUT towards local manufacturers set up to handle and value-add to UUT, employment and novel products are realistic opportunities. Any additional EWP's which consists of UUT resource, will immediately help with demand for products for MTC, and reduce

pressure on existing forestry plantations.

Another aspect raised at WTA was around procurement and specification, and how this would work for UUT. Timber is not homogenous material, and in certifying products, it is hard to compare characteristics with one another. Any potential UUT products need to have a recognised way of being approved or an industry body that can recognise and class UUT products across different countries and regions. Currently, absorbing UUT is achievable when working with a singular supplier on a unique project. However, on a scalable level, it is quite challenging to provide warranties and certifications. This is an area which needs to be looked at further when designing future UUT products.

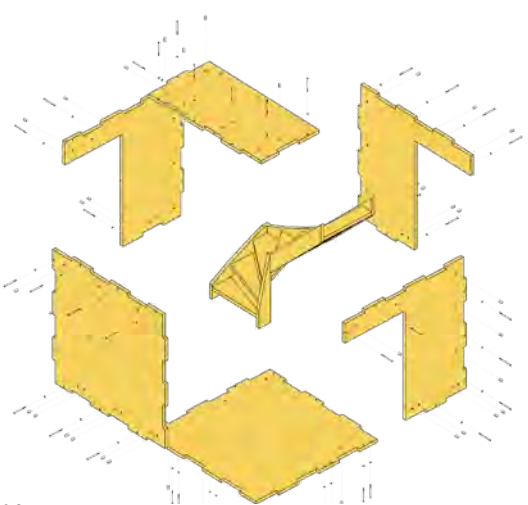


FIGURE 102: MULTIPLY AMERICAN TULIPWOOD CLT (REEVE, ED, 2020)



FIGURE 103: MULTIPLY AMERICAN TULIPWOOD CLT (REEVE, ED, 2020)



FIGURE 104: VITSOE CLT OFFICE, ROYAL LEAMINGTON SPA, (LINDNER, DIRK, & VITSOE, 2020)



FIGURE 105: VITSOE CLT OFFICE, ROYAL LEAMINGTON SPA, (LINDNER, DIRK, & VITSOE, 2020)

HOOKE PARK PLACEMENT

After the time spent in London, the next and final stop was at the Architectural Association's Hooke Park Campus in the UK's Southwest for a short-term placement at the avant-garde school of design Architectural Association (AA) Hooke Park satellite campus. The school highlights how a study of ecosystems can reveal potential economic and cultural values to be gained in forest management processes. The Hooke Park Group take pride in showcasing the opportunities their research has opened up for wood products, furniture, and, indeed, construction.

Hooke Park's history is long and diverse. The campus first began operating as a school for craftsmen in wood in the late 1970s. In the early 1980s, the site was purchased by John Makepeace and set up as a school for woodland industries, combining furniture making and forestry management activities as part of Parham College. During this period, architect Frei Otto developed an extensive masterplan which saw the building of Prototype House in 1986, the Workshop in 1989, and Westminster Lodge in 1995. The AA took ownership in the early 2000s and runs an Architectural Master course, [Design and Make](#), as well as other intensive short course placements on the campus. The park continues operating as its own timber supply chain. It is considered a leading research design centre for novel examples of low-value woodland resources in building design. I spent several weeks at Hooke Park, based at Westminster Lodge, where I participated as a summer builder. The program develops wood handling skillsets and involves participants on fabricating novel timber products, furniture pieces and assisting the Master students on projects. The summer build program runs once or twice a year and attracts a vast

number of applicants from across the globe.

During the placement, I collaborated with 15 summer builders on a series of projects that utilised local woodland resource in an array of differing applications. We sourced and fabricated a large banquet table and benches out of Poplar wood, designed and fabricated a circular bench from UUT-like resource, and assisted on three master projects: (i) a steam-bent pavilion; (ii) a woodland cabin; and (iii) a tree fork bridge. We also played a part in the inaugural AA Hooke Park student open day. Where we sourced felled branches and thinnings from the surrounding woodland estate and fabricated a series of one-off installations which were torched as a celebratory closing for the program.

