studio@trias.com.au
9 Telopea St Redfern
NSW, 2016, Australia
trias.com.au

Timber Buildings Artistically Considered

JONATHON
DONNELLY

Contents

Project: Homerton Dining Hall
Photographer: J Donnelly

Introduction and Topic Overview

This report, entitled 'Timber Buildings Artistically Considered' seeks to collate, analyse, and contextualise outstanding examples of cross laminated timber (CLT) construction to draw conclusions on what is possible with this material.

The title was, in part, inspired by Louis H Sullivan's 1896 essay, 'The Tall Office Building Artistically Considered.' In a similar vein to this report, it was written at a time in history where another innovation, the skyscraper, was yet to become the architect's domain. Describing the origins of this typology, Sullivan writes:

> *"Up to this point all in evidence is materialistic....It is the joint product of the speculator, the engineer, the builder.*
>
> *Problem: How shall we impart to this sterile pile, this crude, harsh, brutal agglomerariont...the graciousness of those higher forms of sensibility and culture that rest on the lower and fiercer passions? How shall we proclaim from the dizzy height of this strange, weird, modern housetop the peaceful evangel of sentiment, of beauty, the cult of higher life?*
>
> *This is the problem; and we must seek the solution of it in a process analogous to its own evolution, - indeed, a continuation of it, - namely, by proceeding step by step from general to special aspects, from coarser to finer considerations."*

In a similar vein, this report arose from a growing interest in CLT and its potential to be "artistically considered" – that is, explored for its full architectural potential, and explored beyond the domain of the engineer, the supplier, the developer or the construction manager. While there is plentiful technical and performative information available on CLT, its uptake in architectural circles has been slow, and its application is therefore in its infancy.

Accordingly, this study focuses on exemplar CLT buildings, considering how the material can be used experientially and creatively. In doing so, this report aspires to promote new forms of timber construction, sharing this knowledge with Australia's architectural culture.

This study focuses on CLT buildings located in the United Kingdom (UK). While the initial scope of the proposal also looked at exemplar projects from Sweden, the Covid-19 pandemic postponed travel and this changed the research parameters.

This report follows a simple and legible structure. To begin with, it situates CLT as a material by describing its material properties and key benefits. It then outlines the environmental case for CLT, exploring the increased interest in the material in light of industry-wide shifts in response to climate change. Subsequent chapters address critical contextual factors that have affected the uptake of CLT, and its potential for innovation, in the UK and Australia. This provides important grounding the case studies and reveals important lessons for our own industry in Australia.

The project methodology highlights four areas of analysis, moving from the larger building scale to its finer construction. The methodology commences with the building diagram, then addresses the broad construction approach, the building's appearance and tactility, and the crafted joint. Text, drawings, and photographs accompany each case study.

There are seven building case studies included in this report. They span a variety of typologies and scales, but all use CLT in at least part of their construction system.

The report concludes with a series of observations and conclusions born from this study. These distil the findings into key takeaways that have the potential to influence architectural practice and culture in Australia.

Project: Drayton Green Church
Photographer: J Donnelly

Benefits of CLT

Cross-laminated timber, otherwise known as CLT, is an engineered wood product that sits within the broader structural family of "mass timber." It was initially developed in Austria in the 1990's and was first called Kreuzlagerholz, or KLH, before being translated to CLT in English. It is thus a relatively new material within the context of architectural construction.

CLT relies on a similar process of manufacture to plywood and is often colloquially referred to as "jumbo plywood." To produce CLT, layers of timber are laminated together with adhesives to form large, stable structural panels. Ordinarily, CLT comprises three panels of timber boards laid perpendicular to one another, which gives the panels high transverse stiffness. The panels are typically made from softwoods, though hardwood products are beginning to appear in Australia and internationally.

As a material, it is light, easy to work with, and simple to assemble, prefabricate, and manoeuvre. The material's density also means it has additional benefits, which are described below.

Common Dimensions For CLT Panels		
Parameter	Commonplace	Available
Thickness	80-300mm	60-500mm
Width	1.2m-3.0m	up to 4.8m
Length	16m	up to 30m
No. of Layers	3, 5, 7, 9	up to 25

Panel size in Australia is more limited, with the following

- Width: 3.4m
- Length 16m
- Layers: 3, 5, or 7
- Thickness: 90mm - 310mm

STRUCTURAL PROPERTIES

CLT can be characterised as a 'slab' product, a quality which makes it an effective material for wall, floor, and roof plans. Structurally, it performs exceptionally well because of its perpendicular lamination process, which gives it lateral strength. CLT has good load-bearing and bracing performance and can span up to 16m.[1]

CLT also works well in hybridised construction systems. The panels have a comparable strength to weight ratio to concrete, despite being five times lighter.[2] This can translate into time and cost savings on site, as noted later in this report.

POTENTIAL FOR PREFABRICATION

Given that it is a panelised product, CLT lends itself to prefabrication. This has numerous benefits for both design and construction. 'The CLT Handbook' draws parallels between CLT and flat-pack systems, noting that it allows architects to precisely cut windows, doors, and services, creating a kit-of-parts - or series of modular units - that can be simply assembled on site.[3] The design process can also be streamlined with BIM and digital modelling and fabrication tools. Design models can be fed directly to fabricators, saving time and ensuring accuracy.

TIME AND COST SAVINGS

CLT has the potential to drastically reduce construction timelines and associated costs. According to Andrew Waugh, director of Waugh Thistleton Architects and a pioneer of CLT construction in London, panelised CLT structures take about two thirds of the time of standard construction, while modular CLT builds can be completed in over half the time of a typical build.[4] In the case of medium to large scale buildings, where time is money, this can translate into significant on-site savings, which usually manifest in a few key ways.

Firstly, CLT is often proposed as an alternative to conventional flooring, roofing, or framing. It therefore replaces traditional on-site labour with a swift and singular install process where the panels are erected in a manner of hours or days, This process can result in significant time savings, especially on mid to high rise buildings, as the site is waterproof, and habitable, in far less time. CLT can also present time and cost savings if it is left exposed on a building's interior. This reduces

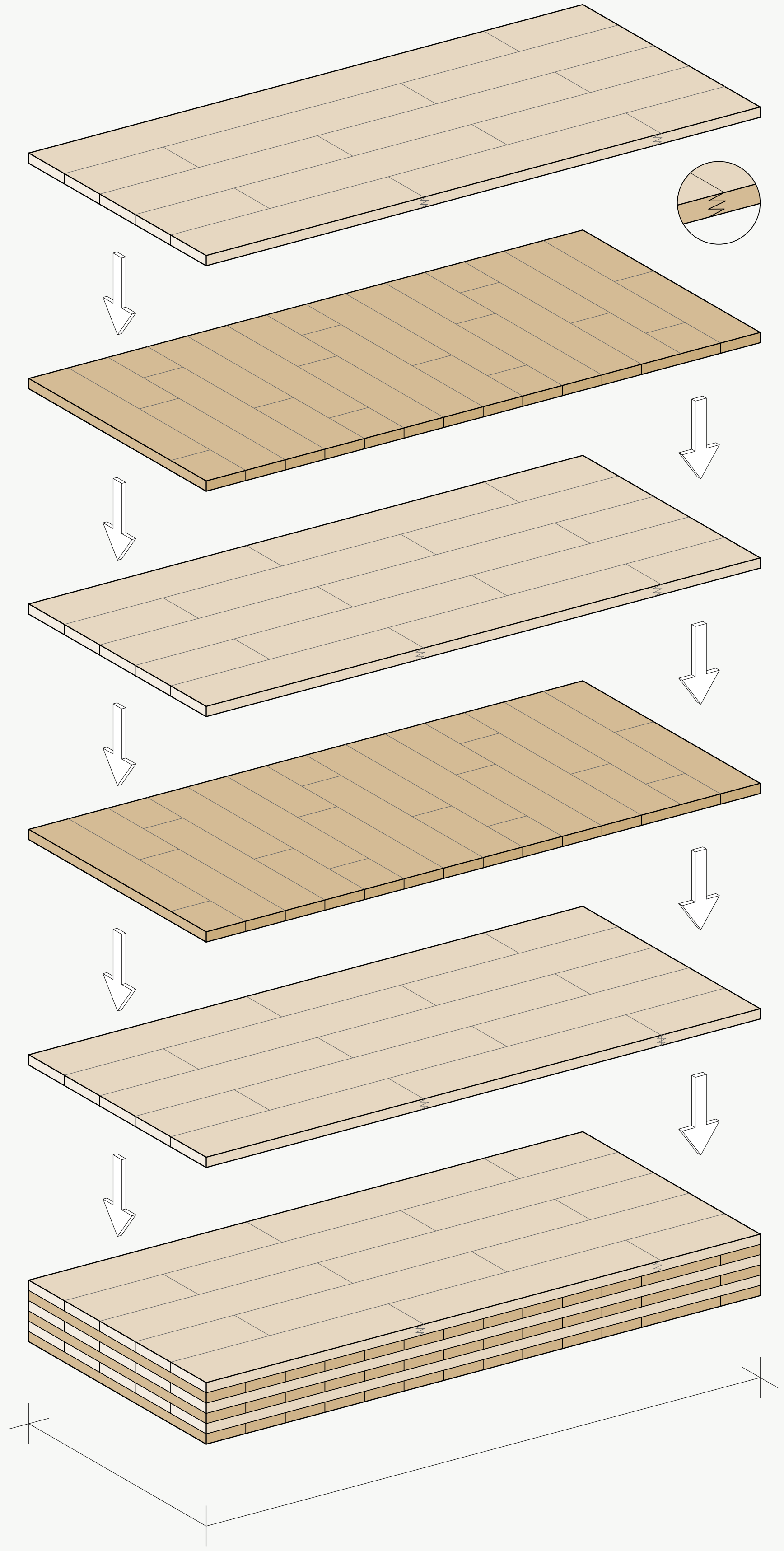


Table: The CLT Handbook, Swedish Wood (pg.16)

Diagram: Redrawn from Stora Enso CLT technical brochure (pg.5)

Benefits of CLT

the need for additional trades, shortening overall build timelines and, in some cases, saving the money linked to further finishing. Finally, the lightweight nature of CLT can reduce the structural loads on a building's foundation, substantially reducing groundworks.

AESTHETIC QUALITIES

CLT panels have an exposed timber finish that is warm, tactile, and organic. The material's visual appearance reflects its original timber, which is most commonly spruce in Europe and radiata pine in Australia. For many people, this is a beautiful and honest finish that feels welcoming and timeless.

The finishing grades of CLT panels range from a structural non-visual grade, through to a rougher industrial finish and then, finally, a more refined visual finish. The structural grades show more visible knots and inconsistencies within the timber, while the visual grades have greater consistency. This variety of finishes means the product can be selected to reflect its end use; for example, a structural grade panel can be clad or lined in another. This is common when CLT is used as part of a wall, floor or roof buildup, but is not left exposed.

PERFORMATIVE QUALITIES

CLT is, by nature, a dense material, which means it has good insulative properties and inherent airtightness. These two qualities are becoming increasingly sought after in contemporary architecture, especially under the principles of Passive House design and construction, given that it preferences sealed buildings.

CLT panels have the potential to garner reasonably good rates of thermal transfer, but performance is improved by an additional layer of bulk insulation. It should also be noted that the material is not as insulative as high thermal mass materials, like concrete or brick.

In terms of airtightness, the panels themselves are excellent at preventing humidity, condensation, and damp. This has been verified in tests performed by the Holzforschung in Austria.[5] The impermeability of CLT aids stable internal temperatures and reduces heat loss. CLT is also less prone to instances of thermal bridging when compared to conventional timber stud construction, given the material is a single continual mass surface and has less joints.

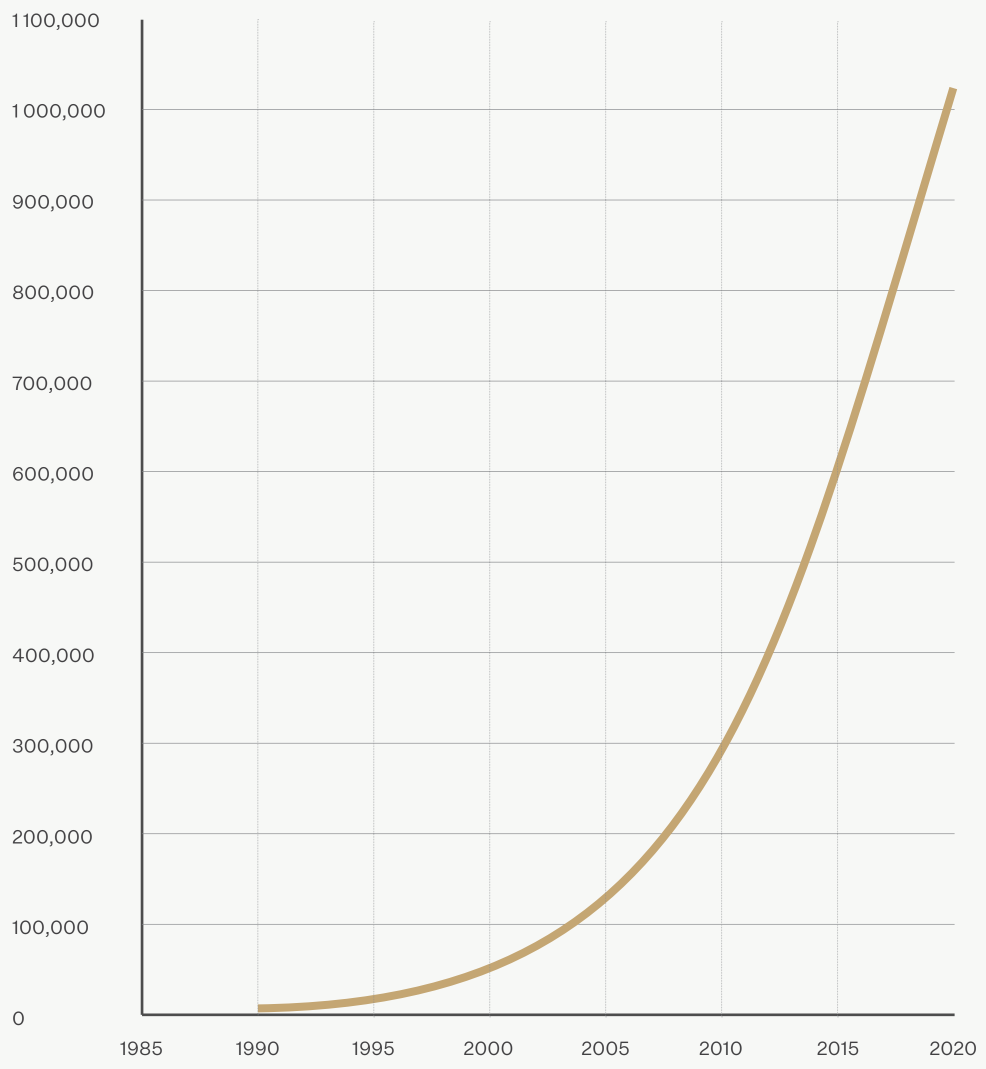
FIRE RETARDING PROPERTIES

CLT has excellent fire resistance properties. This is a natural bi-product of it being composed of dense wooden panels. When exposed to fire, large sections of timber char on the outside, but leave a protected and stable inner core. CLT performs in a similar manner so, in the event of fire, the water molecules within the timber's cellular structure start to evaporate and, upon reaching 200–300 °C, decompose in pyrolysis.[6] It is this chemical process which creates a char layer within the CLT panels, protecting the underlying structure of the timber and ensuring that any structural failure happens slowly and predictably.

SUITABILITY IN CHALLENGING DESIGN SCENARIOS

CLT is particularly effective in certain design applications. It lends itself well to urban densification and adaptive reuse projects, where the ability for an existing site, or structure, to bear loads may be limited, complex, or particularly expensive. Its slender buildups also suit projects where height is at a premium and construction buildups need to be minimised. While the construction industry is often reluctant to use new materials, these novel scenarios are the perfect pairing for CLT, as they promote efficiencies and cost savings.

Graph: The CLT Handbook (UK Edition), Swedish Wood (pg.11)



DEVELOPMENT OF CLT IN EUROPE

1990 - 1995	Concepts, patents & proposals presented in European trade journals
2007	First Use of CLT in the UK
2020	CLT Production Exceeds 1M m^3

The Environmental Case for CLT

Decarbonising buildings, and the construction industry, is undoubtedly the "wicked problem" of our time, and underscores current architectural research, practice, and education. It is within the pressing context of climate change that interest in cross-laminated timber has skyrocketed, as there is a strong environmental case for the material.

Architects are increasingly becoming aware of their role, and responsibility, to help decarbonise the building sector. This is vital work, prompted by recent research and calls to arms. In 2019, the World Green Building Council completed the seminal report 'Bringing Embodied Carbon Upfront.' This drew attention to emissions impacts across the building and construction sector, noting that:

> *"Buildings are currently responsible for 39% of global energy related carbon emissions: 28% from operational emissions, from energy needed to heat, cool and power them, and the remaining 11% from materials and construction."* [7]

Closer to home, the Australian construction industry is responsible for 18.1% of our national carbon footprint, or more than 90 million tonnes of greenhouse gas emissions every year.[8]

These statistics implore architects to take responsibility for their design decisions, and material specifications, as these directly affect a building's operational and embodied carbon. It is within this evolving context that more and more architects are looking to materials that lessen construction demands, remove superfluous finishes, and – where possible – are either regenerative or bio-based, so they suit a future-oriented, circular industry.

Cross-laminated timber is an ideal material for this new era of construction, where targets of reduced, or even net-zero, construction are becoming commonplace. It is naturally grown and replenishable and, when detailed appropriately, can be designed for disassembly. Unlike many other building materials, which generate extensive carbon emissions, timber also sequesters carbon. This occurs while the trees are growing, as they absorb carbon dioxide from the atmosphere while photosynthesising. This results in a scenario where forests, including those used for plantation timber, effectively become carbon stores. This sequestration then transfers to the timber product. As Professor Philip Oldfield, the Head of School at UNSW Built Environment, Faculty of Arts, Design and Architecture clarifies:

> *"A kilogram of wood will have removed around 1.7 kilograms of CO2 from the atmosphere, locking up the carbon until the end of the timber product's life. As such, timber buildings can provide a long-term "carbon sink", locking in emissions for decades."* [9]

Further to this, manufacturers extoll that making CLT is a low impact, energy-efficient process. This sits in stark contrast to concrete and steel, which rely heavily on burning fossil fuels during their manufacture. While CLT production does generate bi-products, such as wood shavings and wood waste, these can be fed back into the kilns to produce energy.[10] New products that use existing timber to make CLT are also emerging, which elongates the material's life even further.[11]

Considering these advantages, it is also worth noting timber's pitfalls, and the potential omissions within these claims. First, the timber used to make CLT must come from sustainably managed forests. These concerns are well summarised by John Fernández, an architect, professor of building technology, and director of the MIT Environmental Solutions Initiative. He explains:

> *"If it's not managed well, a forest can end up releasing more carbon than it captures. Also, growing trees takes many decades, and their full potential to capture carbon is too slow to meet the need for rapid decarbonization today. There needs to be a lot more work done on that side before anyone can claim that wood buildings are going to be overall a positive solution for sustainability generally, including for climate change."* [12]

Second, supply must also keep pace with demand – if the insatiable demands of the construction industry mean that demand for CLT outpaces its supply, it is, by implication, unsustainable. Third, the material must be well maintained, and designed so that it can be disassembled. This will prolong the material's life, ensure it can be reused, and prevent it from being treated disposably.

