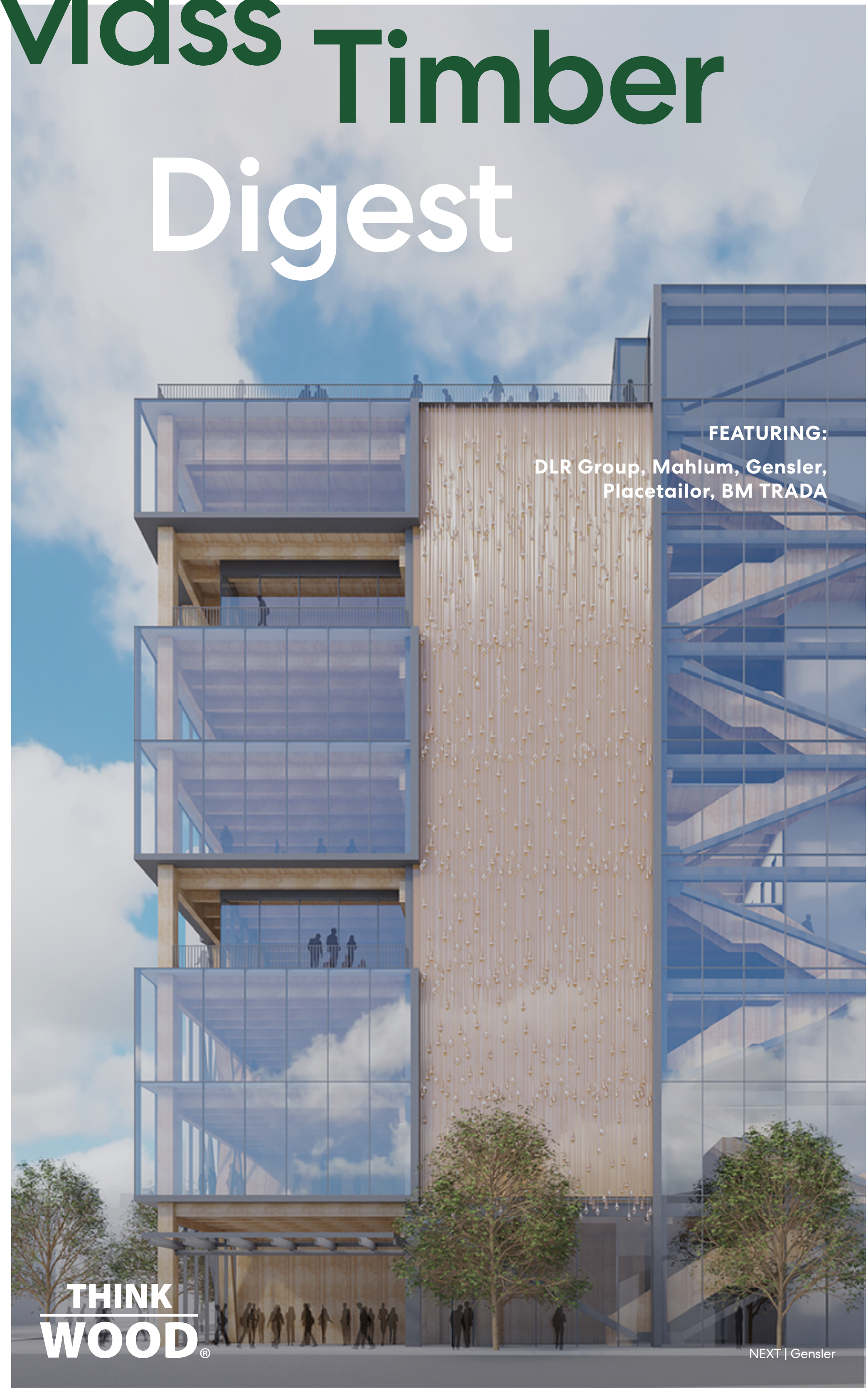
Mass Timber Digest

JULY 2022



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FEATURING:

DLR Group, Mahlum, Gensler, Placetailor, BM TRADA

A journal on innovations in mass timber research and design

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VOL 2

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Mass Timber is Becoming Mainstream

Welcome to Vol. 2 of the Mass Timber Digest, an annual journal curating the latest innovations in mass timber research and design. Since last year, mass timber's popularity has continued to rise at a rapid rate. As of early 2022, more than 1,300 mass timber projects have been built, are under construction, or in design in the US. This is coupled with technical advancements that one architect described as "a timber renaissance, with new milestones in timber construction being reached at a breakneck pace."