Wood handling and machining tasks, shingle fabrication, and the steaming of UUT-like resource were some of the main activities that I enjoyed during the program. Being amongst some of the earlier buildings on site like the Prototype House, the Workshop and Westminster Lodge provided real inspiration, and can be seen in Figures 109 to 114. The way in which the thinnings, a low-value wood resource, was value-added and utilised to create functional, unique and lasting structures were impressive. Some of the more recent projects like the Boiler House or the Wood Chip Barn offered exemplar processes of using advanced technologies to achieve purposefully, thought-provoking and lasting builds with whole wood material. Over the next few pages, photographs show some of the buildings on-site at Hooke Park, activities that I was involved in during the program and a visit down to Dartington Estate.



FIGURE 106: ASSEMBLY SHED, AA
HOOKE PARK (MILLS, 2019)



FIGURE 107: SUMMER BUILD 2019 COHORT (SB AA, 2019)



FIGURE 108: SUMMER BUILD 2019 BANQUET SHOT (SB AA, 2019)



FIGURE 109: WESTMINSTER LODGE (MILLS, 2019)



FIGURE 110: WESTMINSTER LODGE (SB AA, 2019)



FIGURE 111: PROTOTYPE HOUSE (MILLS, 2019)



FIGURE 112: PROTOTYPE HOUSE (AA, 2020)



FIGURE 113: WORKSHOP (MILLS, 2019)



FIGURE 114: WORKSHOP (MILLS, 2019)



FIGURE 115: ASSEMBLY SHED (MILLS, 2019)



FIGURE 116: ASSEMBLY SHED (MILLS, 2019)



FIGURE 117: WAKEFORD HALL
(MILLS, 2019)



FIGURE 118: WAKEFORD HALL
(MILLS, 2019)



FIGURE 119: BOILER HOUSE
(MILLS, 2019)



FIGURE 120: BOILER HOUSE
(MILLS, 2019)



FIGURE 121: TIMBER SEASONING
SHELTER (MILLS, 2019)



FIGURE 122: TIMBER SEASONING
SHELTER (MILLS, 2019)



FIGURE 123: WOOD CHIP BARN
(MILLS, 2019)

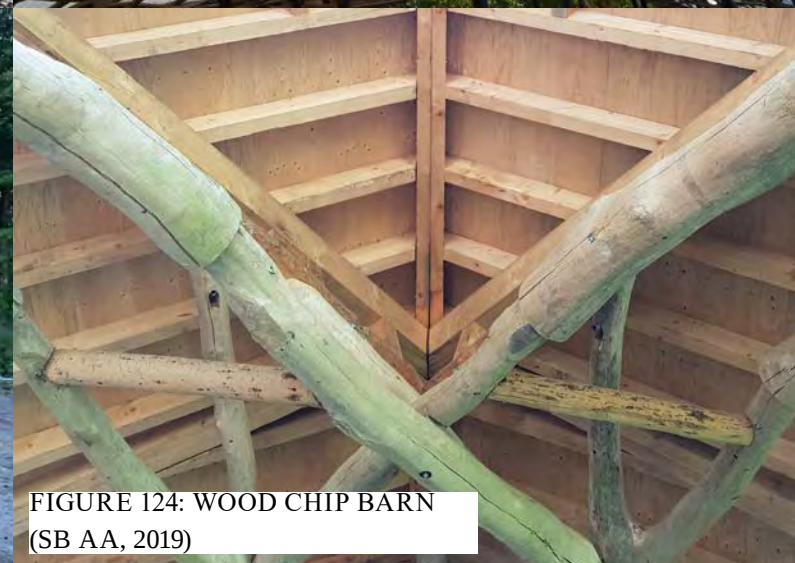


FIGURE 124: WOOD CHIP BARN
(SB AA, 2019)



FIGURES 125 & 126: POPLAR BANQUET TABLE FABRICATION (SB AA, 2019)



FIGURE 127: SHINGLE FABRICATION, (SB AA, 2019)



FIGURES 128 & 129: POPLAR BANQUET TABLE FABRICATION (MILLS, 2019)



FIGURE 130: WOODLAND CABIN STRUCTURE FABRICATION, (SB AA, 2019)