The final environmental argument for CLT is a comparative one. CLT is often heralded as a substitute for its far more carbon intensive cousins, concrete and steel. Given that cement is responsible for as much as 8% of global carbon dioxide emissions [13], and CLT is capable of sequestering carbon, it is simple to conclude that CLT is the preferable material, and can play a vital role in reducing emissions impacts.

As a direct comparison, this argument bears truth. Research collected by Stora Enso, a CLT supplier, compares the emissions impacts of a concrete and CLT external wall. CLT generates significantly less carbon impacts in its production and, under optimal conditions, can also sequester carbon.

While CLT is not a miracle material, and is not the solution for every design problem, it has an important role to play in twenty-first century construction. It can be a valuable substitute for, and companion to, concrete and steel, and is well placed to sit at the forefront of the industry's shift towards low carbon, and net zero, targets.

Project: Sands End Arts And Community Centre
Photographer: J Donnelly

Contextual Factors – The UK

BRITISH CONTEXT

CLT was introduced to the UK in 2001[14] and was used architecturally soon thereafter. This report identifies four key factors that led to CLT's increasing use across the UK. These factors all worked symbiotically with one another, allowing CLT to move from a fringe material to one that has gained traction within the UK's architectural culture.

PROXIMITY TO EUROPE

Comparatively to Australia, the UK is geographically well positioned to benefit from relationships with European suppliers and knowledge sharing. Given that CLT originated in Europe, this proved advantageous as this was the home ground of early testing, experimentation, and regulation. Subsequently, when the material was introduced into the UK market, the local architecture community was able to piggyback on R&D initiated within continental Europe, before expanding upon it.

Most CLT production was initially concentrated in Germany, Austria, and Switzerland. By the early 2000's, it was spreading across Europe and being manufactured at scale. This allowed the material to gain wider traction across the European Union; even today, over half of the world's CLT is still produced in five European countries, Austria, the Czech Republic, Germany, Italy, and Switzerland.[15]

This tight-knit European geography laid the groundwork for early experiments with CLT, allowing it to be explored and implemented. Given the UK is so close to Europe, it no doubt benefitted from this proximity and the knowledge garnered from these early years.

Eduardo Wiegand and Michael Ramage's paper, 'The Impact of Policy Instruments on the First Generation of Tall Wood Buildings,' provided valuable insights into how Europe's regulatory context influenced the initial uptake of CLT. As the paper argues, several nations invested in early research and development, and pioneered the first experiments in mass timber, including in CLT. The paper cites key national and localised policy instruments, funding models, competitions, initiatives and partnerships that facilitated knowledge dissemination and early innovation.

Notable examples include:

- *Austria*, which led the application of global performance-based code solutions. This enabled innovative material solutions that could demonstrate compliance beyond deemed-to-satisfy applications (or their equivalent).[16] A good example of this is early testing performed in 1996 by the Austrian manufacturer KLH, in partnership with the Technical University of Graz. This testing went on to assist Waugh Thistleton Architect's Murray Grove project, which was completed in 2009.
- *Finland*, which pioneered early fire regulations via its 2011 Building Fire Code. This paved the way for the broader implementation of mass timber in multi-storey residential and office applications. Via its National Wood Construction Program, the Finnish Government also supported built projects, education, and research around building with wood, and facilitated cross-disciplinary collaboration and knowledge sharing. These initiatives were also present in local cities – for example, the City of Joensuu, and the City of Helsinki, subsidised mass timber construction and applied favourable zoning to encourage timber buildings.[17]
- *Sweden,* which similarly positioned itself as an early leader in timber construction. Since 2004, the Swedish National Timber Construction Strategy has facilitated R+D partnerships with Swedish universities, and public and private collaborators. A particular success story in this regard was the City of Växjö, which implemented the More Timber in Construction program, which set local targets for mass timber buildings, and provided funding for R&D and academic partnerships that would aid collective efforts.[18] Similarly, the early trade literature produced by Swedish Wood laid the groundwork for knowledge sharing in the UK.

These three examples reveal instances where R&D in the European Union influenced the British context, directly and indirectly. Knowledge could then be shared between their design and construction industries.

Project: Wildernesse Restaurant
Photographer: J Donnelly

Contextual Factors – The UK

LOCAL KNOWLEDGE SHARING AND DISSEMINATION

Building upon its proximity to Europe, the UK was able to quickly establish local industry know-how around CLT. This contributed to a situation where the material went from being used in fringe applications to it entering a greater mainstream.

The European industry provided early precedents, and research foundations, for CLT buildings. However, it took localised early adopters to explore and experiment with the material in the UK, before it became more prolific. These initial users gained on-the-ground knowledge, which was then shared formally and informally within the industry. Certain architects, contractors, and engineers also developed significant public profiles as advocates for CLT construction. They showcased their pioneering projects, allowing the lessons learned to disseminate throughout the industry. This, in turn, positioned them as industry leaders who modelled what was possible with the material.

In a similar vein, the 2016 paper 'Adoption of Unconventional Approaches in Construction: The Case of Cross-Laminated Timber' noted that the main barrier to CLT's implementation in UK-based projects was uncertainty around the material's performance. The paper notes that "designers and contractors rely on the information provided by suppliers to undertake initial design and on specialist engineers for more detailed construction calculations."[19] This, in turn, gives architects confidence in specifying a material that they haven't used before. This same finding arose in informal interviews conducted alongside this report's case studies - a number of architects mentioned that they relied on the knowledge of engineers, and industry peers, to overcome the knowledge gaps they had working with CLT for the first time.

This suggests that networked knowledge, where architects can draw upon the expertise of those around them, has been essential in CLT's wider use in the UK. This same paper also pointed to the important role of the architect in encouraging CLT, describing designers as the primary actors in proposing its use within a project (61.7% of responders). [20]

Painting a positive and inspiring picture, and showcasing what's possible with CLT, has also helped. Some of the UK's leading industry advocates in this regard are:

EURBAN – CLT DESIGN CONTRACTOR AND ENGINEER

Eurban occupy a unique position within the UK in that they are engaged in the design, manufacture, and fabrication of mass timber buildings. They pioneered the material within the UK market and were instrumental in the design and construction of the UK's first CLT building (The Performing Arts Centre at Caldicott School, Henley Halebrown Rorrison, 2004). They have also worked frequently with the Borough of Hackney, whose shelved 'Timber First' policy is discussed in the later pages of this report.

Eurban began working with CLT in 2003 and most of their initial projects were schools linked to the Building Schools for the Future programme. Since then, the contractor has partnered in the delivery of over 150 educational projects.[21] It is noteworthy that Eurban were involved in three of the eight case studies in this report, a live example of the impact of networked knowledge.

Project: Drawing Matter Archive
Source: https://www.eurban.co.uk/mass-timber-construction/

DRMM – ARCHITECT

Drmm, and particularly its director Dr Alex de Rijke, became spokespeople and early adopters of cross-laminated timber construction in the UK. In 2006, the studio exhibited the first cross-laminated timber flatpacked house in Oslo while, in 2007, they began using CLT in school buildings, including in the Kingsdale School. Since then, drmm have partnered with AHEC and Arup to create a hardwood version of cross-laminated timber. This was first used in an installation project in 2013, and this testing ground led to its implementation in a permanent building, Maggie's Oldham Centre, in 2017.

As de Rijke writes on the studio's website:

> *"For over 30 years in academe and practice I have been an outspoken advocate of engineered timber's outstanding versatility, weight to strength performance, sustainability, speed and limitless expression. I will continue to advocate in the UK and internationally, with the added imperative of the climate change crisis."* [22]

Project: Kingsdale School
Source: https://drmmstudio.com/project/kingsdale-school/

WAUGH THISTLETON ARCHITECTS– ARCHITECT

Waugh Thistleton Architects were also amongst the earliest users of CLT in the UK market. They have designed and delivered countless industry-leading projects, many in the Borough of Hackney. One of these is Murray Grove, a multi-residential timber housing project completed in Hackney in 2009, which is cited as an early pioneer of CLT construction in the UK. Another is Dalston Works, a ten-storey, high-density housing project that employed CLT for its external, party and core walls. It was the world largest CLT building upon its completion.[23] Most recently, their Black and White Building, which has a CLT core and floor plates, has received widespread press and countless awards.

Outside of providing built precedent, Waugh Thistleton Architects have also been responsible for creating a series of free downloadable resources on building with mass timber and CLT. These include the manual, 100 Projects UK CLT, published in 2018 with the support of the Softwood Lumber Board & Forestry Innovation Investment. This dossier profiles exceptional examples of CLT across the UK and provides a primer on CLT's design and material performance factors. In a similar vein, the 2023 'Timber Typologies' manual, developed in collaboration with Timber Development UK, contains excellent resources on building with CLT. The aim of this guide is to provide all built environment professionals and clients with collated knowledge on timber construction, with the goal of accelerating lower carbon outcomes and, ultimately, a net zero built environment.[24]

Project: Dalston Works
Source: https://waughthistleton.com/dalston-works/

Contextual Factors – The UK

REGULATORY CONTEXT

In innovation, timing is everything. Without quite knowing it, from the early 2000's onward, Britain's regulatory context inadvertently created an environment that supported the early adoption of CLT. Many of these factors were coincidental and did not directly aim to improve CLT's uptake. However, as time went on, certain policies targeted mass timber construction and supported its growing use. Notable policies and regulatory instruments include:

- In the 1990's, amendments to the UK building code revised the height limits for multi storey timber buildings, paving the way for CLT to be used in this typology.[25] It is therefore no coincidence that many of the UK's early CLT buildings were mid-rise residential developments
- In 2004, the Labour Government introduced the Building Schools for the Future programme. This policy supported the refurbishment and construction of secondary schools across the UK. This unintentionally facilitated a number of the UK's earliest CLT projects, as the material proved ideal for schools and school clients. The engineer and contractor Eurban suggest there is a natural affinity between CLT and education projects because the client acts as both the owner and user.[26] They are therefore committed to quality and may be less cost conscious than a more commercial client. Many of the CLT projects built under this policy then became demonstration projects for other construction types.
- In 2012, the London Borough of Hackney proposed a 'Timber First' planning policy as part of its commitment to sustainability. Although the policy was ultimately shelved, it generated ample public discourse about the benefits of mass timber and CLT in an urban context. It also led to several high profile CLT projects being built in the Borough, including The Cube (Hawkins\Brown Architects, 2015) and Dalston Lane (Waugh Thistleton Architects, 2017).
- As noted previously, research and development conducted in the European Union facilitated local performance solutions. For example, Waugh Thistleton's Murray Grove relied on the European Technical Approval gained by the Austrian manufacturer KLH to meet fire, structural performance, and thermal regulations.[27] It also gained an exemption from mandatory on-site energy requirements, known as the Merton rule, by demonstrating that its timber structure had sequestered carbon comparatively to a concrete or steel structure.[28]

RESPONSE TO THE CLIMATE CRISIS

The final factor that has supported the momentum of CLT in the UK is growing industry recognition of climate change. Again, this relates to the UK's regulatory context and, more specifically, national policies responding to the climate crisis.

In 2008, the UK government passed the Climate Change Act, a piece of legislation that outlined the national response to climate change. As part of this law, the Climate Change Committee (CCC) was established 'to ensure that emissions targets are evidence-based and independently assessed.'[29] In 2019, this Act was amended to include a commitment to achieve net zero by 2050, alongside a legally binding target to cut national emissions by 78% by 2035, when compared to 1990 levels.[30]

This legislative context placed the climate emergency at the front and centre of social and political debate. This, in turn, fostered a culture within the UK where architects appeared at the front line of a changing profession. A groundswell of grassroots industry support emerged via the likes of the London Energy Transformation Initiative (LETI, established in 2017), Architects Declare (2019), and ACAN, or the Architects' Climate Action Network (established in 2019). The Royal Institute of British Architects (RIBA) has also been privy to this change, releasing a paper entitled 'Embodied and Whole Life carbon Assessment for Architects' in 2018, and establishing the RIBA 2030 Climate Challenge in 2019. It has also teamed up with LETI to establish embodied carbon principles in tandem with a typical project plan of work.

All of these organisations share similar goals around disseminating knowledge about the climate crisis, campaigning for policy and political change, and aiding the transition of our construction economy to net zero. As discussions have tilted away from operational carbon, and move towards embodied carbon, CLT has become a powerful actor in the quest for change. The desire to reduce material impacts has resulted in an asymptotic interest in bio-based, regenerative and carbon sequestering materials, including CLT. As noted earlier in this report, CLT also has other benefits in that it can encourage reductionism on building sites, resulting in less construction overall and less waste.

Across practice, policy, and advocacy bodies, it is clear that British architects are compelled to respond to the climate crisis, and CLT is a material poised to perform in this emerging and vital context.

Evolving Local Context - Australia

CLT remains a relatively underutilised material within Australia. However, since this proposal was first written, its position within the design and construction industry has shifted.

CLT took longer to reach the Australian market, and it faced unique regulatory hurdles. There was therefore ample time before Australia saw its first CLT building, the 10-storey Forté block by Lendlease, built in 2012.

Forté was significant in that it was also world's tallest timber residential building, measuring 32 metres tall upon completion.[31] It was, however, constructed from CLT supplied by the Austrian company KLH, as there was no locally sourced CLT available at the time.

Between 2012 and 2016, a modest number of projects were completed using the material, despite promises that Australia had entered a "new era in the future of sustainable development." A number of changes to the Australian building codes then encouraged an increase in uptake.

Much like in the UK, a network of factors are now working to promote CLT construction. Today, timber construction is undergoing somewhat of a renaissance in Australia. This is in large part due to the precedents set by exemplar local and international projects, a changing regulatory context, and an increased desire to respond to the climate crisis with conscious material selections. In parallel to the UK, an evolving culture of knowledge sharing is also underscoring these developments.

EXEMPLAR PROJECTS

Since this proposal was first undertaken, CLT buildings have continued to evolve and be exhibited around Australia, providing greater local precedent and embedded knowledge. This has now evolved across typologies and exemplar projects have appeared around the country.

Exciting projects, such as International House (Tzannes, 2017), 25 King (Bates Smart) and the Phoenix Central Park Performance Space (Durbach Block Jaggers, 2020) have demonstrated the potentials of CLT construction. The material is also being left visually exposed, which ensures it is legible.

At a smaller scale, an increasing number of practices – including Trias, of which I am a founding director – have now built smaller scale domestic projects using CLT. At Trias, this has come about via a collaboration with the prefabricated construction company FabPreFab, with whom we have designed a series of modular homes.
In the residential space, notable projects include CLT Passivehaus (Betti + Knut Architecture, 2020), Seed House (Fitzpatrick+Partners,2019), CLT house (FMD Architects, 2021) and Maianbar House (Ecobuild Design, 2016). In the case of Maianbar House, ninety-five per cent of the structure is CLT and the build was prefabricated off-site and erected in eight days - a true case study of the benefits of building with CLT.

LOCAL SUPPLIERS

A lack of local supply options initially resulted in the slow uptake of CLT, as internationally sourcing was deemed cost prohibitive and logistically challenging for many projects. Most early built examples were therefore in the commercial sector, where the production volume could absorb such challenges and costs.

This began to shift when X-LAM had opened its first local CLT factory in Albury-Wodonga in 2016. The introduction of X-LAM into Australia brought new knowledge and bolstered the design arguments for CLT, in that its local presence reduced time, cost and logistical barriers.

X-LAM is a subsidiary of Hyne Timber, one of Australia's largest producers of sawn timber products. They were the first manufacturers of CLT in Australasia, via their factory in New Zealand. Prior to this, the supplier spent five years shipping CLT from its New Zealand factory to Australia in order to compete with the predominantly European based suppliers.

As new suppliers continue to emerge, costs will likely continue to go down via market competition. NeXTimber, a CLT factory in South Australia opened by Timberlink, began production in October 2023, bringing further supply potential to the Australian market.

Previous Page
Project: Homerton Hall
Photography: Jonathon Donnelly

Opposite
Project: FabPreFab Offices (Trias)
Photography: Clinton Weaver

REGULATORY FRAMEWORK

As in the UK, changing regulations have aided the uptake of CLT in Australia. In January 2016, the Australian Building Codes Board (ABCB) announced changes to the National Construction Code (NCC) that would enable timber buildings up to 25 metres in height to be lodged with planning under deemed-to-satisfy provisions. Proponents of CLT construction rejoiced unanimously because the change ultimately removed another barrier dissuading developers and consultants from using CLT.

Regulations are also slowly emerging that specifically encapsulate - for example, there is a Glued Laminated Timber (GLT) standard for the region, AS/NZS 1328- parts 1 [40] and 2 [41]: Australian and New Zealand Standard for Glued Laminated Structural Timber. However, in the 'Mass Timber Construction Journal,' Shaghayegh Kurzinski, Paul Crovella and Paul Kremer note there is still a gap in the Australian Standards when covering CLT:

> *"However, at present, there are no specific CLT structures code and construction standard. Also, CLT is not covered under the 'deemed-to-satisfy' provision of the Building Code of Australia (BCA). The most recent and commonly used timber standard in the continent is AS 1720.1: Timber structure [42]. The standard was developed by the Joint Standard Australia/ Standards New Zealand Committee, Timber Structures, in 1997.... It also addresses specifications regarding test methods, and timber products, including Laminated Veneer Lumber, plywood, and Glued-laminated Timber. Since this standard does not include any particular section explaining Cross-laminated Timber, a CLT manufacturing standard is needed to accelerate the adoption of the product."*[32]

As was evidenced in the UK, more progressive legislation would incentivise CLT usage and assuage doubts, concerns and fears about using the product. When these framework changes are partnered with emerging supplier relationships - and knowledge from local architects and consultants - the material's use should surge.

Project: Minima (Trias)
Photography: Clinton Weaver

Project Methodology

Seven distinctive case studies were chosen and visited as part of this report. The final case studies included in this report are noted below. They are presented chronologically, in order of their completed construction dates:

1. The Museum of Garden History, Dow Jones, 2008
2. Drawing Matter Archive, Hugh Strange, 2012
3. Wildernesse Restaurant, Morris + Company, 2018
4. Drayton Green Church, Piercy and Company, 2018
5. Sands End Arts and Community Centre, Mae Architects, 2020
6. Homerton College Dining Hall, Fielden Fowles, 2022
7. Old Street, Mary Duggan Architects, 2023 (under construction)

Most of these buildings were included within the initial proposal but others, such as Mae Architect's Sands End East Arts and Community Centre, were only uncovered during the research tour. In the end, these studies replaced other buildings that proved difficult to visit or could not be documented comprehensively. While it was unfortunate to miss some of the initial case studies due to COVID, it proved serendipitous to be able to visit newer buildings that showed CLT being used in exceptional and unexpected ways. In the same vein, the opportunity to visit Mary Duggan Architecture's Old Street Project while under construction was helpful in seeing a work-in-progress that involved CLT.

The methodology for assessing and analysing each case study was kept consistent, though expands and contracts to reflect the information available within each discrete example. Discussions with project architects, studio founders and building users allowed for certain case studies to be more embellished and detailed; similarly, some projects had more detailed documentation and drawings available, which underscored their analysis.

All of the included buildings were visited in person. The value of experiencing these buildings in the flesh is not to be underestimated; not only did allow each work of architecture to be truly appreciated, but it allowed initial assumptions to be challenged and tested. It also revealed the material's idiosyncrasies and pitfalls. It was possible to witness the affects of time, ageing and wear and tear; to see where new finishes, such as fire retardants, had been applied; and to experience how CLT looks and feels when a building is lively and in use. All of these dynamics are impossible to understand with photographs alone.