Once considered an emerging building technology, mass timber has gained momentum as a low-carbon alternative to energy intensive structural materials. Light-weight yet strong, versatile and nimble, these easy-to-prefabricate building products are being specified by everyone from governments and educational facilities to multi-family developers and major corporations. With a looming climate crisis and exponential demand for affordable housing on the horizon, mass timber's assent is a bright spot for industry leaders looking for cost-effective solutions to decarbonizing the built environment.

Vol. 2 features a diversity of design teams across the country breaking new ground through novel research, conceptual designs, rapid prototyping, and technical testing. DLR Group gives a sneak peek into how their full-scale mass timber hotel prototype is rewriting the rules of hospitality design, and Seattle-based design firm Mahlum shares highlights from a recent study exploring the feasibility and benefits of building more schools with mass timber. Reimagining the next generation of science buildings, global design innovator Gensler shares a cutting-edge mass timber laboratory project, while Boston-based Placetailor discusses how their integrated design process is helping achieve net-zero passive house design for a mass timber affordable housing project. Providing key insights into mass timber performance, BM TRADA shares their research findings on cross-laminated timber and moisture management.

Each article offers an abridged summary of original research, written by the leaders and experts themselves, along with a link to read more from the source material. As mass timber goes from niche to mainstream, stay up to date and discover what's possible with the Mass Timber Digest.

Timber Hotel Prototype | DLR Group

written by Steven Cavanaugh | Design Leader

Rewriting the Rules of Hotel Design

DLR Group, in collaboration with the University of Minnesota, is completing a conceptual design and a prototype to study the viability of mass timber systems in the context of hotel construction, under a paid research grant from the US Forest Service. Alongside the conceptual design, a prototype room is currently being constructed—set to open fall 2022—allowing prospective developers and owners to experience the room at scale.

Jumpstarting Change and Recovery

The hospitality industry reeled under unprecedented turmoil over the past two years. Amidst a post-COVID rebound, competition is fierce with hoteliers seeking every differentiating advantage. Research shows that a rising class of consumers are willing to pay a premium for environmentally and socially conscious projects. Could timber construction be the answer to jumpstarting change?

Over two years, DLR Group is leading a collaborative process with a wide-range of industry experts, from mass timber manufacturing leaders to international hotel brands. Together, the group is working on real-world ideas and applications for a replicable prototype using mass timber in hospitality design and construction.

The outcomes of this process will inform full-scale built mock-ups for testing, demonstration, and awareness-building; a prototype adaptable hotel design; and detailed cost analysis. Design considerations include structural optimization, mechanical systems integration, acoustic testing, aesthetics, carbon negativity, fire safety, and biophilic wellness.

Timber Hotel Prototype | DLR Group

Overcoming Barriers and Misconceptions

Emerging material technologies often face adoption barriers related to misconceptions about cost, performance, and availability, as well as a general lack of awareness and understanding. Bringing almost a decade of pioneering "tall timber" work through our partnership with Hines on their T3 office program, as well as recognized design expertise in the hospitality sector, DLR Group is advancing the acoustics, systems integration, and aesthetics of timber in hospitality applications. The goal of this work is to accelerate the momentum behind timber and its carbon benefits into real-life, financially viable, high-performing prototypes.

Dispelling Material Myths

According to our consultations with industry experts, three factors are most often cited as reasons timber won't work for hospitality: sound, structure, and safety. The research team set out to test these myths, debunking them one by one. Acousticians modeled timber assemblies to discover a unique combination of structural, wall, and connection details that meet the demanding sound requirements of Marriott International, a well-known American multinational hospitality company participating in the research.