FIGURES 131 & 132: STEAM BENDING JIG TESTING (SB AA, 2019)



FIGURE 133: WOODLAND CABIN STRUCTURE FABRICATION, (SB AA, 2019)



FIGURES 134 & 135: STEAM BENDING JIG TESTING (SB AA, 2019)



FIGURE 136: CIRCULAR WASTEWOOD BENCH PROJECT(MILLS, 2019)

I was able to discuss the scope of the UUT research project and learn more of the professionals during my time at Hooke. Martin Self, Director Design and Make Course, and recent founding Director of [Xylotek](#), gave some thoughts on UUT and surrounding context. Martin, an Engineer, spoke of his aim of designing for efficiency and elegance while remaining faithful to the materials produced by the existing supply chain. He spoke of the importance of education; teaching and mentoring budding engineers and, indeed, designers early in their careers in the characteristics of different types of materials. By doing so, instills a good sense of logical explanatory thinking, to allow for questioning the prevailing industry norms as necessary.

To some extent the process of designing has been deskilled, and Martin spoke of how the art of engineering has been lost. Some engineers refer to the regulation book and run the design through code. A process reliant on standardised materials like concrete and steel. Standardisation of the engineering profession, where various materials have been defined for their properties and characteristics, has created issues for the use of timber. Wood is troublesome to classify to the same level of specificity as other materials as it has significantly more variation in properties. Additionally, an engineer's design has to assume a worst-case scenario for a structure, a situation which often penalises wood.

Christopher Sadd, Head Forester for Hooke Park, provided some further points for discussion. Christopher described how Hooke Park has two main outlets for its timber resource. The first is the supply of timber for the students to ensure that there is enough round wood, and raw material for biofuel for use in the energy centre. The second, a smaller outlet, to sell wood resource to open market. Any timber sold typically goes to the sawing market, ending up as structural building products such as roof trusses and beams columns. Christopher spoke of Hooke Park's earlier days during the 1980s when it operated as Parham College. The focus was primarily on finding ways to add-value to thinnings and premature tree material. Wood of this nature at the time would have gone to fencing and the like, compared to nowadays where it's reduced to biofuel and pellets for energy.

Christopher provided an overview of UK forestry where he spoke of an increase in interest to diversify woodland. Policies are allowing for species which have started growing on their own to continue. Tree species that would have previously been classed as weed are now being actively cultivated. This is because forestry

is moving into uncharted waters with changing climatic conditions affecting the characteristics of the woodlands. He suggested that focusing on hardwoods or broad leaves is risky and short-termism. He proposed that forestry could be looking towards conifer species like Douglas Fir, where several grow among the woodland at Hooke Park. Western Red Cedar was another species brought up, a softwood which has become a widely popular resource in the UK because of its durability features. However, Christopher noted that questions exist remain of its structural properties.

A local woodland estate was introduced, who operate an alternate model nearby in the UK called [Longleat](#). The estate caters for specifiers, architects, designers and engineers to come in and request the type of tree they would like to use for a particular project. Buy and select the tree on-site rather than choose from one in a brochure. This framework that allows the end-user to come in and select the tree for fabrication, is a niche market at present but does provide an alternative concept for timber milling and products in the future.

I also sat down for a meeting with Hooke Park Warden, Zachary Mollica. Zac oversees the forestry and the workshop activities at Hooke. He was able to speak of how the place operates with a degree of flexibility that allows the Design and Make course to pursue one-off projects. The approach enables students to create unique projects, which at face value, may have little resemblance to real-world designs. This flexibility allows for new thinking, the development of novel processes, and research into initiatives and systems unconventionally utilising timber. Zac discussed the role forestry can play in tackling UUT. He suggested that for absorbing UUT, developing a new framework or grading system that can be applied to marginalised resource wood-like UUT for a medium to long term benefit. EWP's, for an immediate impact on absorbing UUT, were suggested as a way forward.

UUT at Hooke is a concept that is much earlier in the supply chain, often in the forestry realm, compared to that of the research being undertaken in Australia. UUT in Hooke applies to a full tree or thinnings—tree forks or whole logs—while non-structural boards or planks are just chipped and burnt for energy.