A consistent methodology was applied to each case study. This noted the following four areas of investigation:

THE BUILDING DIAGRAM

Each case study begins with a diagrammatic analysis of the chosen building. The intent of this is to explain the key architectural concepts within the building, and to note the role that CLT construction plays within the larger whole. The building diagram is documented with a simple diagrammatic drawing. This intends to showcase where CLT is deployed within an overall architectural diagram, revealing its most common uses alongside more unusual or innovative applications.

CONSTRUCTION APPROACH

This section explores how CLT works within each structural system. Each case study showcases where CLT is used structurally and attempts to understand why it was chosen. It also notes where the material is left exposed, and where it is clad or covered. Using drawings, diagrams and photographs, this part of the methodology distinguishes hybridised parts of each structure from elements that rely exclusively on CLT. It begins to understand the structural systems that CLT is commonly paired with, intuiting why these combinations are used and what architectural possibilities this offers.

THE BUILDING'S APPEARANCE AND TACTILITY

Each case study showcases the places where CLT appears as a visible finish. It considers when and why CLT is left exposed, and highlights material coatings or finishes that have been applied to the timber. This is documented with photographs.

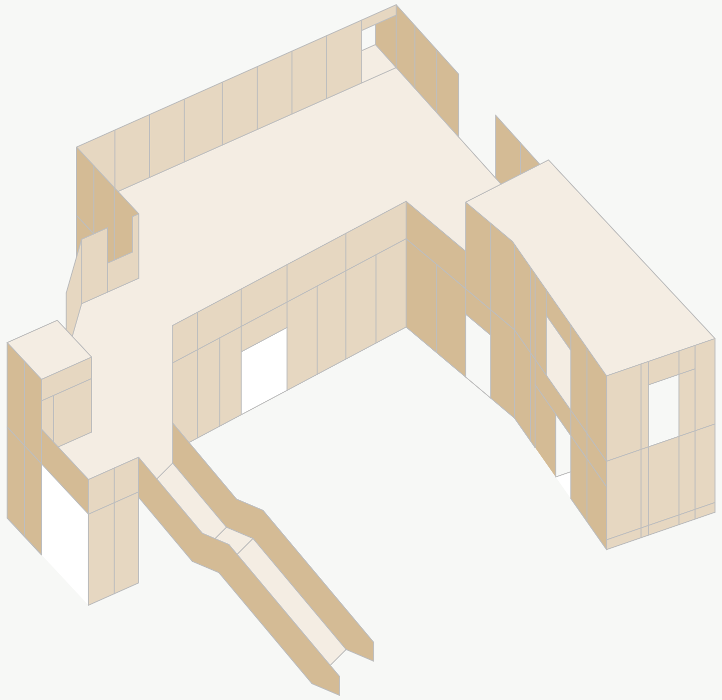
THE CRAFTED JOINT

The final layer of analysis assessed the joint. At this finer scale, there was an opportunity to explore the crafting of massive timber buildings and how the meeting of elements might expand beyond typical 'plate' or 'slab' construction, to more inventive solutions. These details and moments of craft were documented with photographs and, where possible, drawings.

Project:
Cowan Court (6a Architects)
Photographer: J Donnelly

01 The Museum of Garden History

Location: Lambeth, London, UK
Area: Unknown
Engineer: Eurban
Client: The Garden Museum
Completed: 2008



The Museum of Garden History

THE BUILDING DIAGRAM

The Museum of Garden History is an adaptive reuse project that makes use of St-Mary-at-Lambeth, an existing Grade II heritage listed church. It sleeves a new CLT museum exhibition space within the larger church volume, adapting the heritage shell for a new use.

The architect, Dow Jones, won the project by competition in 2007. Their design strategy introduces a new, CLT walkway structure – described by the architects as a belvedere - within the interior volume of the church. This increases the usable floor area of the museum, allowing the ground floor to be used for public programs, such as lectures, and for income-generating events, like weddings. The new, elevated CLT structure hosts the museum's permanent collection and group activity rooms, while the resulting 'undercroft' spaces house temporary exhibitions.

The project is inventive in the manner in which it interacts with the heritage church. The pathway made by the new CLT structure is a snaking circulation route that meanders alongside the museum's displays. The path occupies the two sides of the church aisles, which visitors are immediately invited to ascend. A bridging structure then assumes a single path, before finishing back downstairs in the central space.

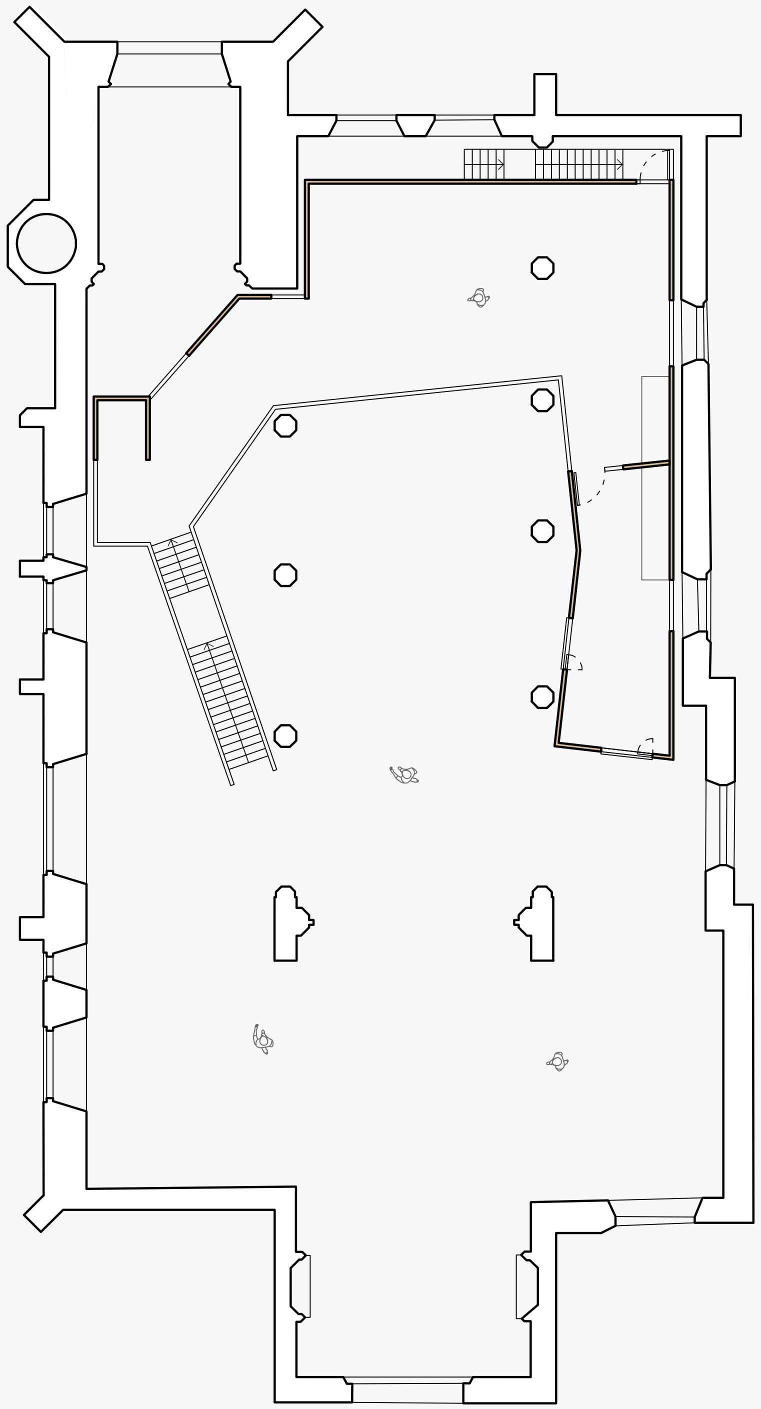
Along the way, visitors are offered opportunities to peer down into the former church nave from up high. These delightful vignettes are a welcomed part of the museum experience. Similarly, at key moments, the CLT is cut back to create reveals that showcase parts of the surrounding church. This ability to encounter the church while elevated – and enjoy close proximity to its ornate ceiling and stained-glass windows – is one of the defining features of this architectural experience.

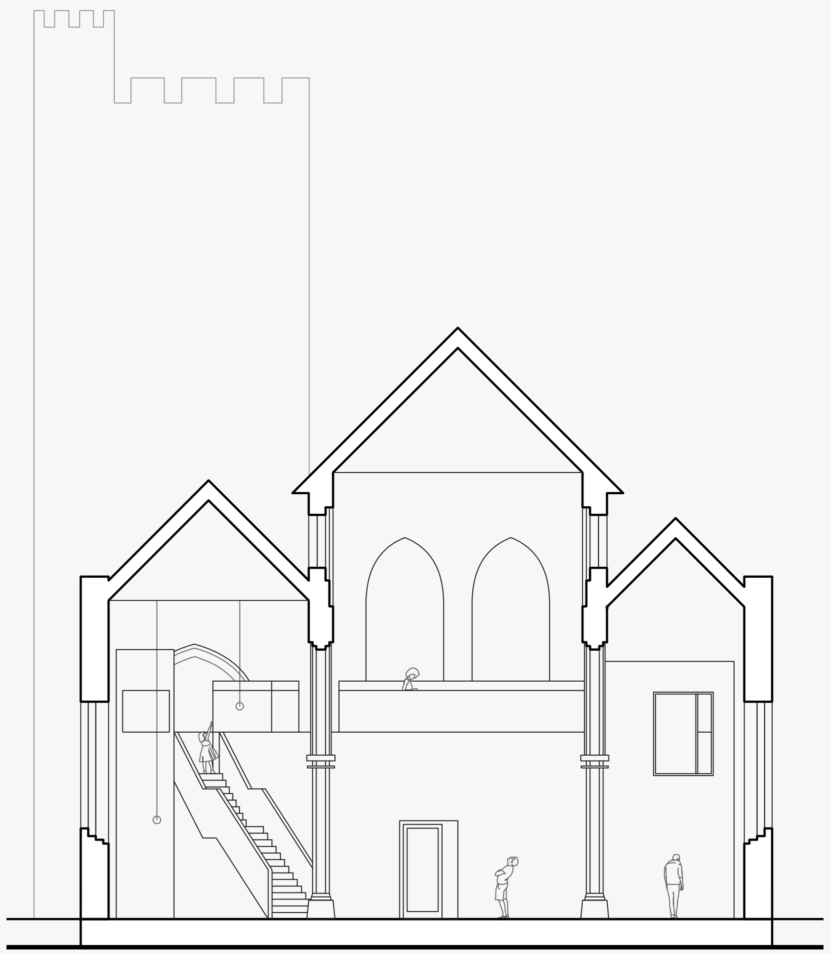
CONSTRUCTION APPROACH

The new structure is self-supporting and exists independently of the church walls and windows, and only touches its floor. This means the church is left largely in tact, and there is a clear delineation between old and new built form. In achieving this, it is a successful example of how contemporary architecture can converse with a historical building and leave its fabric relatively unaltered.

The new structure relies on pre-cut CLT panels. These are used for the stair treads, balustrade, infill walls and exhibition displays. The entire structure is freestanding, and uses a combination of thick and thin CLT panels. It is also reversible and designed for disassembly.

CLT was chosen for the structure because it is both lightweight and strong. It could also be prefabricated, which shortened the museum's closure time to only three weeks.





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THE BUILDING'S APPEARANCE AND TACTILITY

The interior of the Museum of Garden History is a balance of grandeur and intimacy. The bones of the old church lend the project a vastness and volume, while the more recent CLT intervention adopts a more inviting human scale. Similarly, the expression and detailing of each architectural layer is a study in contrasts: the fine filigree of the church is offset by the simple, unadorned planes of the new CLT stairs and bridges.

This project is a simple and relatively singular celebration of CLT. The material is left exposed across most of the interior. The result is a recessive structure that blends into the pale church surrounds. The floor is a contrasting black linoleum. Elsewhere, selected CLT walls are painted or stained to complement exhibitions, while layers of plasterboard allow for displays to be easily repainted or changed.

The finishing of the CLT was distinctive to the other case studies; its surface appearance was white and quite chalky. This finish came about from two layers of coating, both of which were unplanned. Initially, a white stain was applied to the CLT as it started yellowing. Soon after, a white fire retardant was applied to the surfaces. This happened in response to changes in fire regulations. The result is a unique interior finish, where CLT has an almost petrified appearance that closely resembled the pale limestone within the church. This made the CLT look 'heavy' and masonry-like and removed a lot of the visible timber grain.

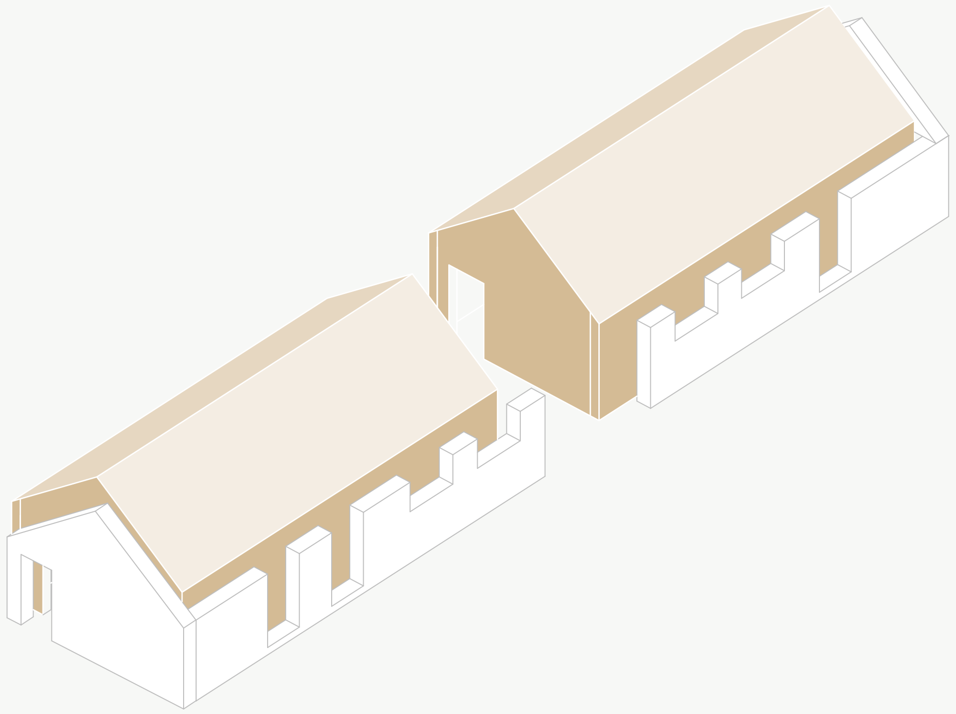
TOP

Drayton Green Church

Photographer: J Donnelly

02 Drawing Matter Archive

Location: Yarlington, UK
Area: 120m^2
Engineer: Price + Myers
Client: Niall Hobhouse
Completed: 2014



Drawing Matter Archive

THE BUILDING DIAGRAM

The Drawing Matter Archive is located on Shatwell Farm in the UK. The farm remains a working agricultural property, but also includes a series of experimental, whimsical architectural follies commissioned by the client and benefactor, Niall Hobhouse. A keen collector and architectural enthusiast, Hobhouse also owns an astonishing archive of architectural drawings, models and design fragments amassed from globally renowned studios. As the former curator of Drawing Matter, Markus Lähteenmäki, writes: "The archive and the operations around it – entitled Drawing Matter – are the heart of the farmyard. The ambition of the project is to explore drawing as a medium that makes architecture. Its many activities comprise a website, print publications, educational initiatives, summer schools, academic collaborations and, at least when I was still working there, exhibitions."[33]

The archive is composed of two halves, with one side containing a working studio space, bookended by a small bathroom and kitchenette, and the other holding Hobhouse's extraordinary collection. A covered entryway sits between the two structures, forming a void in the project diagram.

The Drawing Matter Archive inserts itself within the remnants of a former stone and brick barn. While this appears as a visible ruin, in actuality the old barn was taken apart, stabilised and reinstated to form a perimeter wall. The old and new structures sit independently of one another, while a singular roof, covered in fibre cement sheeting, sails confidently over both structures. The result is a delightful and clear diagrammatic reading of one structure, which sits nestled within the footprint of the other.

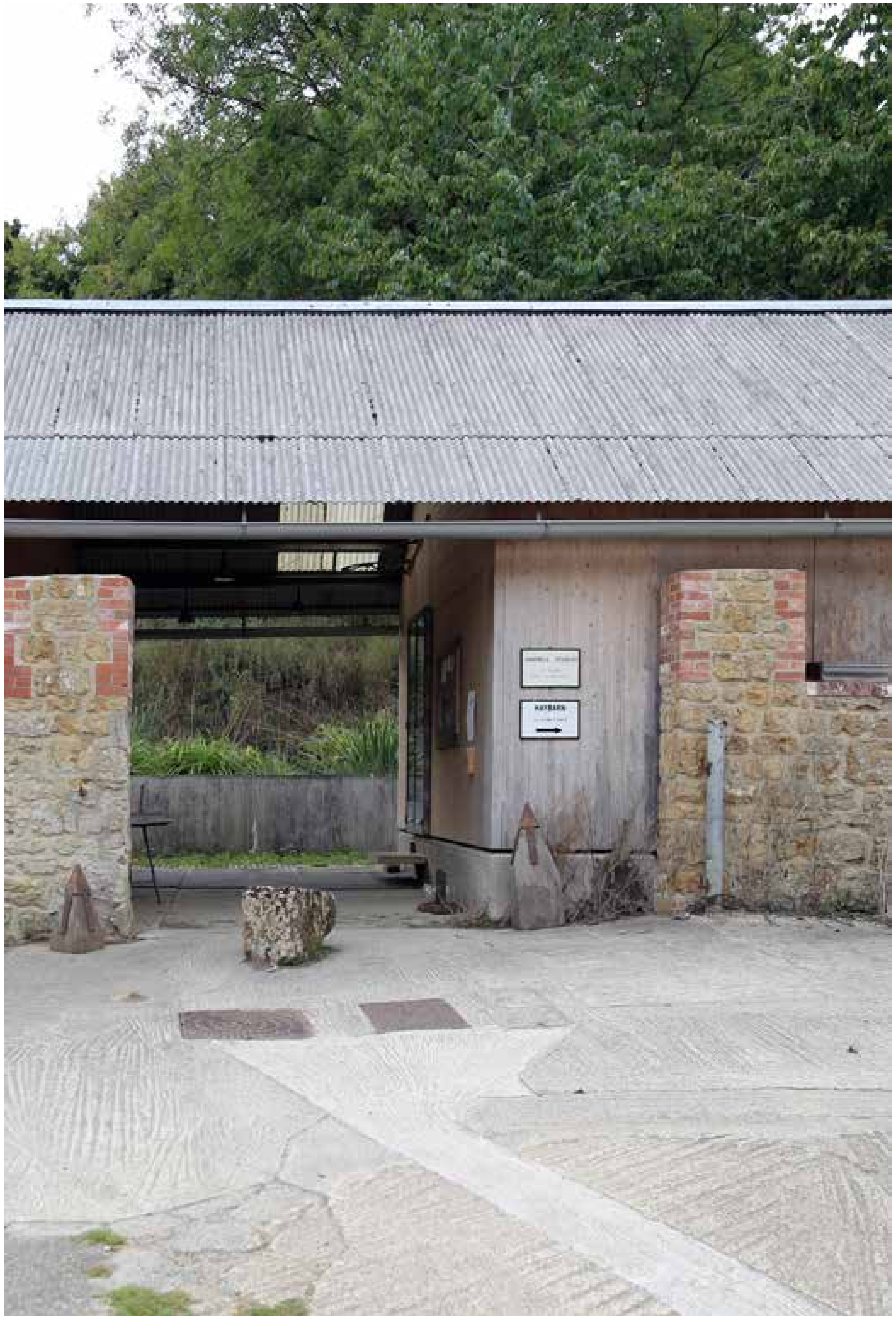
The walls at the Drawing Matter Archive are made of massive, singular slabs of CLT. They therefore have no additional structure, lining, cladding or insulation. This factor alone makes the Drawing Matter Archive a highly experimental structure, devoid of the technified layers so common within contemporary architectural construction and detailing.