Structural engineers tested timber structural modules against cost and typical hotel room modules, finding the sweet spot where the space between structural members neatly houses a hotel room with little modification. Advancements in wood and fire protection science ensure life safety, and fire modeling demonstrates how the prototype assembly meets performance code with no significant disadvantages.

Most importantly, the prototype is different from sky-high timber concepts that only work when a city bends their building code. This prototype could be built, today, in any North American city working under the commonly adopted 2021 building code. This is mass timber for the masses.

Quantifying the Benefits

Mass timber helps reduce emissions and store carbon and is a renewable building material that can be domestically sourced. The prototype's 73,000 cubic feet of wood products directly reduce the building's carbon footprint by 22% compared to a similar concrete structure. However, the benefit of timber extends beyond its first impact: trees absorb and store carbon. Capturing this stored carbon inside a building where it won't be released back into the atmosphere translates to an 86% carbon footprint reduction over the prototype's life cycle.

With 500+ hotel construction starts projected in 2023, the ecological benefit magnifies even if timber is only used in a small percentage. And, for frazzled guests seeking a respite, research shows staying at a timber hotel with biophilic design could boost relaxation and lower stress hormones, heart rate, and blood pressure.

According to Matt DeBold, Marriott's Senior Design Manager, "this isn't just about using natural materials and biophilic design. It's sharing a building that improves the environment for everyone."

ARTICLE

Materiality and Hospitality: Researching Mass Timber Design for Hotels

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Calculating a Cost Model

As a functional prototype, the module was feasibility tested across a variety of North American climates, geographies, building zones, and common codes. A comparative cost model between the timber prototype and a similar hotel built with concrete and steel saw the timber system priced out with a slim 4% premium. That construction premium would quickly be recouped as timber construction efficiencies can translate to opening weeks faster.

What's Next?

Having explored hundreds of options in research and predictive modeling, it's time to build out the prototype. Developers and hoteliers will be able to tour a walk-through room—and see, feel, and touch the revolution—in early fall 2022 at the University of Minnesota.

Once the Wood Innovations Grant is complete, the University plans to use the prototype room for further research related to timber hotels, but also as a research station for timber and forestry management.

Timber Hotel Prototype | DLR Group

K-12 Mass Timber Prototype | Mahlum Architects

written by Joseph Mayo | Associate | Mahlum

Building More Schools with Mass Timber

Mahlum, an architecture firm with offices in Seattle and Portland, wanted to know why more mass timber K-12 schools—especially larger and multi-story structures—were not being built in Washington State. Is it feasible to construct more schools with mass timber, and, if so, what are the benefits? Mahlum received a United States Forest Service Wood Innovations Grant to explore the use of mass timber to deliver exceptional K-12 educational spaces in Washington State that are cost-effective, resource efficient, and low carbon.

K-12 Mass Timber Prototype | Mahlum Architects

The Need for Quality School Design

There is a critical need in Washington State for high-quality, healthy learning environments that foster creativity, critical thinking, and growth. At the same time, we face a critical climate crisis that calls for bold action. Our next generation of leaders, thinkers, and doers must be welcomed, nurtured, and empowered by a climate smart environment.


K-12 Mass Timber Prototype | Mahlum Architects

Feasibility of Schools Built with Mass Timber

The feasibility of tall classroom buildings up to three stories high in Washington State was the primary focus of the study. Findings are applicable across the Pacific Northwest as well as in other regions of the U.S. Our research compares a prototypical 2-3 story mass timber school to one built predominantly of structural steel (the current norm for multi-story K-12 schools in Washington). This included a dissection of all aspects of the two different construction types, analyzing their design flexibility, embodied carbon, indoor environmental quality, acoustics, mechanical distribution, structural framing, sourcing, constructibility, and cost.