Zac described in detail the [Wood Chip Barn](#) project, which can be seen in Figures 123 & 124. The project is made up of natural Beech tree forks, selected and extracted from the surrounding the woodland estate. Beech trees were once planted as a valuable resource for furniture making. However, UK mass

manufacturing has moved offshore, and coupled with modern manufacturing techniques, has resulted in beech having little value nowadays, and is primarily used as firewood. The Woodchip Barn was able to use beech in a structural capacity in its large truss structure. The fork truss is a large spanning unique structure at Hooke that Zac describes the fork truss as being too beautiful and sculptural. Factoring in labour time, it is perhaps not ready for mass-scale fabrication, at the moment. Selecting, milling and designing with a tree fork takes considerable time and requires a high level of expertise. The different trades can range from carpenters to technicians skilled enough to operate the advanced technologies needed to undertake the tasks. Zac believes that for UUT uptake, it is important to think about how to engage and convince end-users to use the UUT product. Suppose a UUT product can be made to look similar to an existing UT product. In that case, it is important to convey the properties to the end-user to show there is no difference. Again, if a UUT product has different aesthetical features, it will be an important marketing tool to talk about these in a positive light, rather than try to hide them.

While based at Hooke, I had the opportunity to travel further south to the [Dartington Estate](#) to meet with Jez Ralph of [Timber Strategies](#). Jez, formerly Estate Manager at Hooke Park, founded Timber Strategies which is a consultancy firm based in the UK whose work spans the timber supply chain. The consultancy looks to bring innovation and provide value-adding opportunities to businesses, consortia, and the public sector (Timber Strategies, 2020). The meeting with Timber Strategies provided a thorough analysis of the UK market and thoughts on UUT.

In the UK, there are areas of low-quality woodland forests, typically remote and hard to access. While vast, the woods are scattered and typically in low volume across farmland. The woodlands were often planted without the intention of processing for board and plank product. The wood is rarely straight and features an abundance of growth characteristics such as tapering and knots. Jez talked about a collaboration between Vastern Timber and Timber Strategies that looked to utilise some of this resource. Together they developed a thermally modified cladding, named [Brimstone](#), which absorbs underutilised species such as Ash, Sycamore, and Poplar (Vastern Timber Limited, 2020). This product, which serves a non-structural application, gives an example of turning an underutilised hardwood resource into a high-value product. In discussing the opportunities for board and plank UUT, EWPs were again suggested as the

absorber. Standardising UUT and how its marketed to consumers were two issues raised. Traditionally, CLT and other EWPs would have absorbed this resource. However, it is more cost effective for manufacturers to use UT rather than UUT in much of EWP manufacturing at the moment.

Education was identified as an area of opportunity, with Jez speaking of Hooke Park's role as an outlet for architectural and design students to engage in building knowledge of forestry. He noted that in teaching forestry and architecture, there was a level of unawareness of where wood is from to how it is processed. The lack of understanding creates a disconnect with industry from the real world and is leading to fragmentation. Jez suggested that by providing platforms across the supply chain, different groups can begin to interact and increase the transfer of knowledge and skillsets. Ultimately, resulting in an increase in opportunities and collaborations for the industry.

Jez made a closing comment on the difference in time for the timber industry. Rewind a decade or more, and millers and manufacturers were heavily focused on structural/non-structural conversation rate. If structural product extraction for sawn wood was below 70%, significant wastage was occurring. Nowadays, large scale mills are processing their resources with conversion rates around 50% to 60%, and the leftover is utilised as biomass to fire the kilns. This led to the question; what is the incentive for large scale sawmills to be interested in board and plank UUT? Jez speculates that in the coming decades, the supply of resources may become more restrictive, meaning timber users and timber processes are going to have to adapt. As forests have had to adapt to changing climate, Jez proposed that manufacturers and designers are soon going to have to learn to work with different types of resource. This could mean different species, with varying degrees of quality, and, perhaps, lower conversion rates.