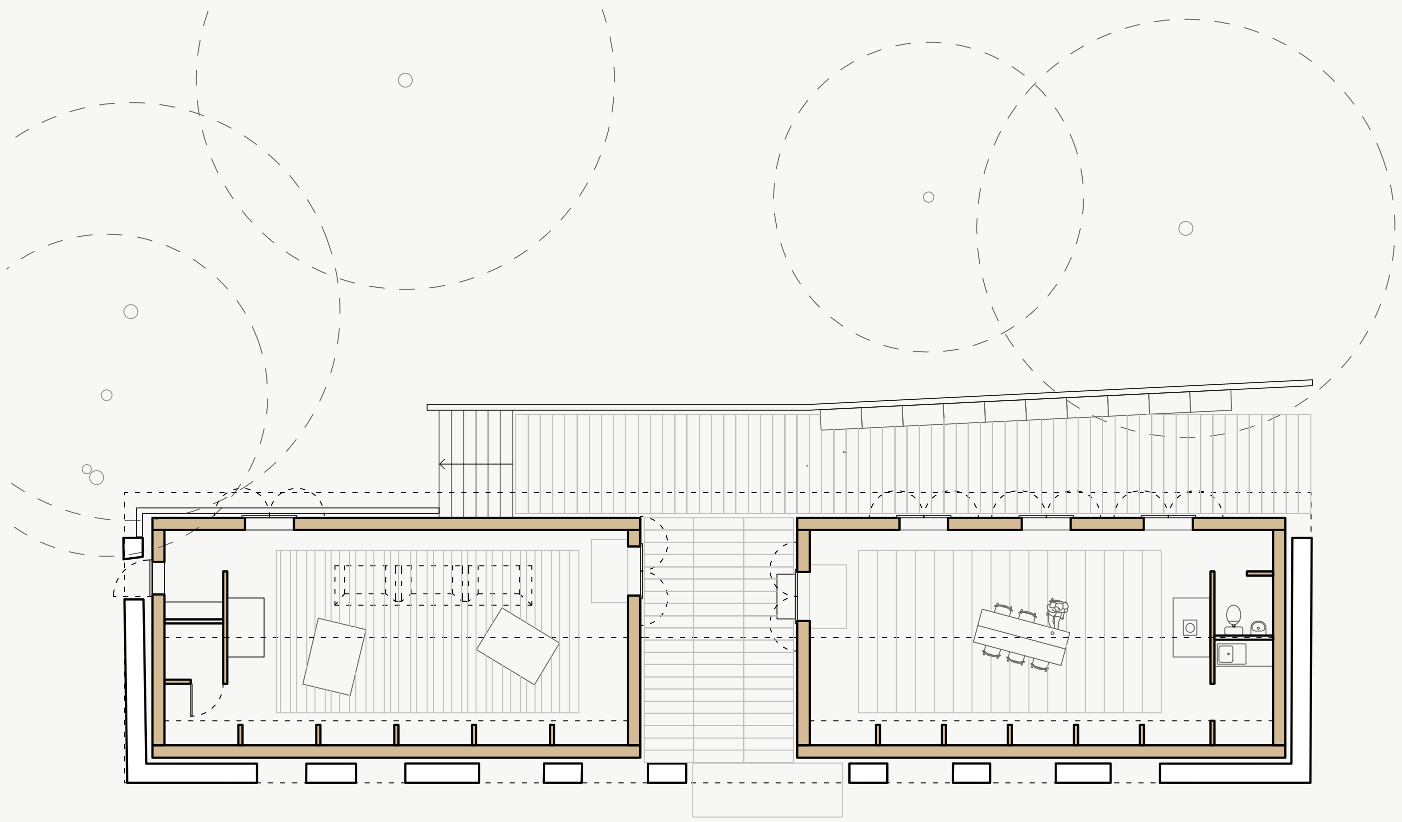
Interestingly, Hugh Strange was the only architect within this study who had worked with CLT previously. An interview, undertaken at Strange's studio in South London, revealed how he first used CLT in the construction of his own home, Strange House. In this original project, he thought of the CLT, which was used for walls and the roof, as being akin to blades and planes, and described it as slender and yet supportive. In contrast, Strange sought to experiment with the heft and mass of CLT within the Drawing Matter Archive. In this way, Strange creatively inverted the reasons many architects use CLT and embraced counterintuitive qualities to produce something unique.

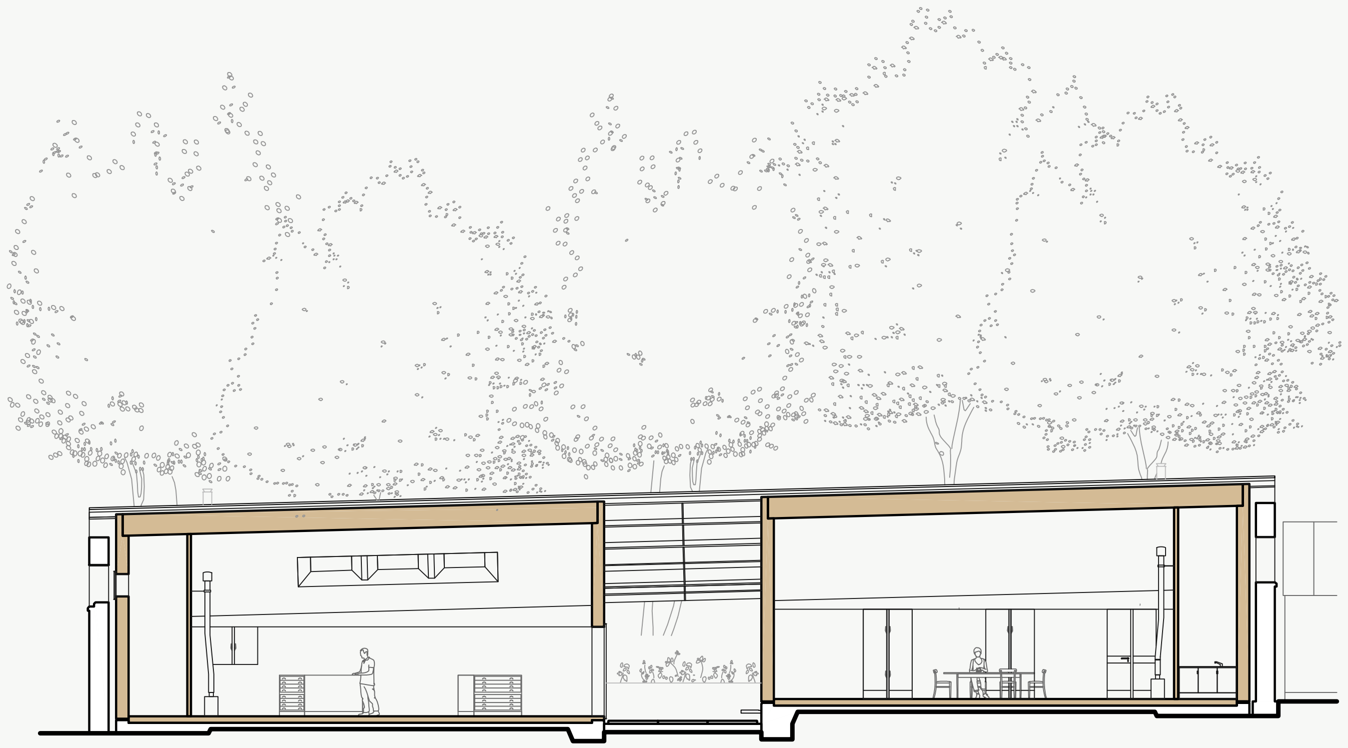
Within the Drawing Matter Archive, the timber appears carved at, almost like stone, and yet the building is still assembled in the same planar manner as Strange House. Conceptually, the material was conceived of as a monolith, providing dense, thick and thermally protective walls. The CLT is left exposed on both the outside and inside walls, with a projected eave protecting the exterior face. While the material is more worn externally, it is still in reasonable condition – a fact that is also no doubt a product of the UK's climate and would be far more difficult to achieve in Australia.

The CLT walls, which are made of spruce, were assembled as panels and sliced to create openings. The thickness of the panels, and the planar joints of the large panels, is expressed in the window reveals and carved out skylights. The resulting architectural language – of a dense and heavy building, made of seemingly light timber - is unique to this project and was a biproduct of the more generous dimensions used for the walls.

Strange initially suggested CLT for the Drawing Matter Archive simply because it was seen as a relatively untried material. This spirit of experimentation suited Hobhouse's vision for







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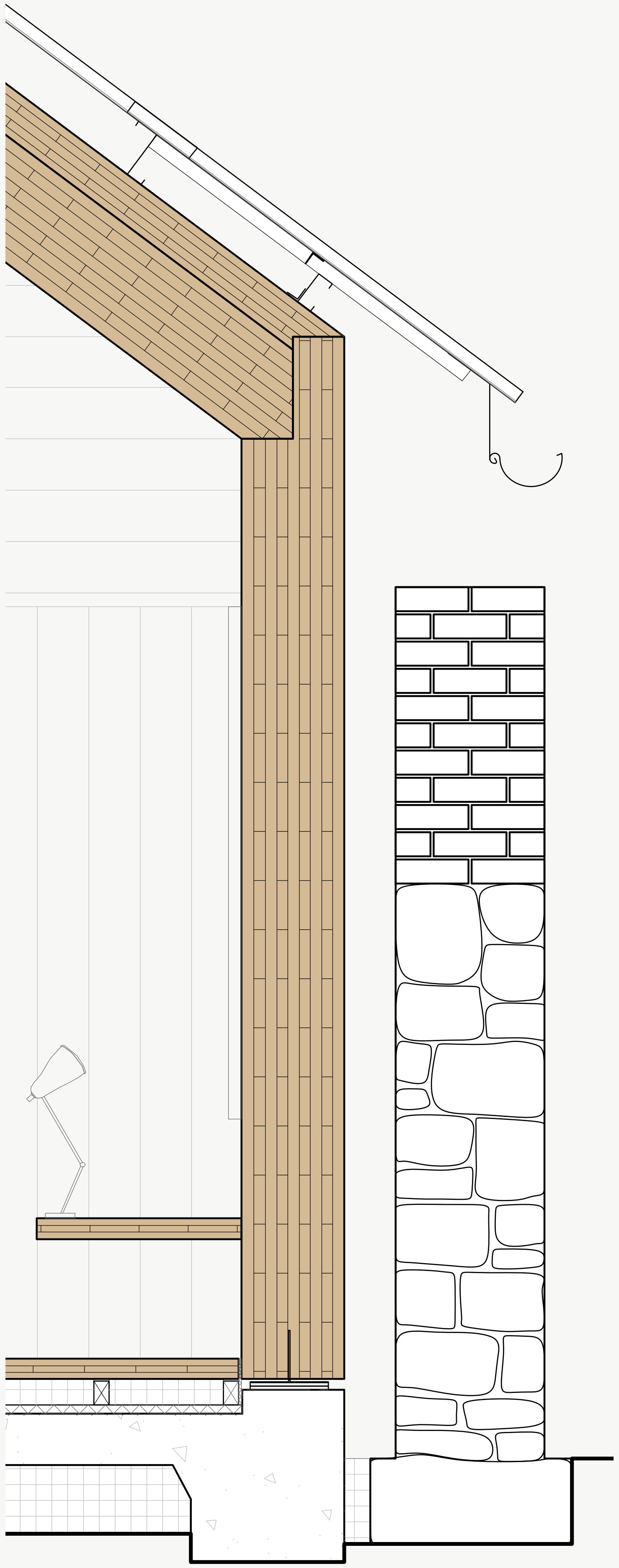

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Shatwell Farm, given it is a playground for architectural testing.

CONSTRUCTION APPROACH

The building structure is comprised of massive, thickened CLT slabs, used on the walls and roof. Interestingly, this thickness was sought to improve the building's thermal performance, and was not done out of structural necessity.

The Drawing Matter Archive is the only case study where CLT was preferenced for its insulative properties. The walls measure 300mm thick, and have a U-value of 0.35, while the roof is 420mm thick, with a U value of 0.25.[34] To see how this translates into performance, the project is now subject to hourly temperature and humidity monitoring, courtesy of a research team from Kingston University.[35] This is intended to better assess and understand the structure's thermal stability throughout summer and winter, and determine whether it can meet the stringent temperature and moisture requirements of an archival space.

Interestingly, these hypotheses are reflected in industry literature. CLT supplier Stora Enso notes:

> *"With three layers and more, CLT elements are "air-tight" but not vapour-proof. CLT is permeable and the adhesive bonds form vapour barriers for the insulation plane.*
>
> *Thus, CLT reacts like a variable vapour barrier. During the heating season, when the relative humidity inside the building decreases, CLT loses its ability to transport moisture and becomes more diffusion-resistant. On the other hand, during the summer, when the level of humidity inside the building increases again, CLT becomes more open to diffusion."*[36]

This suggests that CLT has the ability to regulate humidity, absorbing moisture when it is humid and resisting it when the humidity drops.

The decision to use massive CLT walls also eschews a more conventional structural buildup, which would typically include external cladding, a waterproof membrane, insulation, and an internal lining. The decision to eliminate these performative layers has several consequences for the architectural form and structural diagram.

In the roof, the thicker structure meant that the panels could span lengthwise. According to an article in 'Architecture Today:' "This meant the long side walls took minimal loads and a downstand at the apex of the roof pitch could be avoided, allowing the creation of simple internal volumes."[37] The use of a ventilation cavity between the roof sheeting and CLT structure also helps regulate internal temperatures, especially within the warmer months.

Notably, the Drawing Matter Archive was the only case study that used CLT externally. This was made possible in part via the use of a concrete upstand, which lifts the material off the ground and away from water. A soaring fibre cement roof and eave covers the entrance and perimeter walls, providing further weather protection, while a water-repellent and UV resistant coating was applied to all of the exterior walls as a final line of defence.

The decision to use thickened CLT walls proved challenging during construction. The panels weighed around 3.6 tonnes, which made craning difficult and resulted in the material splitting around the mounting holes. While these defects were patched with timber plugs, the scenario reveals some of the challenges of pushing this material, and its associated machinery, to its limits.

Having heavier CLT panels also required precise on-site installation. The CLT panels slot into aluminium T-sections which sit at the base of each concrete upstand.[38] The tightness of this joint required careful manoeuvring on site, especially given the size and weight of each panel.

Last of all, the construction of the Drawing Matter Archive reveals some interesting truths about hybridised construction systems, particularly when CLT is used alongside existing structural elements. Strange describes the construction timeline as being completed in three distinct chapters: the first being wet trades (demolition, stone repair, concreting), the second including the CLT install, and the third encompassing the interior fitout, electrical work, and door and window installation. The clarity of this sequencing is evident in the final building, in that each of these construction layers – the concrete floor and stone surrounds, the CLT barn, and the sheeted roof – reads as a clear and distinctive architectural element. Down to its jointing, the CLT appears almost like a jigsaw, sliced

and spliced together to form each of the two volumes.

THE BUILDING'S APPEARANCE AND TACTILITY

The Drawing Matter Archive is an example of an interior that leans heavily on raw CLT to create its atmosphere. As the Drawing Matter website details:

> *"Working with the remains of a 19th century store structure and retaining its form, pattern and material presence, Hugh constructed two separate enclosures from monolithic cross-laminated spruce engineered by Eurban. The result is two beautiful rooms, each with a particular character derived not only from the idiosyncratic contents of each, but present in the atmospheres created by equal but differently distributed openings in the massive and continuous envelope, where the smell of the timber, paper, felt, leaves mingles with the open air that passes through."*[39]

The interior of both spaces is comprised of expressed CLT panels; it appears on the walls and tapering ceiling. The floor finishes differ in the two buildings; the office contains rough-sawn cedar floorboards inlaid into the floor, while the archive has smoother oiled ash and beech. Both have a CLT border.

The CLT has yellowed with age, but this is seen as part of the beauty and honesty of the material, which conveys generosity and warmth. This ageing complements the building's function as an archive, and the fact that it sits within a weathered former barn. The materials' characteristic texture, knots and whorls also suit a working site, appearing both contemporary and timeless.

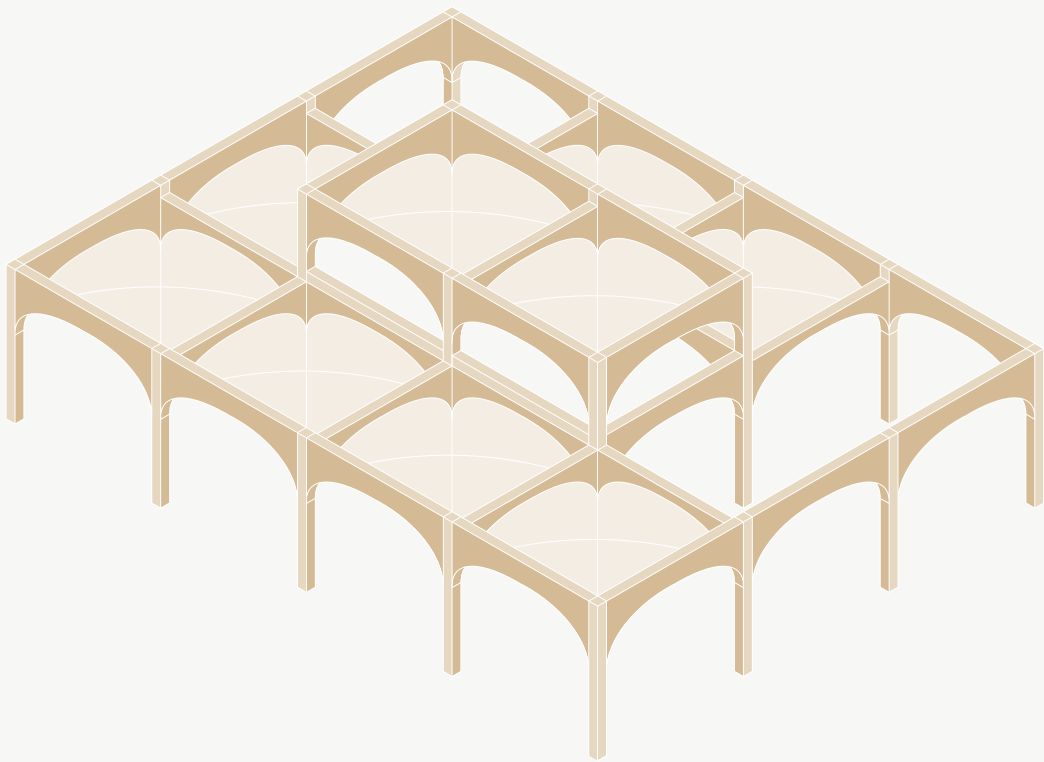
While the two sides of the barn are identical from the outside, their interiors contain distinctive openings and fitouts. This means that the light and spatial arrangements differ in each, creating subtly different experiences. The southern building, which hosts the archive and display spaces, is bathed in soft light emitted from the roof, while the northern building, an office space with a bathroom and kitchenette, has a perimeter of glazed doors that overlook the surrounding forest. In both cases, the use of light and outlook is a reminder that CLT is a natural material, hewn from timber, and connected to the landscape. Or, as Ellis Woodman writes:

> *"...workaday materials have been elevated through the attention paid to their assembly."*[40]

Given the decision to build the Drawing Matter Archive from CLT planes, the CLT end grain was noted as a point of potential failure. These joints were protected by mounting all of the doors, windows and skylights to the outside face of each CLT panel. This protects these junctions and also means the full depth of the CLT is legible throughout the interior.