The research is based on several presuppositions:

→ With a growing population and mandated reductions in classroom sizes, Washington State has a capacity crisis and must quickly deliver additional classrooms and learning spaces to meet its Constitutional mandate for basic education.

→ Land is at a premium today, and many school districts do not have access to greenfield sites or large swaths of developable land.

→ Education must be affordable, and likewise new school construction and renovations must be financially within reach of the communities they serve.

→ The world around us is rapidly changing, and consequently the physical landscape of schools must also be capable of change.

→ With impacts from the climate crisis growing, creating more sustainable and resilient buildings has never been more important.

Although the study focused broadly on all aspects of mass timber construction of educational facilities, in this summary, we call out specific highlights related to the biophilic benefits and flexibility in design and layouts that mass timber can offer K-12 facilities.

Biophilic Benefits and Indoor Environmental Quality

Schools can be stressful places, where social, academic, and environmental pressures influence and impact learning. How can we improve the quality of schooling and create spaces that are optimal for learning, cognition, development, and creative thinking? And how can principles of biophilic design support these goals?

To answer these questions, we explored how light, temperature, air quality, ownership, flexibility, complexity, color, and access to nature all impact learning outcomes when it comes to classroom design. A growing body of research suggests that incorporation of biophilia into learning spaces can have significant effects on educational outcomes. This includes positive neurological impacts of natural materials and surfaces featuring exposed wood. The careful selection of real wood elements, the use of daylight, and broad views into nature can provide rich cognitive stimulation, priming students to face daily challenges.

One study found biophilic elements in a classroom setting can reduce perceived stress by nearly 65 percent and boost test scores by more than three times. These findings suggest wood can play an important role in healthy, high-quality school design, offering biophilic benefits and indoor comfort for students.


K-12 Mass Timber Prototype | Mahlum Architects

written by Joseph Mayo | Associate | Mahlum

Versatility and Flexibility of Mass Timber Systems

Schools need to provide varied learning spaces with spatial opportunities to support a student's unique cultural identity and individual interests. Over time, as pedagogies and priorities change, spaces should be able to change, too. A National Center for Education Statistics report from 1995 found that around three-fourths of schools reported having undergone at least one major renovation, and a 2020 report from the U.S. Government Accountability Office found that an estimated 54% of public school districts needed updates or replacement of major features. Renovations will occur, but with good design, their impact can be minimized and disruptions to learning from construction held to a minimum.

When considered as a kit-of-parts, prefabricated mass timber can make it easier to modify or add on to an existing structure. It offers a flexible, versatile building system, can be sourced locally, built economically with prefabrication — and ultimately its sustainability elements can be learning tools in the classroom.

A post and beam mass timber structure eliminates the need for load-bearing interior walls, which can greatly impede options for future renovations. Long-span structural elements limit the number of columns within spaces, allowing for more versatility. When done right, this approach makes for mass timber building systems that can accommodate a diversity of layouts.

Overall, the research reflected in this report demonstrates that the use of local, natural, carbon sequestering materials can offer a broad benefit for climate health, as well as the health of students, teaching staff, and our communities. What's more, taking a holistic view of construction and cost shows mass timber can compete economically with other standard building materials.

ARTICLE

Growing Schools: The Feasibility of Mass Timber K-12 Schools in WA State

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K-12 Mass Timber Prototype | Mahlum Architects

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written by Chad Yoshinobu | Principal + Global Practice Area Leader | Gensler

Designing the Lab of the Future

Gensler is rewriting the rules when it comes to designing more innovative and versatile science and lab facilities—the result includes more flexible layouts, a broader connection to the surrounding community, and the abundant use of low carbon, biophilic materials, such as mass timber.

The Next Generation of Science Buildings

Designing lab buildings comes with a raft of unique challenges. Concerns about vibration, ventilation, containment, and specialized equipment go beyond the scope of traditional workplaces. Developers must meet exact specifications to ensure safe and successful working environments for a variety of scientific endeavors.