FIGURE 138: WOODLAND CABIN INTERNAL FORK STRUCTURE (MILLS, 2019)



FIGURE 137: ROBOTIC CELL, TREE FORK FABRICATION, (MILLS, 2019)



FIGURE 140: DARTINGTON HALL, DEVON, (MILLS, 2019)



FIGURE 141: SURROUNDING WOODLAND HOOKE PARK, (MILLS, 2019)



FIGURE 142: DARTINGTON HALL, DEVON, (MILLS, 2019)



FIGURE 143: SURROUNDING WOODLAND
HOOKE PARK, (MILLS, 2019)

DISCUSSION

The research project supported by the Gottstein Fellowship grant has provided an understanding of UUT and, more broadly, UUT's place within the construction industry and the timber product supply chain.

The study discovered several products and processes which could be directly applicable for absorbing UUT resource in Australia. Finger-jointing for board and plank product or EWP's, wall cladding products, to even furniture pieces were absorption outcomes identified in the regions. In particular, DLT, NLT, brettstapel, lignatur, and for the veneer marker, MPP were EWP's identified. It also became evident early on in the trip that there were a wide array of other impacting factors for UUT. Topics like disconnect and fragmentation across the supply chain; lack of transparency to where the wood originates; procurement and marketing strategies of UUT were all raised. There was strong enthusiasm across the board for the potential of UUT to incorporated into existing, or the creation of novel products for construction purposes.

UUT in the visited regions was generally lower in volume in comparison to Australia, and this can be attributed to a couple of reasons. Firstly, the wood resource varied considerably. In most regions, the structural board and plank product percentage extract was markedly higher. The types of species milled across the visited areas differ significantly and certainly provide alternative models for future plantations in Australia. Secondly, climate and environmental contexts are widely different. Thirdly, more alternative absorption streams for UUT-like resource exist.

Policy, regulation, and climatic change are also factors driving industry agenda in the regions visited. For instance, in Portland, Oregon of the United States, interest in upcycling salvaged timber is initiating innovative product development. In Copenhagen, Denmark, the concept of circular futures is resulting in renewable and recycled product development. In Central Europe, changing quality of softwood resources is resulting in a rethink of hardwood as a potential resource. Finally, in the UK, new policy is driving research for tall timber design. At the same time, from a forestry perspective, species which were typically weeded out decades ago are being encouraged to grow.

Collaboration and establishment of alternative partnerships across the supply chain was an important

area identified for UUT absorption. Examples of architects working with foresters and advanced manufacturers in the UK, to architects and engineers initiating the uptake of mountain pine beetle affected wood being absorbed in CLT and other EWP's for use in the North American market were two standout takeaways.

Across the interviews with manufacturers and millers, it was identified that it is hard to value-add to UUT for existing mills currently. Establishing additional lines to distribute and process UUT is too costly an exercise. This is the primary reason that UUT ends up as chip and or exported overseas. If UUT can be transferred to another facility, or onto a secondary manufacturer nearby, it may be easier to add value to UUT without incurring added transport and handling costs. For any potential UUT product, the importance of being able to highlight the qualities and characteristics of UUT was seen as critical from the meetings across the supply chain. Through built prototypes and examples, this shall enable further interest and exposure to UUT.

CONCLUSION

Designers have a role to play in both specifying local materials, as well as communicating and engaging with other stakeholders across the supply chain. UUT, a resource which is high in volume in Australia, can play an important role in the continued rise of timber products for the built environment, and to help mitigate the effects of climate change. COVID-19 has brought to light the importance of local manufacturing, and through increasing knowledge transfer and collaborating with different professionals along the supply chain, new partnerships, novel products, and employment opportunities can arise.



FIGURE 144: BALLARD BRANCH, SEATTLE PUBLIC LIBRARY (MILLS, 2019)



FIGURE 145

ABOUT THE AUTHOR

My name is Harry Mills, and I'm an architectural designer and researcher passionate for environmental and climatic responsible design for all. At present, I'm completing a PhD with the Future Timber Hub looking at product design and absorption opportunities for underutilised and marginalised timber for built environment purposes. The project is associated with the School of Civil Engineering at the University of Queensland. I have worked in many regions around the world and been recognised locally and internationally for my work in industry and academia. If you would like to discuss the scope of this research further, or new a project, please touch base through the email below.

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