03 Wildernesse Restaurant

Location: Sevenoaks, Kent, UK
Area: 198m²
Engineer: Peter Brett Associates (Structural engineer), Eurban (CLT subcontractor)
Client: Pegasus Life
Completed: 2018



Wildernesse Restaurant

THE BUILDING DIAGRAM

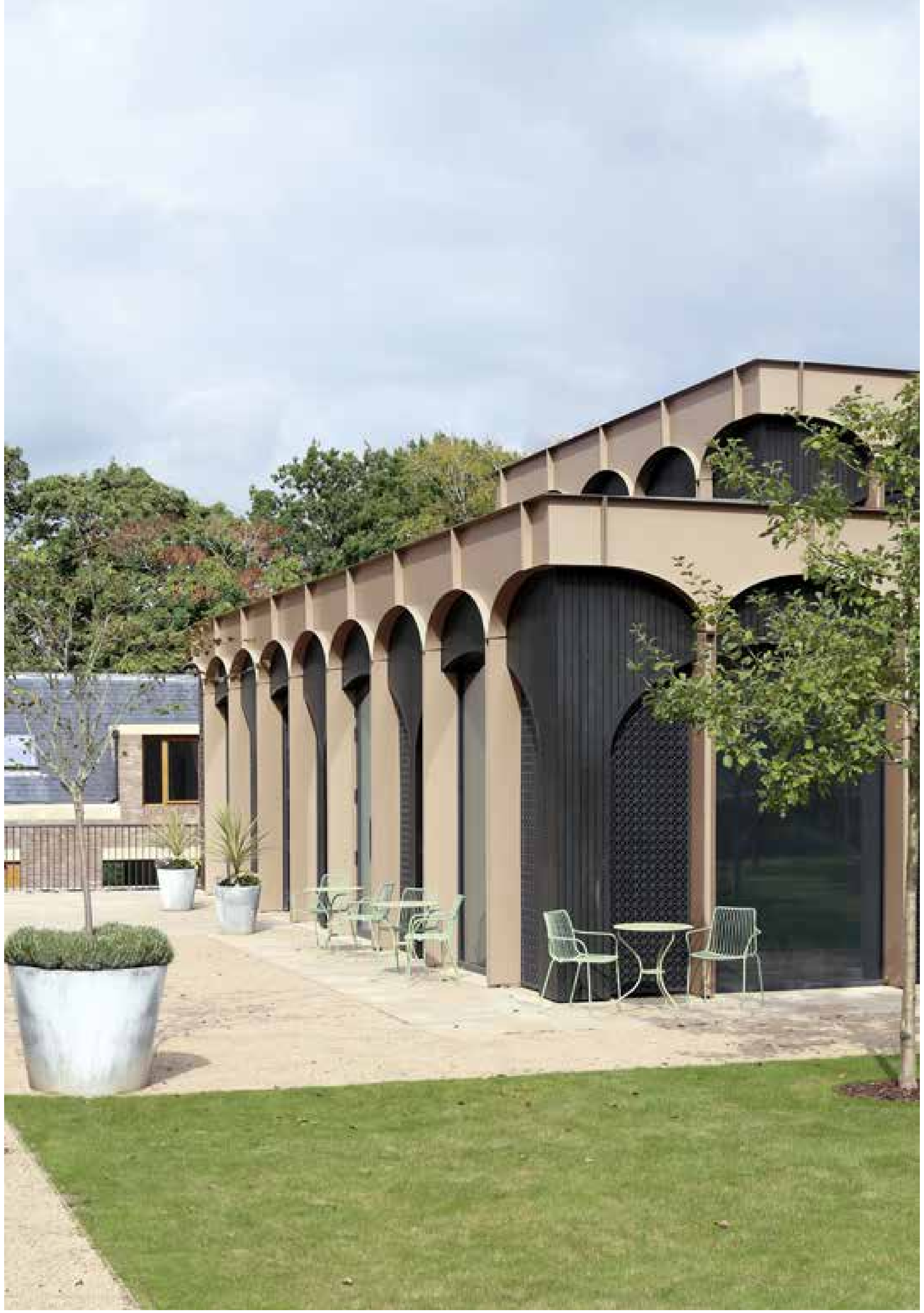
The Wildernesse Restaurant, by Morris + Company, is part of a newly constructed, upmarket retirement community in Sevenoaks, Kent. The masterplan, which is still under construction, will ultimately include eight mews houses and fifty-three apartments, alongside the restaurant and a refurbished Grade II heritage listed dwelling.

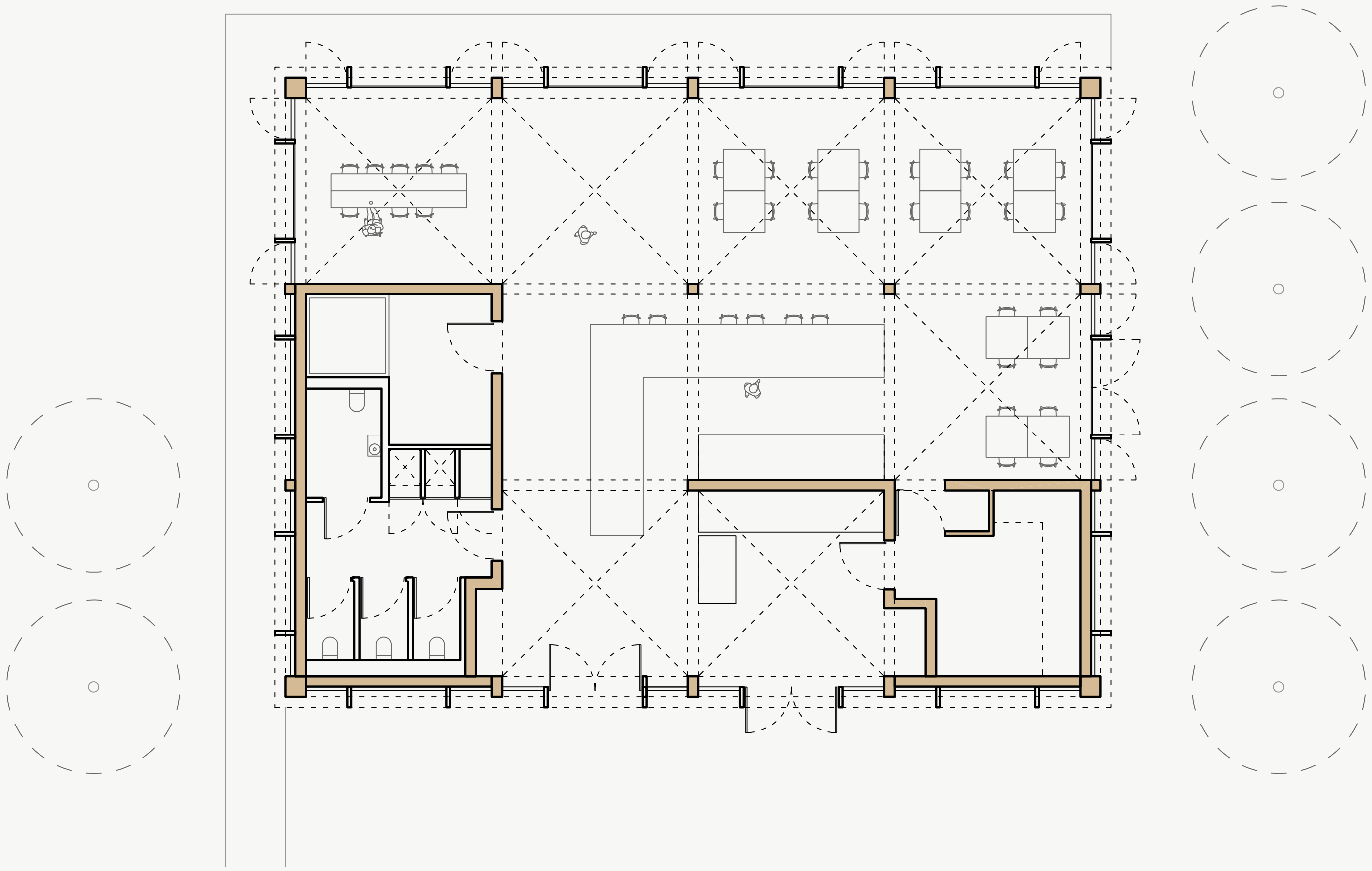
The Wildernesse Restaurant was always intended to serve the community's residents as well as outside guests, a brief which allowed it to take on a distinctive architectural quality. The floor plan is intentionally flexible, allowing the building to function as a bar, restaurant or events space.

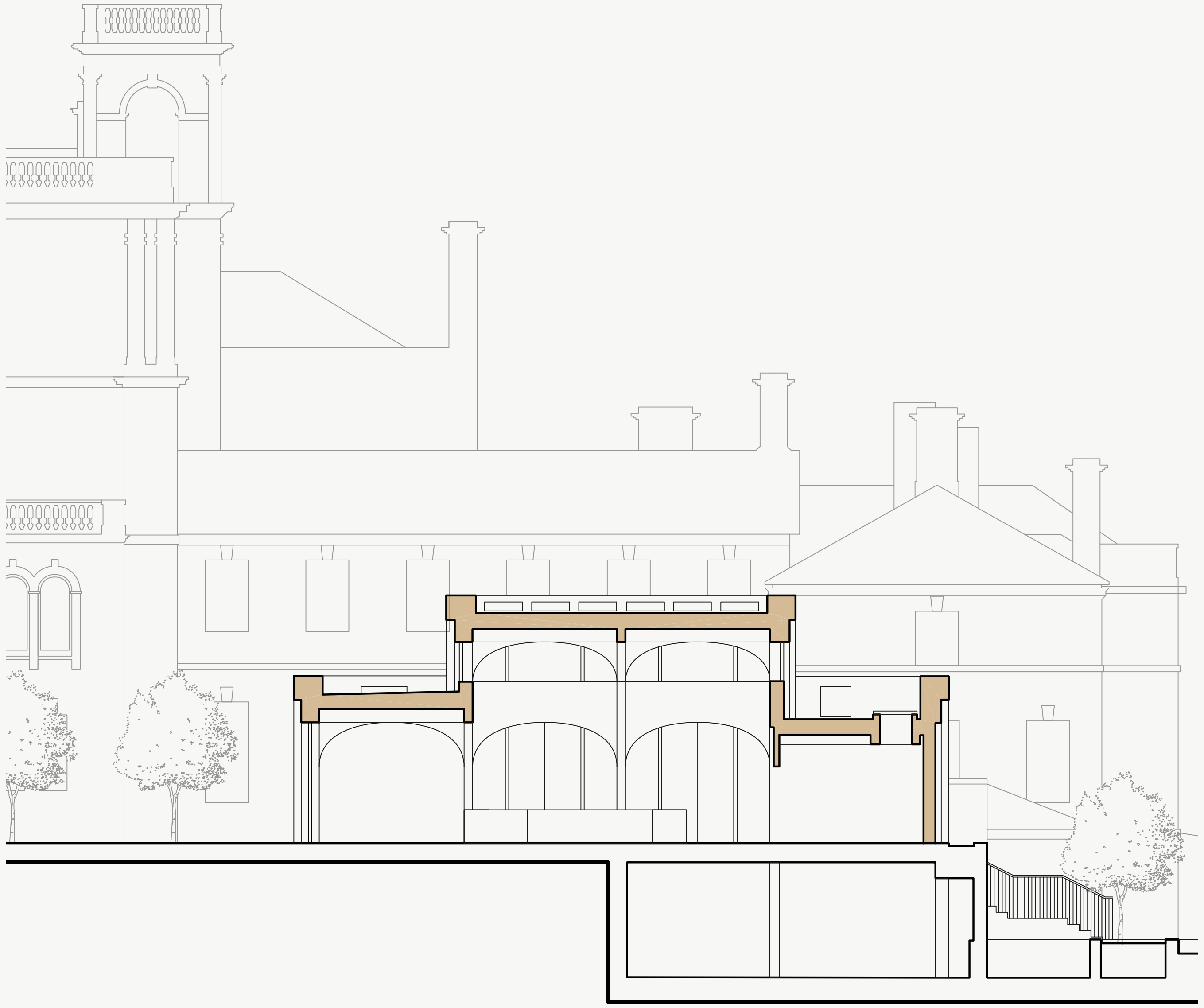
The restaurant is sited in the location of a former conservatory and kitchen garden. The design's diagram was inspired by classic Victorian tea houses, known as orangeries. These 19th century archetypal structures were a type of glasshouse, known for their Arts and Crafts motifs as well as their transparency, ornament and filigree detailing. The refined design gestures at the Wildernesse Restaurant, including the perforated façade, rich interior finishes and arched patterning, each reference this historical precedent alongside details within the adjacent Grade II listed building.

To translate these ideas, the building is a crafted timber vaulted structure arranged around a 4 × 4m grid. The plan is composed of a series of square bays, demarcated by a solid yet elegant timber column grid. Parts of this grid remain open, forming open plan dining spaces. Elsewhere, the columns are infilled with partition walls and curtains to demarcate private dining areas, services and back of house functions. The perimeter of the restaurant is wrapped in a darked stained timber and powdercoated aluminium façade. Openings are placed between the bays, framing views to the surrounding grounds. The dark exterior belies a warm timbered interior. The dining space is equipped with a lower ceiling, while the kitchen and entry enjoy a more generous double height.

The design is based on a repeatable and modular structure that could be prefabricated off-site. This meant that the principal CLT structure was assembled in just two weeks, saving time and cost.[41] Another advantage of this material, according to the architects, is that it is carbon efficient, such that the 84 tonnes of cross-laminated timber and glulam used within the project sequesters 48 tonnes of embodied carbon.[42]







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CONSTRUCTION APPROACH

Due to a limited project budget, the structure is based off a gridded diagram. The CLT system was chosen for its ease of construction – it has minimal, repeated elements, was fabricated off-site, and is both efficient and cost effective.

The Wildernesse Restaurant is predominantly a timber structure and uses a combination of CLT, glulam and plywood. Interestingly, while this case study contained ample timber finishes, the CLT structure is only partially visible. CLT Is used to form the structural portals, and the material is revealed in different states throughout the interior. The CLT structure is visible between the vaults, while the vaults themselves are lined in plywood. In double height areas, where the vaults are pushed upwards, more of the structure is visible.

As Eurban, the projects' CLT contractor, describes:

> *"The superstructure comprises a grillage of glulam beams (with arch cut-outs) and columns on a 4.0m x 4.0m grid. Cross-laminated timber slabs span between the beams to form the flat roof; this is raised in the centre of the building by approximately 2.5m to form a 4.0m x 8.0m 'lantern'."* [43]

This lantern also provides stack ventilation, exhaling warm air from operable windows above.

According to the architects, "the timber vaults were formed of a CNC lattice structure with layers of ply overlaid. The accuracy offered by prefabrication ensured these vaults could be precisely fitted to each opening, concealing all services and joints. The design process involved numerous workshops, mock-ups and tests with the specialist subcontractors." [44] This description verifies one of CLT's key benefits, as noted earlier in this report, which is its suitability for prefabrication.

THE BUILDING'S APPEARANCE AND TACTILITY

The interior is warmed by plentiful timber surfaces, ensuring that the Wildernesse Restaurant clearly reads as a timber building. Interestingly, though, while timber is heavily present throughout the interior, none of what is visible is CLT, with this being used exclusively as concealed structure. The glulam arches read very similarly to CLT, however you can see in the arch cutouts that there is no cross lamination.

Wood, in the form of timber battens and plywood, lines the interior walls to an expressed datum line, the columns and arches are comprised of exposed glulam. The vaults between these arches are lined in plywood. Timber mouldings are also used as joinery facing, a gesture that assists in providing acoustic dampening.

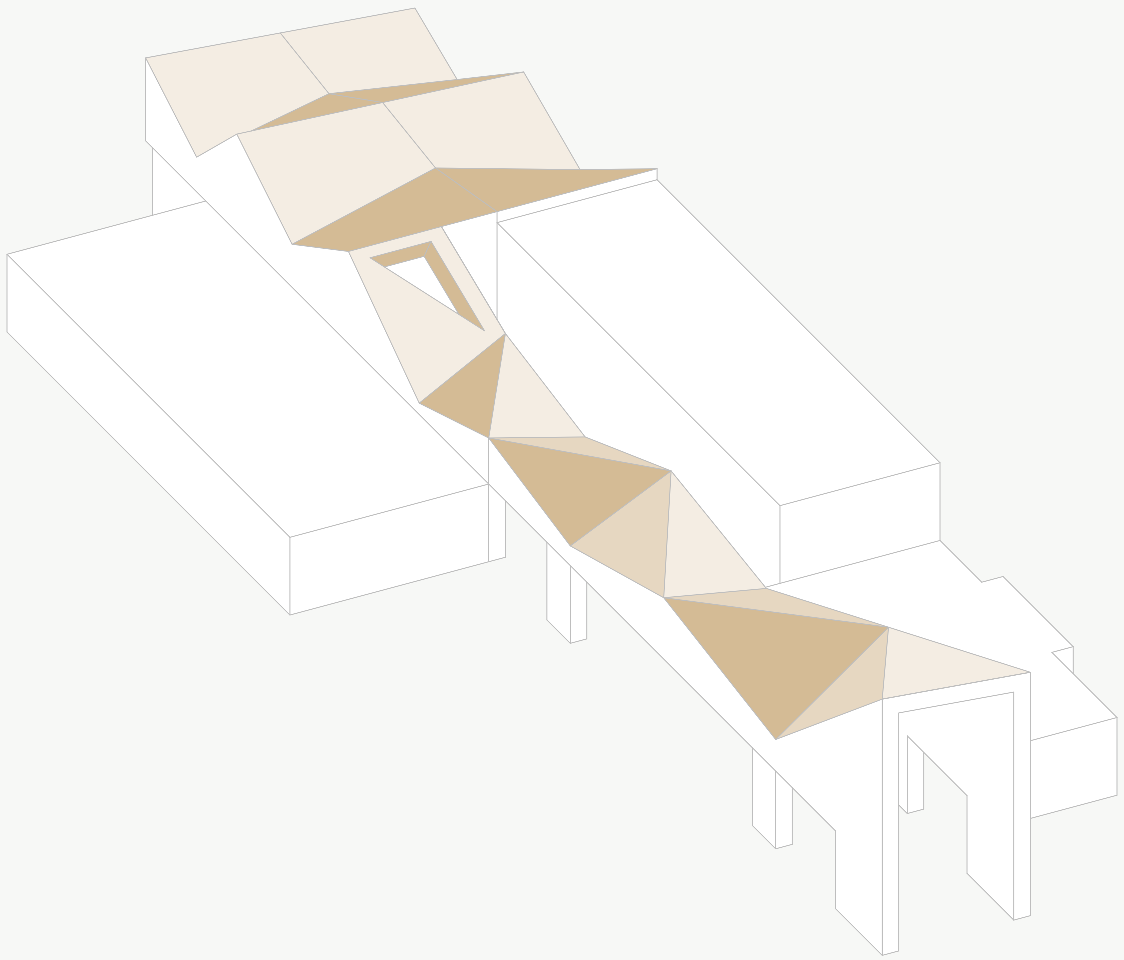
Other materials used throughout the interior include fabric, steel and tile. The floor is a stone plinth, in a gesture that marries in with the nearby stone heritage house and helps resolve site levels. The idea of an expressed counterpoint is therefore clear, with a solid base on which this timber pavilion perches.