As part of ongoing, measurable-impact research funded by the Gensler Research Institute, Gensler partnered with Buro Happold and KPFF to develop a conceptual framework for the next evolution of science buildings—how they will perform and what they will look and feel like.

Locating the lab concept in Seattle's Uptown Arts District, we based our decisions and design interventions around industry-specific research and data. The project had three goals: liberate the space and make it more than just a container for people, increase product differentiation in the market to allow our developer clients to leapfrog past their competition, and offer solutions that prioritize decarbonization as a method of resiliency. We call this idea NEXT, and it redefines what a lab can be.

NEXT | Gensler

written by Chad Yoshinobu | Principal + Global Practice Area Leader | Gensler

Using Mass Timber for Flexibility and Sustainability

The use of mass timber in large building construction has gained a lot of traction in recent years because of its ability to significantly lower the carbon footprint of a project. The material also has an emotional appeal because it lends warmth to a building's interior; steel and concrete must be covered with extra material to achieve the same result.

We also discovered that timber is particularly suited to off-site modular construction, which would allow us to produce the project in a nearby factory and deliver it to the site as a kit of parts. This approach would be 30% faster and 10% cheaper to construct than a conventional concrete building. With 85% fewer deliveries to the site and a 75% reduction in construction waste, NEXT uses 80% less carbon to build than a conventional concrete lab building. This amounts to a savings of approximately 5200 total metric tons of CO_2.

We extended the sustainable approach to the building's operations as well. NEXT uses an all-electric heat pump chiller (EL1) system that is more efficient than a natural gas system in all locations and sectors. All-electric systems result in lower building Energy Use Intensity (EUI) in all markets and achieve zero carbon emissions on a clean grid. In total, NEXT produces 50% less greenhouse gas emissions and uses 30% less energy annually than a conventional lab building.

Rethinking The Lab Layout

Another innovative feature of NEXT is the flexibility of the building grid. Lab building layouts are determined by two things: the lab bench and vibrations in the floor plate.

The lab bench is where equipment is stored, experiments take place, and work is prepped. It is a key building block of any science building. As for vibrations, they must be kept to an absolute minimum to prevent disruptions in science experiments.

We created the most flexible grid for our tenants at 33 X 33 feet. This is optimal for a lab bench layout because it allows our tenants to choose what's best for them by orienting their lab bench north south or east west. However, the size of this grid in mass timber doesn't work well with vibration, so we partnered with our engineering partner KPFF to make it work. Together we achieved a vibration of 6,000 MIPS, a go-to standard for most lab buildings.

We also relocated the building core from the center to the side of the building. Putting a core in the middle of a building is like putting a fireplace in the middle of your living room. It bifurcates and separates tenants. This move allows our tenants even more flexibility on their layout, without the obstruction of the building core hampering their options.

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written by Chad Yoshinobu | Principal + Global Practice Area Leader | Gensler

A Focus on Health and Wellness

Science workplace tenants are increasingly looking for spaces that can promote the health and wellbeing of their employees and of the communities in which they're located.

NEXT puts a premium on natural ventilation and outdoor spaces. With a multitude of operable windows, the workplace portion of the floor will have abundant access to fresh air. And in Seattle, where the climate is optimal for natural ventilation, the workplace can spend 34% of total occupied hours in natural ventilation mode, which helps yield energy savings of 30% compared to a conventional lab building.

Each floor also has direct access to outdoor spaces that run up and down the building. According to the Gensler U.S. Workplace Survey, science workers ranked outdoor space as their #1 most desired workplace amenity. We also took the most under-utilized component of the building—a fire stair—and flipped it into a tenant amenity. We pulled the stair to the perimeter, flooding it with daylight and views.

This stair acts as a wellness amenity, liberating tenants from relying on elevators. Furthermore, with access control technology, this arrangement means the common stairwell can also act as an interconnecting stair for specific tenants on multiple levels—thus eliminating the need to build their own costly internal stairs, saving money, reducing unnecessary construction, and bringing the space to market sooner.