The expression of the arch and column connection is elegant in its concept, but reveals some of the challenges in executing such a fine joint. Where shadow lines are used, the expression is clean and simple, however where the timber wedges taper to a near zero edge condition, and are glued flush to the adjacent beam, you are left with messy joints and chipped sections of wood. This joint hasn't stood up well to the realities of modern construction techniques and is a good reminder that timber does not lend itself to razor thin edges.

Overall l the project celebrates simple timber craft and the warmth that is afforded from an interior lined in wood.

04 Drayton Green Church

Location: Drayton Green, London, UK
Area: 758m²
Architect: Piercy + Company
Engineer: Heyne Tillet Steel
Client: Presbyterian Church Ealing
Completed: 2018



Case Study 4: Drayton Green Church

THE BUILDING DIAGRAM

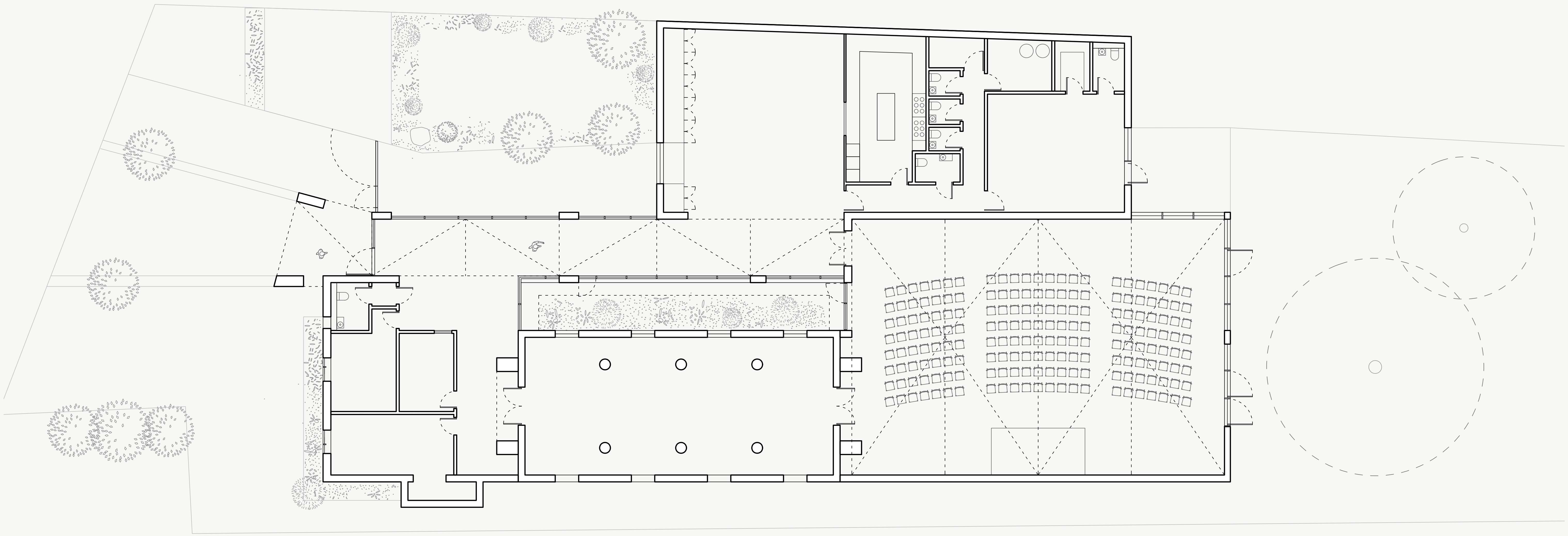
Drayton Green Church is an extension to an existing Grade II listed Edwardian church. The project was commissioned to accommodate the parish's growing congregation, which could no longer fit within the existing building. It also provides a home for new community functions, which extend the church's role in the borough. To meet this brief, the project retains the original church and expands the existing structure by adding new spaces around its perimeter.

An interview with Daphne, a member of the parish, described the original church as charming but ineffective at hosting the two hundred parishioners who regularly attend Sunday services. The existing building also had acoustic problems, something which felt like a compromise, especially given that singing forms a significant part of Presbyterian worship.

The diagram of Drayton Green Church evolved from this brief. In plan, the new structure wraps around the original brick church to provide a new entry, a larger worship space, flexible community meeting rooms, function spaces, and administrative offices. The existing structure is retained.

Three-dimensionally, the architectural form is playful, adopting a series of folds and pleats across the ceiling and roof. These formal gestures reference the pitched roofs found in the surrounding residential streets. They also relate to the soaring ceilings commonly found within ecclesiastical architecture. The entry is formed by a brick 'spire,' folded to compliment the roof. The result is a joyful building that is contemporary and yet clever in its interpretation of traditional ecclesiastical motifs.

CLT plays a impactful role within the project diagram, appearing within the ceilings of the entry corridor and main congregation space.



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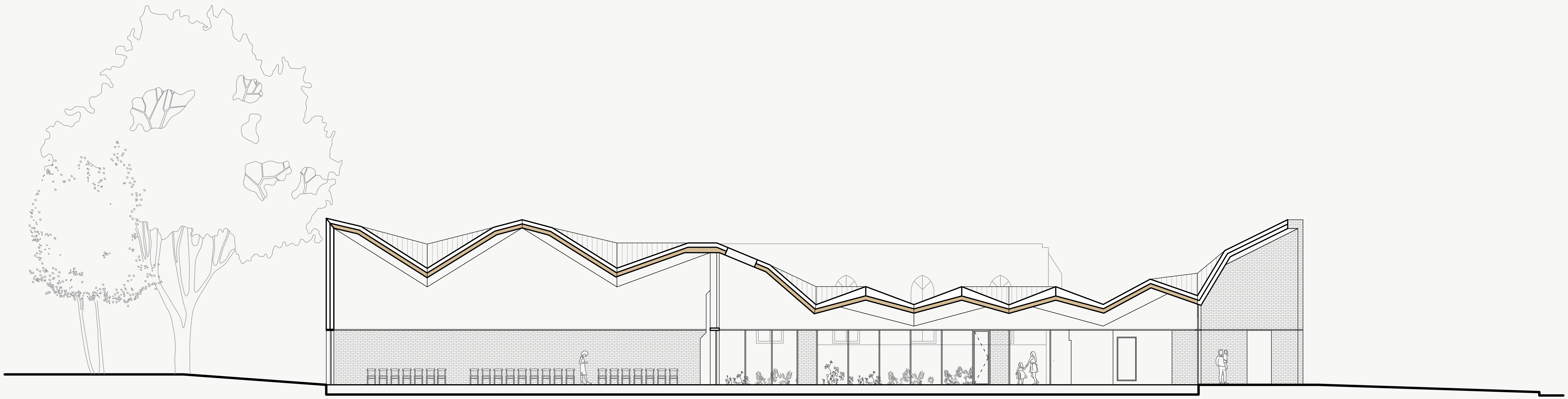

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CONSTRUCTION STRATEGY

Drayton Green Church is a hybridised structure. According to the project engineers, Heyne Tillet Steel, the new building's framing comprises a combination of CLT, steel work and load bearing construction. The existing church is a brick building.

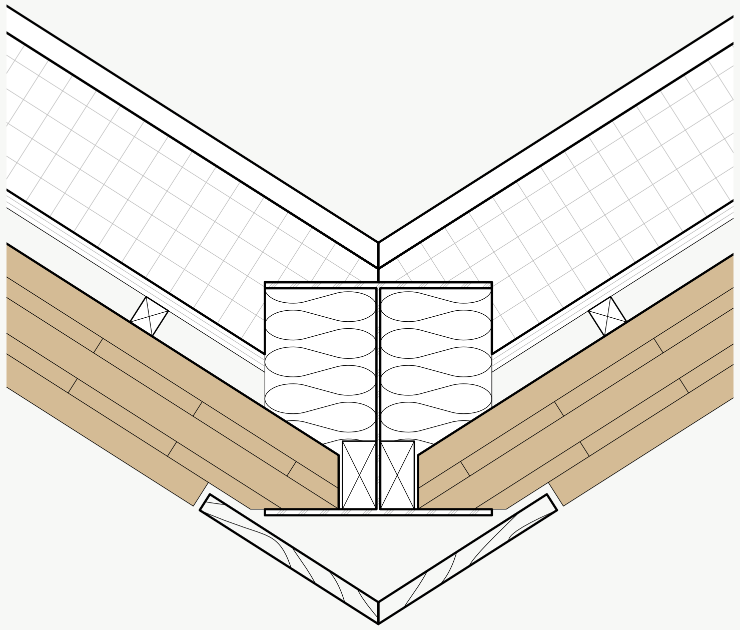
While the primary roof structure is formed with steel members, 160mm thick panels of CLT are used for the exposed ceilings, which soar up to 8m high. This allows the elegant, origami-like folds of the roof to be expressed throughout the main congregation space, and in the entry corridor, which leads down to the new extension.

The room's lower walls are a combination of brickwork and glass windows, which align to a datum that marries in with the existing church. Above this continuous datum line, framed plasterboard walls and white painted acoustic panels mediate between these two materials and the folded ceiling above.

Within this hybridised structure, each material performs a different practical, aesthetic and symbolic role. The use of brick and plasterboard allows for a conversation between the old and new buildings, and the complementary tones and textures – and aligned datums - unify the structures. Meanwhile, the CLT ceiling and pleated roof reference the soaring vaults of traditional church design.

Interestingly, in this particular case study, CLT was also chosen for its on-site efficiencies and potential to save costs. Given the project budget was limited, the architects proposed CLT as a cost-effective alternative to conventional construction. The project was extensively modelled in Revit as a means to coordinate the structural steel, CLT and brickwork.[45] This digital model allowed the design team to seek efficiencies and limit the number of structural elements which, in turn, minimised costs. Further to this, the model guided on-site prefabrication, so the ceiling panels were made off site and then delivered for streamlined assembly.

While it was not conclusive if any net savings in time - or cost - were achieved at Drayton Green Church, this process did highlight the potential for CLT to short-circuit conventional construction timelines, especially when it allows for efficiencies within the design and documentation process.



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THE BUILDING'S APPEARANCE AND TACTILITY

CLT is foundational to this building's tectonic expression. While the visible CLT components are limited, the material still excels at creating an interior environment that feels uplifting and inviting.

At Drayton Green Church, the CLT structure is expressed on the chapel and corridor ceilings. According to the architect, CLT was chosen due to the way its "warmth and familiarity bring a more domestic scale to the soaring structure."[46] The CLT ceilings create cathedral-like spaces that are welcoming and jubilant, clearly signifying the spaces for worship and congregation.

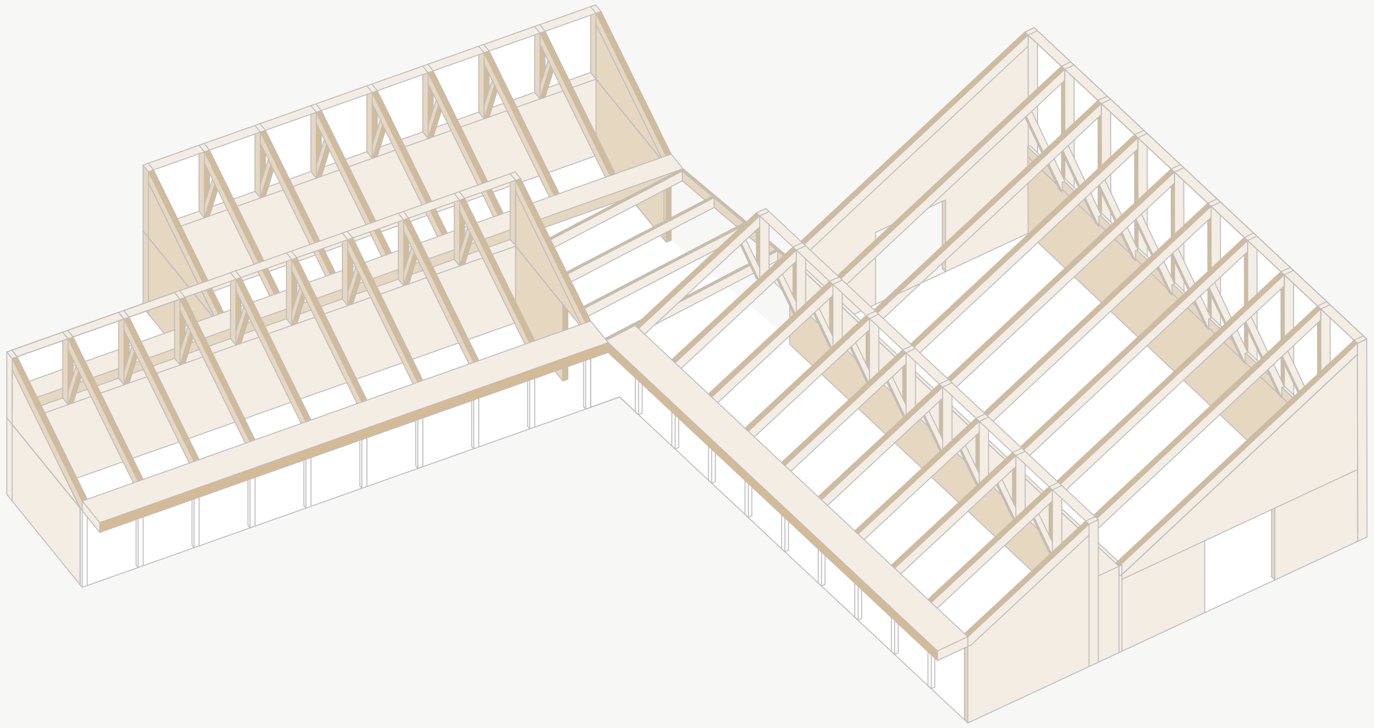
The CLT in this project is also unique. Drayton Green Church uses a wide board CLT facing, which resembles timber lining boards. A whitewash finish has been applied to reduce the material's inevitable yellowing, alongside a white tinted fire retardant.

Aside from the CLT, the material palette is rather subdued, with a combination of tonally consistent brick, white plasterboard, perforated panelling, and carpet. This reductive palette reflects the Presbyterian ethos, which tends towards plain and unadorned spaces free of religious icons. In this sense, the architects also excelled by crafting a space that is sculptural, yet uncluttered and calm.

The CLT joints at Drayton Green Church are expressed where the panels meet in folds. As demonstrated in the construction details, each 160mm CLT panel is supported by a series of steel flange beams. The panels are notched to meet the web and bottom flanges of each beam and are then bolted in place. Flush-fixed spruce boards are then used to line these junctions, giving the appearance of a seamless finish. Similarly, where the panels meet at ridge points within the roof, a half-lap joint is utilised to conceal the junction.

05 Sands End Arts and Community Centre

Location: Fulham, London, UK
Area: 662m²
Architect: Mae Architects
Engineer: Elliot Wood
Client: Hammersmith and Fulham Council
Completed: 2020



Sands End Arts and Community Centre

THE BUILDING DIAGRAM

The Sands End Arts and Community Centre (SEACC) is a community building, equipped with a café, social and educational spaces, and a nursery. It sits adjacent to Clancarty Lodge, on the edge of Fulham's South Park.

The building diagram reads as a cluster of discrete buildings, tucked behind a street-facing, Victorian-era brick wall. The buildings are arranged to respond to the existing lodge and street frontage, and the spaces between them become courtyards for entry and congregation.

The project's main street façade is a compelling blend of old and new. The new buildings, which nestle under a series of skillion roofs, peer above the brick boundary, offering a hint of the activity within.

In plan, the building footprint is loosely arranged, allowing for courtyards and outdoor spaces to sleeve in between various functions. These external areas work in tandem to the internal rooms, forging successful indoor-outdoor connections.

Meanwhile, the building section is buoyed by a series of pitched ceilings. According to the architects, these raked forms were inspired by former glasshouse structures found in nearby South Park and Fulham Palace. The height of each skillion varies to complement the scale of the program below: for example, more public functions enjoy taller ceilings, and vice versa. To suggest subservience, all the new roofs are smaller than the existing lodge building, a gesture which ensures the historical structure remains prominent.

CLT is used in two main places at SEACC: in the internal walls, where the material is visible, and in the roof structure, where it is covered up.

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1:200 @ A3

CONSTRUCTION APPROACH

The structural strategy for SEACC is hybridised, with a variety of building elements working together to achieve the design outcome.

SEACC is an example of an expressive timber building that uses both CLT and glulam. Each timber member is designed to suit its purpose, meaning that CLT is used for the wall and roof planes, while glulam provides a legible framing structure that supports the roof and shapes the interior experience.

The choice to use these two types of timber was largely driven by a desire to be climate-conscious. As the engineer, Elliot Wood, described: "It (SEACC) was designed with a circular approach from the outset, and in addition to the reduction in embodied carbon afforded by using structural timber, the glulam and CLT structural system brought simplicity, efficiency and beauty to the whole design."[47]

SEACC is best described as a timber structure with minor steel bracing. The project rests on a concrete slab, which is finished in brick pavers. Above this, the walls are a combination of CLT panels and brickwork. The roof is made from CLT structural panels, which are not visible. These panels are supported by a series of glulam timber beams and columns. Windows and doors are glazed aluminium.

Interestingly, while the structure uses some carbon-intensive materials – namely concrete in the floor slab – the CLT structure did reduce the load on the building's foundations. This means that the concrete slab is only 175mm deep and needs less steel reinforcing.

Another key feature of SEACC is its commitment to contemporary, sustainable materials. Impressively, over 35% of the building materials are recycled, while the building's details – from the choice of bolted connections over glue, to the inclusion of CLT – reveal a commitment to future-conscious practices of design for disassembly. This ethic is clear in the aesthetic of the building, which visibly celebrates these credentials.

THE BUILDING'S APPEARANCE AND TACTILITY

The appearance of SEACC is a biproduct of its admirable ambitions to be a welcoming and sustainable work of architecture.

The interior of SEACC is especially tactile, relying on a combination of natural and recycled materials to introduce a variety of colours, tones and textures. The chief materials that appear throughout the interior are brick and timber, in the form of both CLT and glulam. On the interior walls, the CLT panelling is stained with a green finish, which reveals and celebrates the natural timber grain. This finish is matched in the surrounding materials, including a line of pine doors, which conceal storage. The result is an immersive and fresh interior experience. The ceiling above this retains more conventional, blonde timber tones, which offset and compliment the green-stained walls below.

The expression of timber is integral to the interior experience. As Matthew Dillon, an Associate at Mae Architects, noted:

> *"We decided at an early stage to remove as many unnecessary linings such as plasterboard from the building. The timber proves a hard-wearing and more robust finish for heavy use, which we hope the centre will get in due course. It allows for adaptability, and also offers a warm tactility."*[48]

Throughout the interior, the glulam roof structure is left exposed, with woodwool insulation visible between the rafters. The CLT is visible on the interior walls. The floors, which use both timber and brick, help anchor the spaces with some solidity. Elsewhere, a strong interior datum creates a consistent line of low doors and windows, while high clerestories bathe the interiors in diffuse northern light.

The other key interior material is a recycled, honey-toned brick, a WasteBasedBrick made by Dutch company StoneCycling. The bricks are made with a high proportion of recycled material, which includes 28 tonnes of discarded sinks, toilet bowls, glass, insulation, bricks and tiles. The resulting material is both visually striking and a progressive example of the future of construction materials that rely on regenerative waste products.

THE CRAFTED JOINT

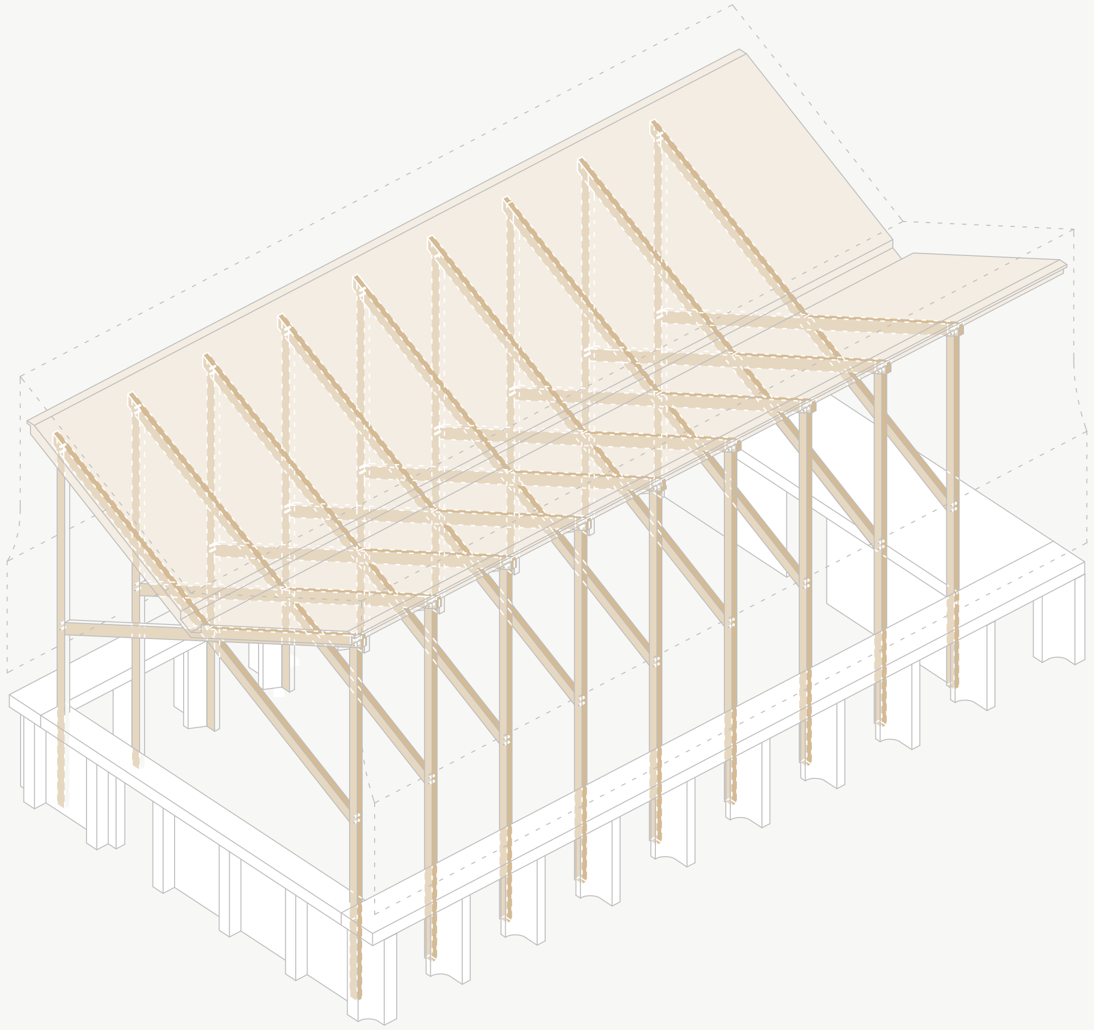
The expression of the glulam frame is critical to the architectural outcome, while the CLT plays a supporting role. This is largely due to the fact that the material is used in conventional locations, namely, on the walls and roof.

At key thresholds, and at panel junctions, the CLT's thickness is expressed and understood. For example, the CLT is exposed at the thresholds between pavilions, where it's possible to see a double skin of CLT and brickwork. These details have been recorded via photographs and are included here.

One notable feature of the detailing is that the building is primarily bolted together, rather than glued, which means it has the potential to be disassembled in the future.

06 Homerton College Dining Hall

Location: Cambridge, UK
Area: 1665m^2
Architect: Fielden Fowles
Engineer: Structure Workshop
Client: Homerton College, Cambridge
Completed: 2022



Homerton College Dining Hall

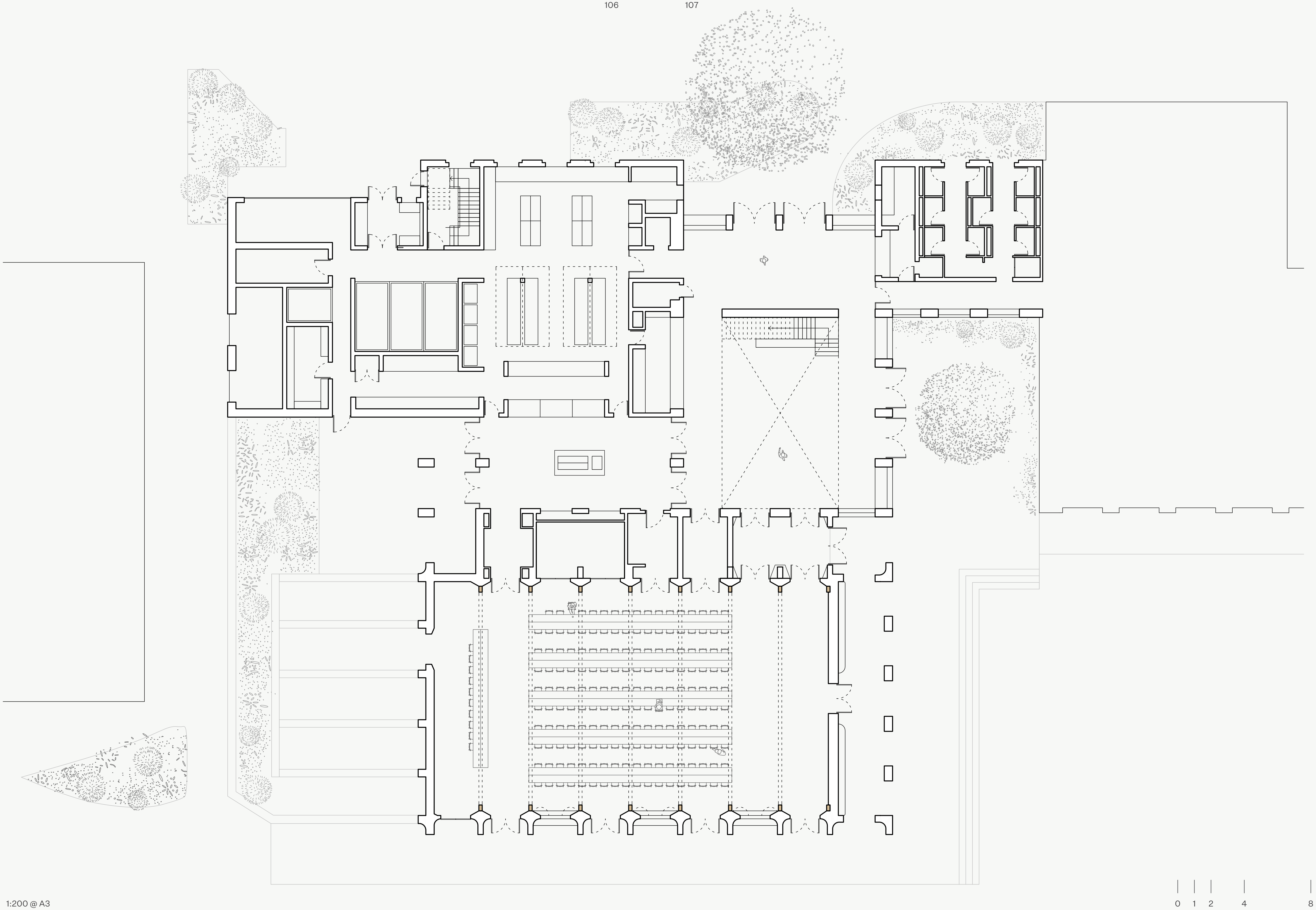
THE BUILDING DIAGRAM

Homerton College Dining Hall services one of Cambridge University's youngest colleges, Homerton. The building includes a generous dining hall, capable of housing 366 people, a smaller eating room - known as a buttery - a kitchen, and staff amenities. The project sits adjacent to the Arts & Crafts Ibberson Building and completes a row of historically significant campus facilities.

Homerton College Dining Hall is surrounded by a colonnade and can be approached from two points: one formal, one informal. Both entry experiences lead into the buttery, a café and dining room that simultaneously acts as an eatery, informal study and social space. Architecturally, this also forms the more intimate precursor to the larger dining hall. Walking into Homerton Hall, the space reveals itself exultantly, with grand, soaring ceilings and expressive structure. Back of house spaces line either perimeter edge of the dining hall, and broader building diagram, and are efficiently organised to complement the adjacent social areas.

The central dining hall is an uplifting space, with low openings to the surrounding fields and high clerestory glazing welcoming natural light. The ceiling is crowned with a series of expressed butterfly trusses, which rest on slender timber columns. These trusses support a CLT ceiling, but the material is not visible – instead, the interior is lined in painted acoustic plasterboard. Outside, the structure is expressed as a butterfly roof, tapering into a central valley. Externally, the volume of the dining hall is clad in traditional green faience tiles, which glisten and mottle in the light.

The sustainability ambitions of this building are notable. Working with sustainability consultants Max Fordham led to the creation of twenty-two bespoke sustainability targets that exceed best practice. The result is a building that is all electric, uses passive ventilation strategies, and relies on a ground sourced heat pump to provide internal heating.[49]



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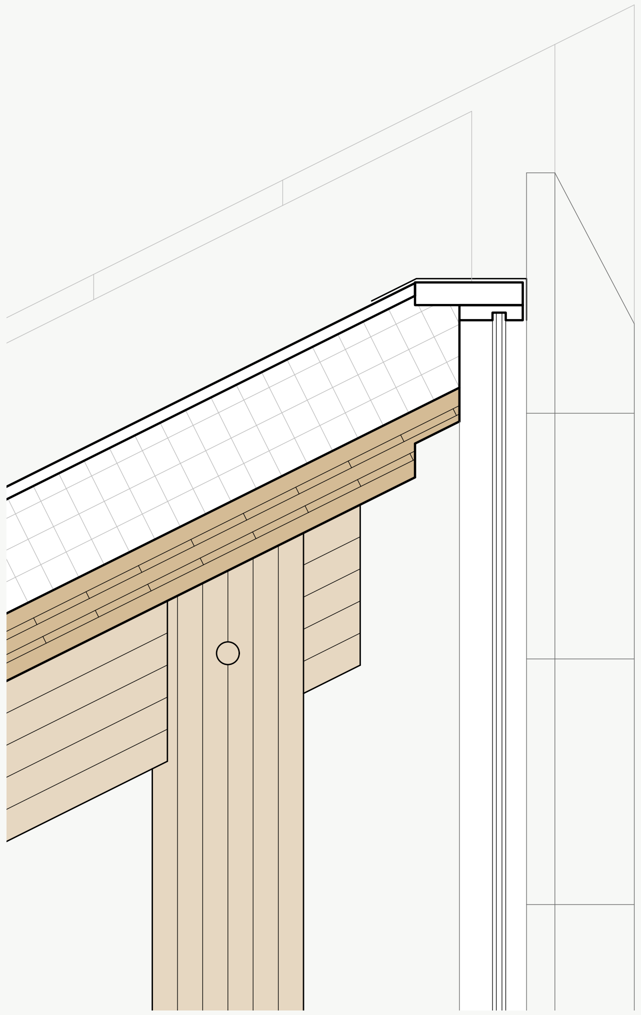
CONSTRUCTION APPROACH

The architects described Homerton College Dining Hall as “an embodiment of low-tech principles, an arts and crafts of the 21st century.”[50] This approach is reflected within the structure, which combines innovative and traditional techniques to create a striking work of architecture.

Homerton College Dining Hall is primarily a massive timber building, in which CLT plays a supplementary role. The visible timber elements, notably the butterfly trusses and dining room columns, are a glulam sweet chestnut, while fluted and carved cherry timber veneer panels line the walls. The glulam trusses and frame were fabricated off-site and are fastened with traditional dowel joints.

While CLT is part of the structural solution, it is not at all visible. CLT was used in the structure’s roof and assumedly was chosen due to the fact that it is lightweight and relatively slender bracing solution . However, none of the architect’s statements could verify this.



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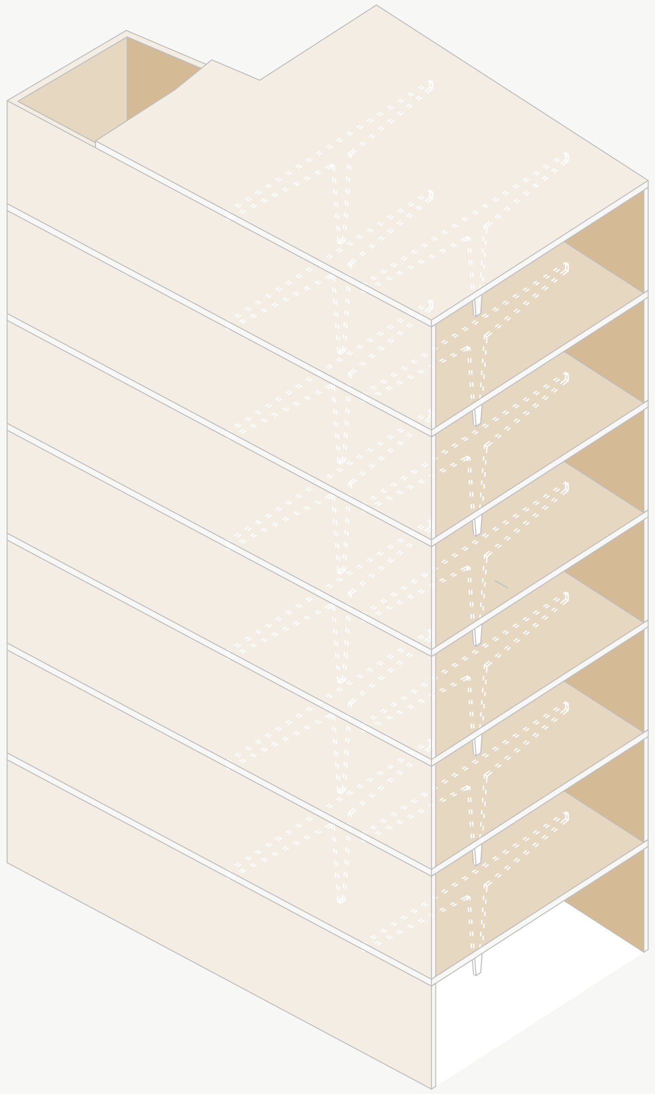
THE BUILDING'S APPEARANCE AND TACTILITY

Homerton College Dining Hall's interior possesses warmth and grandeur. The materials are luxurious without becoming overly showy or ostentatious.

A consistent colour palette of reds and greens is visible across the terrazzo floor, pigmented red concrete, and red-stained timbers. Brass accents elevate key junctions, including where the timber columns meet the floor, while expressed datums lend this generous space a more human scale. Details are cleverly and creatively executed, such as in the folding timber window shutters, and services are carefully conceived of. The result is a refined and seamless work of architecture, whereby the details recede and compliment the celebratory structural timber.

07 Old Street

Location: London, UK
Area: 720m^2
Engineer: Webb Yates
Client: Claritas / HGG
Completed: Under Construction



Old Street

THE BUILDING DIAGRAM

Old Street is a commercial building, composed of a ground floor retail space with six storeys of commercial space above. The site was subject to heritage restrictions, which meant that there was limited opportunity for foundations or bearing on party walls. The resulting diagram is a consequence of this context, in that it clears the adjacent party walls and minimises contact with the ground. As MDA explain:

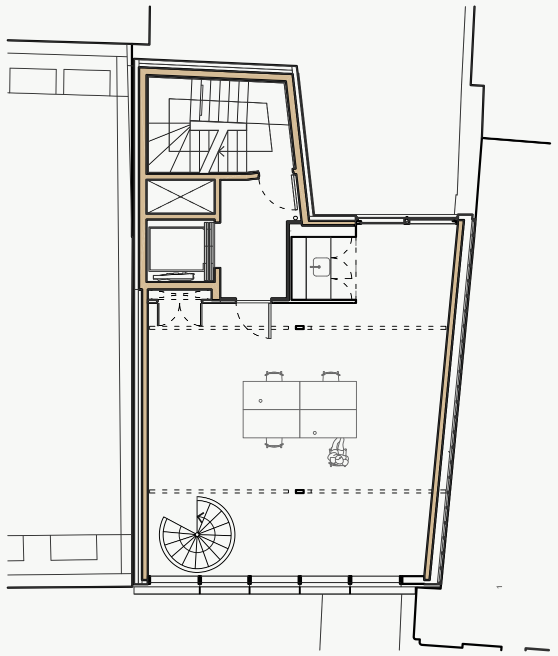
> *"By using an inner steel structure surrounded by a cross laminated timber shell, the building is not only efficient but minimises environmental impact."*[51]

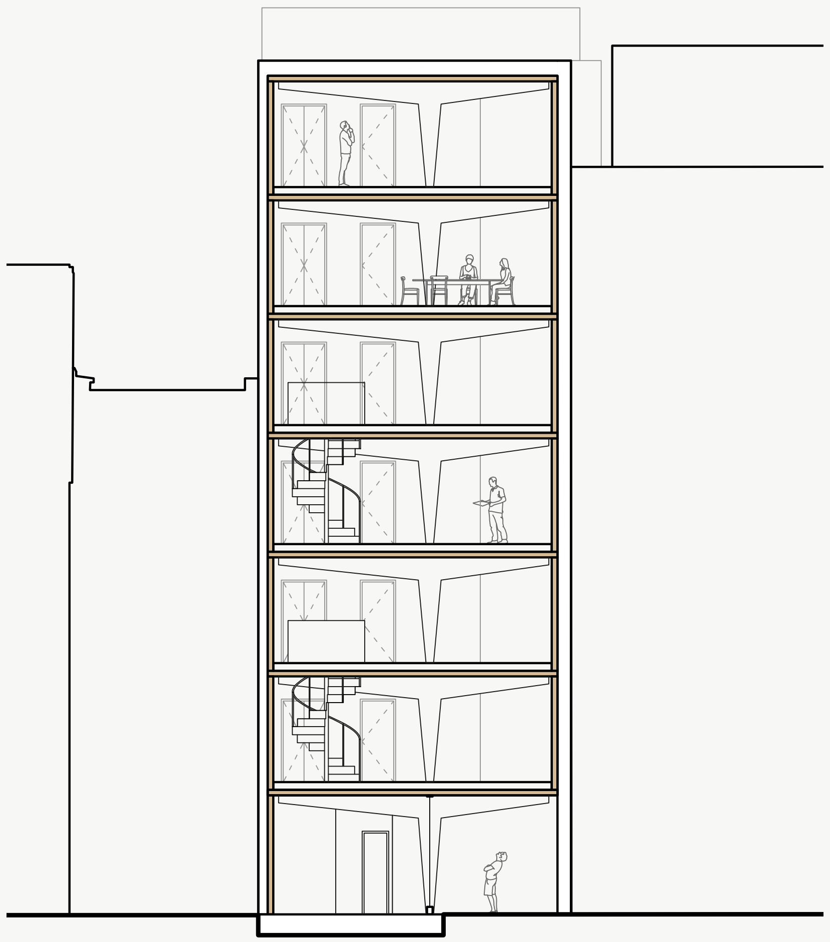
The commercial spaces, which are intended as offices, are arranged as mezzanines, with the two floor plates made accessible to one another via an internal spiral stair. Within each office, the upper floor is set back as a balcony, maintaining sight lines to a local cathedral. Each of the floor plates measures 120sqm and contains a kitchen and WC alternating on every second floor.