Connecting to the Community

Finally, we wanted to show how a science building could connect to its local community. The ground floor is designed to hold a multipurpose arts and entertainment venue as well as a restaurant incubator to diversify the culinary arts in the city.

Ultimately, NEXT is a platform that allows tenants and developers to reimagine what a science building can be. In addition to delivering top-of-line functionality within the lab and workspace, NEXT offers opportunities for a variety of connections—to the outdoors, the community, and the surrounding cultural context—without sacrificing tenant flexibility. This is our call to action to shift from the past to a more resilient and inclusive future for lab buildings.

BLOG

The Lab Building of the Future is NEXT

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201 Hampden CLT Passive House | Placetailor

written by Elizabeth Hauver | Designer | Placetailor

Net Zero Passive House Case Study

Placetailor's Boston-based 201 Hampden CLT Passive House Case Study is demonstrating how mass timber can help tackle some of the biggest challenges facing the AEC sector. From prefabricated rapid assembly and energy-efficient thermal advantages to biophilic benefits, this demonstration project shows how mass timber can help us get to net-zero—while delivering more affordable, sustainable, and Passive House-certified homes.

Cutting Carbon with Mass Timber Passive House Construction

The 14-unit affordable zero-carbon housing project in Boston's Roxbury neighborhood will be constructed with CLT made from reclaimed blighted eastern hemlock, sustainably harvested timber from U.S. forests. Choosing CLT over a conventional concrete steel structure substantially lowers the building's carbon footprint, essentially turning it into a carbon sink.

In addition to being an eco-friendly structural choice, CLT's natural thermal mass helps 201 Hampden achieve its Passive House design by reducing the amount of potential thermal bridging moments and normalizing interior temperatures.

CLT's thermal mass eliminates the need for thick exterior insulation, which in turn cuts embodied carbon, while reducing operational emissions over the life of the building.

> "Thanks to the CLT and continuous exterior insulation layers, 201 Hampden will act like a next-generation log cabin."

201 Hampden CLT Passive House | Placetailor

Mass Timber's Biophilic and Cost-Saving Benefits

201 Hampden's Passive House design offers many advantages; when left exposed, the CLT structure also offers health and biophilic benefits. Beyond the warm, soothing effects of visible wood grain, avoiding encapsulation reduces the need for additional materials and paint, ultimately decreasing the interior's overall volatile organic compound (VOC) emissions.

To achieve the project's biophilic benefits while keeping it affordable, 201 Hampden will maximize the time savings and cost benefits that can be achieved through precisely planned, prefabricated mass timber construction. This will help reduce crew size, simplify construction site coordination, expedite construction schedules, and reduce overall timelines, in turn reducing the project's overall cost.

Construction is set to begin on 201 Hampden in the latter half of 2022. There will no doubt be more lessons to learn before its completion as we explore how we can rapidly transform to a zero-carbon housing future.

201 Hampden CLT Passive House | Placetailor

201 Hampden's Integrated Design Process to Achieve Passive House

To achieve Passive House standards, and incorporate prefabricated CLT as 201 Hampden's primary structure, the design team followed an integrated design process that included:

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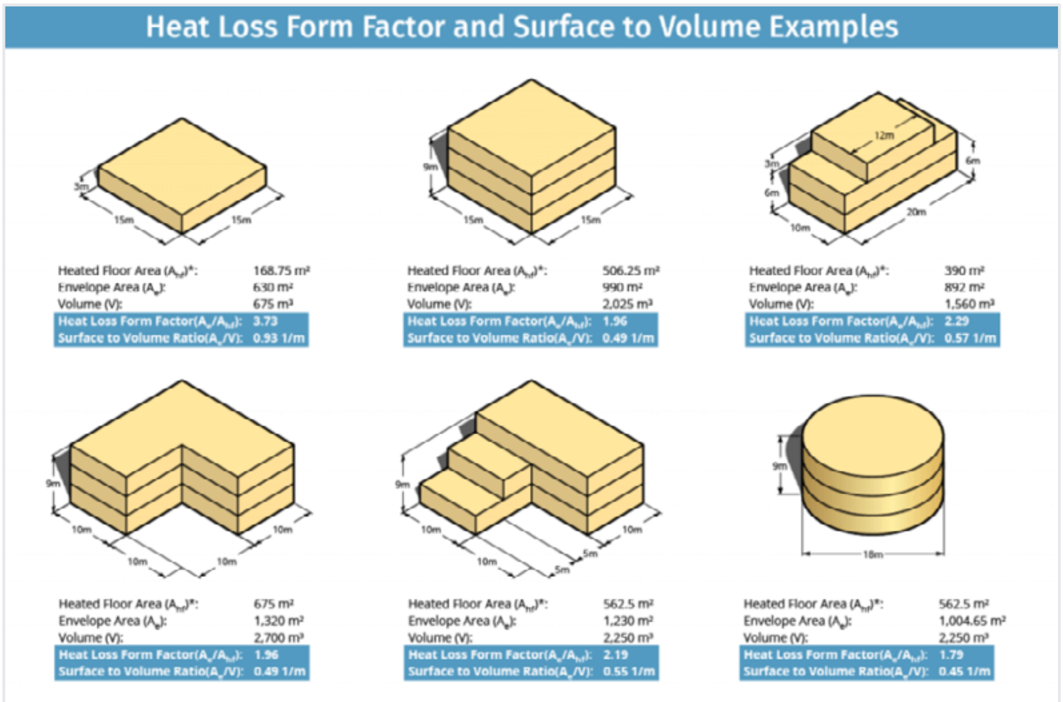
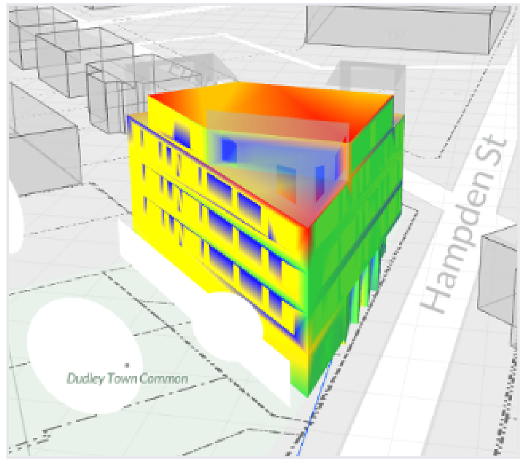


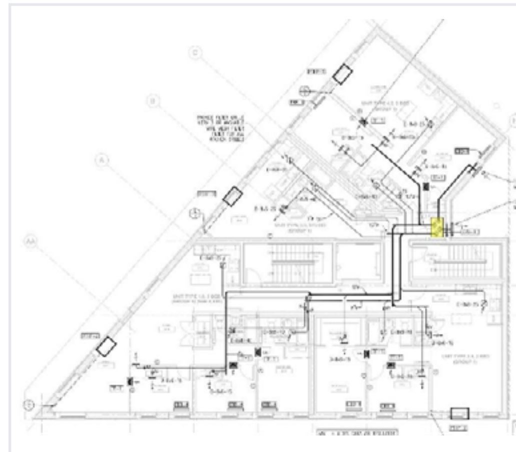
Preliminary design

During preliminary design, the design team considered surface-to-volume ratios (SVR) and heat loss form factor (HLFF) calculated for optimum thermal performance and minimal heat loss. These calculations, along with solar exposure analysis, then guided the best placement and selection of glazing and ideal window-to-wall ratio.



Simulated energy modeling

Energy modeling starts in schematic design and continues into construction documentation. In the case of CPHC, three different scenarios were used to make a cross comparison of different assembly and mechanical, electrical, and plumbing (MEP) system options. 201 Hampden performed well in the Case 2 scenario (Architectural Drawing Set) due to the architect and design team utilizing robust assembly and system assumptions. Therefore, very little had to change to satisfy Passive House criteria in Case 3.