Old Street was the first time this studio used CLT. The material was chosen because it allowed them to resolve their design problem, which required a cantilevered solution.

MDA gained their material knowledge by speaking to others within the industry and relying on the prior experience of their structural engineer, who had worked with the material before. Likewise, the original project client, Claritas, were open to using CLT, especially once they understood the benefits and its suitability for the project site. They were also progressive in their outlook and willing to work with a less common material.

Previous Page
Project: Old St (Mary Duggan)
Source: www.maryduggnarchitects.com/2021/06/28/old-street/





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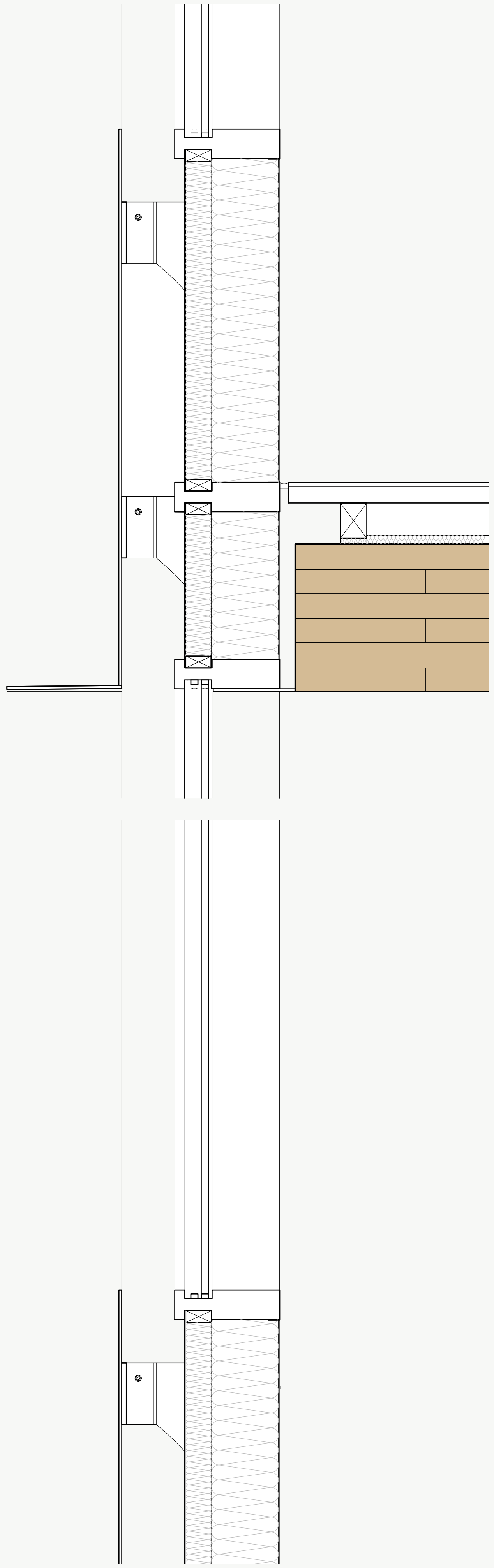
CONSTRUCTION APPROACH

Described by MDA as an "expressly lean approach to structure, weight and material selection,"[52] the project uses a hybridised CLT and steel structure. Slender steel 'T' horses cantilever to the site's edges, supporting the CLT floor plates and cores. The building is then clad in a glass and aluminium rainscreen facade. The stair core provides the building with lateral stiffening.

The combination of CLT and steel is highly efficient and works to resolve the particularities of this design problem. This structural system ensures there is no bearing on neighbouring walls and allows the structure to clear a historically significant ground floor right of way.

While CLT was chosen for its lightweight properties, this structural system had additional benefits. Groundworks were minimised, saving time and cost, while simultaneously resolving the limitations of a heritage site. It also allowed for more efficient off-site fabrication, meaning that neighbourhood impacts, such as street closures, were minimised.



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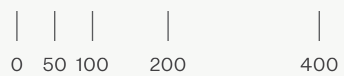

THE BUILDING'S APPEARANCE AND TACTILITY

Within Old Street, CLT will be exposed on the ceiling soffit of the main office spaces and in the stair core. The CLT is an industrial-visual grade, a finish which was chosen for cost reasons. It contains visible plugs and checks and will be whitewashed to offset yellowing.

The other colours and tones are soft and complimentary, but move away from the all-timber interiors seen within a lot of the case studies. While CLT is used for the boundary walls, these walls will be lined in plasterboard to cover up Fermacell fire insulation. The floor will be a lilac marmoleum and the staircase is raw folded steel.

A particular strength of Old Street comes from the way in which services have been considered. This can be a challenge that detracts from mass timber projects, where building services sometimes cluttered the appearance of the finished CLT. This also reflects the foreplanning that is possible with CLT when it is well considered in the design process. Air conditioning, electrical services, and mechanical systems are artfully concealed, ensuring that the exposed CLT is clear and expressive. Tactics used to achieve this include concealing equipment within the floor buildup and relying on the building core to carry all services. By way of example, electrical transformers are accessible from the floors above each, rather than their ceilings. This allows lighting to sit unobstructed on the CLT ceiling below. Similarly, electrical conduit and powerpoints are confined to the boundary walls, meaning that exposed conduit is absent from the CLT surfaces.

The result of these design decisions is a balanced interior that remains welcoming and warm, despite combining timber with other materials and finishes.

At Old Street, each material is celebrated for its unique qualities, and there are occasional juxtapositions between the heft of the CLT and fineness of the steelwork. This contributes to the overall architectural experience and translates to the expression of joints.

The CLT construction is visible in thresholds like the door jambs, which are pulled back to allow for the 'cut' in the CLT to be revealed. Similarly, slices in the CLT floor plates – which will hold the spiral stairs and skylights - also showcase buildup and reveal the CLT's properties. This shows an interest in exposing the material and celebrating its thickness, heft and density. Architecturally, there is an interesting contrast whereby the steel structure appears light and filigree and CLT is expressed as more solid.

Conclusions

Material Lessons: From the Case Studies

CLT IS A VIABLE "SUBSTITUTE MATERIAL" THAT SUITS HYBRIDISED STRUCTURES

Most of the case studies employed CLT as part of a hybridised structural system. Due to its indoor nature, the Museum of Garden History was able to employ a full CLT system, while the Drawing Matter Archive used CLT in all but the floor and foundations. In some cases, such as the Drawing Matter Archive, the CLT had a starring role while in others, like Homerton Dining Hall, it worked in the background. In many cases, it also acted as a 'substitute material' for conventional timber or steel framing, or concrete.

The case studies revealed that CLT works well for "slabs and planes." It is a material that has a good strength to weight ratio and spans well. For this reason, it was often used (and argued for) as an effective substitute for steel or concrete. MDA's Old Street was a good example of this: the use of CLT floor plates coupled exceptionally well with steel structure to achieve good spans and necessary clearances. The material also had time and cost advantages.

As CLT becomes more prolific, and our industry continues to act in the face of the climate crisis, it is more and more likely that CLT will be used as a direct substitute for concrete floor plates situated above ground. The fact that the material is low in embodied carbon, and can be designed for disassembly, means it is well positioned to replace more commonplace materials.

THERE IS FLEXIBILITY IN HOW CLT CAN BE FINISHED

The case studies reveal a variety of ways in which CLT can be finished. Many of the architects were concerned with the material yellowing, so a range of white washes and fire retardants were used to counteract this natural ageing process. It was also enlightening to see examples of the material being stained and coloured, as was seen at Sands Ends Arts and Community Centre. Other projects, such as the Wildernesse Restaurant, used CLT for its structural capacity but applied a more architecturally appropriate finish.

In other instances, the natural warmth and patina of CLT was celebrated. This was perhaps best shown in the Drawing Matter Archive, where the CLT was left to age. In other projects, complimentary tones and textures were used strategically to offset and compliment the exposed timber. In projects like the Museum of Garden History, this was provided by the existing structure while, in others, it came through a freshly assembled palette. MDA's Old Street also revealed the impact that integrated design can have on the appearance of CLT, in that well designed electrical and mechanical services allow the material surface to appear clear and uncluttered.

CLT IS ONE PART OF VISIBLE TIMBER BUILDINGS

Many of the cases studies looked and felt like timber buildings, in that they had a legible timber structural expression and plentiful visible timber. However, visiting the buildings – and experiencing them in person – revealed the role that CLT played in the overall ensemble. In some cases, the CLT was highly visible; in others, it played less of a major role but was employed for particular properties as part of an overall construction logic.

In short, many of the buildings that looked and felt like timber buildings concealed much, if not all, of their CLT. This is especially true if the building expression wanted to be more skeletal, or celebrate expressed structure, rather than planes or thickness. This revealed the value of CLT can be in its efficiencies, and not necessarily in its appearance - or that a timber building, artistically considered, might lean heavily on alternative elements.

The most common way that this was achieved was to pair walls, floors or roofs with expressed timber post and beam, portal, or truss structures. In Fielden Fowles' Homerton Dining Hall, this was achieved with wooden columns and trusses, with CLT concealed in the roof buildup. In Mae Architects' Sands End East Arts and Community Centre, a repeated series of glulam columns and beams frame out the interior, with CLT visible in moments between. In these instances, the use of visible structure adds architectural rhythm, human scale and crafted jointing. These qualities are challenging to achieve with planar CLT, so alternative timber elements were sought.

In a similar vein, there were case studies that used timber linings to create architectural affect with timber. Spruce boards became the visible lining used for folds and pleats, in the case of Piercy and Co's Drayton Green Church, while Morris and Co's Wildernesse Restaurant used plywood to line its vaults.

Regardless of its application, CLT was always used intentionally and with intelligence. Timber was embraced for its warmth, tactility and vitality and, in doing so, these buildings felt like bastions of a new type of architecture that is humane yet climate-conscious.

CLT CAN HAVE THE ARCHITECTURAL QUALITIES OF MASS, THICKNESS AND HEFT

In contrast, there were also buildings that celebrated CLT's visual density as a thick, singular surface. By way of example, both Mary Duggan Architecture's Old Street and Mae Architects' Sands End East Arts and Community Centre employed detailing that appeared to 'slice' through single, or paired, CLT walls. CLT was seen in thresholds and in cuts between floor plates. These became places where the visible layering of the CLT panels, and the trademark criss-cross of small sections of timber to make large panels, was put on display. Seeing this sectional cut was always beautiful and surprising, and gave this material, which is often perceived of as light, a sense of heft, presence and inherent strength.

Perhaps the best embodiment of this principle, though, was the Drawing Matter Archive by Hugh Strange. This project, with is intentionally hefty walls and floors, afforded all kinds of architectural possibilities that were unseen elsewhere. CLT is often selected for its spans and, by extension, its length and width. Yet, by supercharging CLT in one of its underutilised dimensions, its depth, Strange was able to work with the material as if it were stone. At the Drawing Matter Archive, the CLT appeared carved at and punctured with skylights, windows and doors. The result was a work of architecture that revelled in its material but also used timber, a typically light and skeletal material, to create a feeling of protection, solidity and presence.

CLT'S JOINTING IS AN UNDEREXPLORED FACET OF ITS CRAFT

One of the last lessons of the case studies defied expectations. A key aspect of this study was to explore each of these buildings at the scale of the joint, to see how the larger architectural ideas were translating into detailing. The hypothesis was that the material would be used experimentally and expressively at this finer scale. However, visiting the buildings revealed that the CLT joint was not often treated as a place for craft. While the surface, or its ends, were left exposed, there were no instances where the jointing of the panels was conducted in an expressed or particularly innovative way.

This in and of itself is interesting as it raises the question as to why this might be the case. Reasonable assumptions can speculate that cost would be a factor, along with the fact that this is a relatively new construction material and innovation at this scale is yet to come. Whatever the reasons, it is exciting to consider the potentials for architects to better exploit the places where CLT panels meet, or where CLT meets an adjacent material. Inspiration could easily be drawn from cabinet making, or traditional Japanese wood jointing techniques. With CNC machining already available at the production stage of CLT panels, this is very possible.

Project: Drawing Matter Archive
Photographer: J Donnelly

Lessons for Industry and Policy

MATERIAL UPTAKE REQUIRES NETWORKED KNOWLEDGE

This report crystallised the importance of networked knowledge in the adoption of new materials, be they CLT or whatever might follow.

Many of the architects noted in this report were using CLT for the first time and yet managed to make exceptional work. To do this, they relied on the knowledge and experience of their consultants, especially structural engineers, their contractors, and trades. By borrowing their expertise, they were able to use the material with greater confidence.

An interview with the architect Hugh Strange also revealed the value of knowledge sharing within the architectural network. It was clear that many of these architects were able to pick up the phone and call their peers to have formal and informal conversations about working with CLT. This, it is fair to assume, helps with uptake by diffusing some of the perceived risks of working with an unknown material, and being able to tease out challenges with informed industry.

This network of experience across the industry also helped convince clients to use CLT. Across the research and case studies, many of the clients were described as "progressive" or "forward-thinking." Having experience within the project team would have helped assuage doubt.

Last of all, comprehensive trade literature continues to play a role in promoting the more widespread use of CLT. A great example of this is the 'Timber Typologies' guide created by Timber Development UK in collaboration with Waugh Thistleton Architects. As studio Associate Alastair Ogle explains:

> *"Two further guides are coming. Timber Typologies is part one. Part two is going to be on policy, providing an overview of what timber-based policies, guidance, and initiatives are being implemented around the world. Currently, the UK has fallen behind with its adoption of timber as a construction material. We used to be the global leader but, post-Grenfell, fire concerns and misconceptions about the material have led us to what are essentially backward steps. What we hope this guide will do is set a framework showing what the rest of the world is doing so that the UK can look to adopt some of these policies."*[53]

All of these examples hold valuable lessons as CLT gains traction in Australia. As certain architectural studios, engineering firms, suppliers and contractors develop built experience with CLT, they will come to be custodians of knowledge. The British industry serves to demonstrate how, when this knowledge is shared generously, a rising tide can lift all boats and a culture can facilitate cutting-edge architectural outcomes.

CLT NEEDS ADVOCATES AND EARLY ADOPTERS

The broader CLT research also demonstrated the value of advocates when a new material emerges. Certain architects, namely, Andrew Waugh and Alex de Rijke, acted almost like missionaries for the material, adopting it early and using it openly. Aside from showing what could be done with CLT via built examples, they extolled its virtues, answered common queries and assuaged concerns. This paved the way for other practices to follow suit, get excited, and build on lessons learnt.

This advocacy also gave other architects insight into CLT's benefits, lending them various entry points into its use. Both Piercy and Co and Morris and Co suggested the material because it could offer precision and certainty through prefabrication. To their clients, this appealed in that it had flow-on benefits in terms of time and cost. At Sands End Arts and Community Centre, CLT's environmental credentials wove into a project that placed sustainability at its core.

This, then, has a ripple effect, whereby each round of projects becomes inspiration for another. In this way, it would be brilliant to see Australia's architectural culture begin to build upon early successes and design better, bolder and more expressive CLT buildings. It would also be instructive to see figureheads within the industry emerge, formally or informally, as local champions of CLT.

POLICY INSTRUMENTS MATTER

The contextual research, and subsequent precedents, clearly showed the importance of policy in allowing CLT to flourish. Policy creates "carrots" and "sticks" by incentivising and limiting material experimentation and uptake. This, in turn, feeds into culture and goes on to affect architectural outcomes.

A prime example of positive timber policy that emerged in the UK was the 'Timber First' strategy proposed by the Borough of Hackney. While it did not ultimately move ahead, it raised the profile of CLT and celebrated its benefits and potentials. As we approach 2030 and 2050, and their associated climate targets, it is more and more likely we will see these sorts of positive incentives that favour carbon neutral, or carbon negative, timber construction. This, in effect, would act as an accelerant in promoting CLT.

In contrast, policy limitations have the potential to stymie innovation, experimentation and implementation. It can only be assumed that this is part of the reason why CLT has had more limited applications in Australia. Unlike the UK, we have not benefitted from borrowed European Standards or continental R+D. Instead, we have had to amend our own construction codes and building standards so they are locally relevant.

While such change has started to happen, it would be beneficial to see more "carrots" and less "sticks" associated with CLT. Doing this would ensure the material is more readily considered, artistically or otherwise.

ALL SCALES OF PRACTICE, AND ALL BUILDING TYPOLOGIES, HAVE A ROLE TO PLAY

The last conclusions suggests that all scales of practice, and all building typologies, have a role to play in a material's proliferation and experimentation.

As noted in this research, the first CLT buildings in the UK were mostly schools and mid-rise multi-residential buildings. Yet, what is fascinating in the context of this study is what came after them.

The case studies in this report, which focus on the creative potentials of CLT, are arranged chronologically, and the first projects mentioned are all very modest. They are small projects, by small practices, experimenting in low risk settings. The first project, The Museum of Garden History, was completed by an emerging architecture studio, won by competition, and built inside an existing structure. All of this meant experimentation was possible and that certain realities, like waterproofing and airtightness, were irrelevant. The second case study, the Drawing Matter Archive, emerged from a similarly ideal context. Shatwell Farm is an experimental project and CLT was a new material. The client and architect were both willing to take a risk.

These preconditions - willing clients, courageous architects, contextually appropriate projects - remained constant in all of the case studies. This reveals the importance of all of these factors in encouraging project excellence, but it also shows that CLT has the potential to be showcased across a huge range of sites, conditions, building types and budgets.

Of the architects included within the case study, the only one to have used CLT more than once was Hugh Strange. His interest in the architectural potentials, and qualities, of CLT was undoubtedly a consequence of his ongoing use of the material, which he pioneered in his own home, Strange House. Rather than working with it simplistically, he was notably innovating and beginning to explore its various spatial, structural, performative and tectonic qualities.

This report began assuming that CLT could be more than a fringe material here in Australia. Time will tell how prolific it becomes. But whatever the future might hold, this is a material with enormous potential - experientially, functionally, and of course, artistically, too.

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Project:Minima (TRIAS)
Photographer: Clinton Weaver

About the Author

I am a founding director of TRIAS, an architecture and design studio based in Sydney, Australia. I have a Bachelor of Design in Architecture (B.Des.Arch) (2009) and Master of Architecture (M.Arch-Hons.) (2014) from the University of Sydney.

Before starting TRIAS, I gained experience in both large (Grimshaw) and small practices (Andrew Burns Architects) across a variety of sectors including sports facilities, multi residential, commercial and residential projects. Prior to Architecture, I have worked across a number of design disciplines including graphic design and furniture design. This variety of experience has given me a appreciation for the importance of design at all scales.

My passion for a more sustainable approach to architecture and construction has steadily grown over my first decade in practice. Increasing global awareness of the climate crisis has spurred me to reposition my approach to architecture, and seek new knowledge around how to better contribute to the future of our profession.

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