Mechanical, electrical, and plumbing systems

For ventilation, the design team specified a Topvex TR800 with MERV 13 filters for the supply air and MERV 9 for the exhaust air. Topvex TR800 is AHRI and CAS certified. For heating and cooling, a decentralized system was selected with one Ephoca heat pump per residential unit. For plumbing, a SanCo2 heat pump water heater was incorporated — this system uses a CO2 refrigerant line, which reduces system heat loss and has a low global warming potential.

written by Lewis Taylor | Senior Timber Frame Consultant | BM TRADA's Technical Timber

Moisture Management of Cross-Laminated Timber Construction

When it comes to cross-laminated timber (CLT) construction, excess moisture can wreak havoc, causing water damage and the risk of mold. New research explores what design teams need to consider when it comes to managing moisture and reducing wetting throughout all phases of a CLT project.

Over the past decade, CLT buildings have been making headlines. A common thread among all CLT projects is a consideration for CLT's exposure to the prevailing weather—the larger and more complex the building, the greater the risk of wetting during construction. In collaboration with Stora Enso, BM TRADA spearheaded research on CLT and moisture management to determine the mechanism and extent of water uptake when CLT panels are exposed to wetting, evaluate the effectiveness of temporary preventative strategies to minimize risk, and investigate how panels dry once wet.

The research was divided into two phases:
Phase 1 consisted of assessing ways to protect CLT panels from wetting during construction, and **Phase 2** consisted of investigating the most effective ways to dry panels if they get wet.

Warringtonfire Testing and Certification Limited

written by Lewis Taylor | Senior Timber Frame Consultant | BM TRADA's Technical Timber

Phase 1 Objectives

The purpose of **Phase 1** was to assess water uptake during construction and investigate methods for reducing risk.

This included investigation of the following:

- Use of end-grain sealers to protect joints
- Use of end-grain sealers to protect the face of panels
- Use of adhesive tapes to protect joints
- Use of a temporary protective membrane
- Influence of joint type
- Influence of wetting regime

Warringtonfire Testing and Certification Limited

Summary of Phase 1 Findings

After completing Phase 1, it was concluded that end-grain sealers can be used to protect joints between horizontal panels and joints between horizontal and vertical panels. A single-coat application can reduce water uptake at joints. A two-coat application will provide greater protection, but may not be practical in a commercial setting.

The use of self-adhesive tapes can be both beneficial and problematic. On sloping or vertical surfaces, correctly applied tapes can provide a good defense against wetting. However, when applied to horizontal panels, water is more likely to stand rather than drain through joints increasing the length of time panels are exposed to wetting.

Standing water should be removed from panels as quickly as possible (at least daily if not twice daily), by brushing water away or preferably by designing flat roofs to have a sufficient fall to cause rapid and effective drainage. While loose-laid temporary membranes may offer short-term benefits, they risk trapping moisture below them.

Testing indicates that the risk of excess water absorption could be similar between summer and winter. Solar gain in warmer summer months can dry the surface of the panels; however, under certain conditions, wetting and solar gain can result in a more rapid uptake of moisture into panels when compared to colder/less sunny conditions.

Phase 2 Objectives

In **Phase 2**, basic material drying tests were conducted to establish baseline data. It was agreed that laboratory work would be undertaken to validate the drying model for CLT. In addition, a greater number of smaller CLT test blocks would be exposed to a wide range of conditions to offer a broader understanding of the factors that influence drying time.

Two batches of tests were undertaken:

- 300mm x 300mm blocks of 100mm-thick five-layer CLT
- 75mm x 75mm boards that are 18mm and 44mm thick

Summary of Phase 2 Findings

Under test conditions in Phase 2, increasing drying temperatures reduced drying times, and drying rates slowed as the timber approached equilibrium moisture content. Low relative humidity results in low equilibrium moisture content, leading to an increased risk of splits and fissures.

In all instances, when the CLT test panel was able to dry, the drying occurred in a relatively short period of time (up to four weeks). However, where the wet face of the panel was covered, drying was far slower (over 12 months).

When CLT flat roof panels were enclosed with non-breathable materials with a moisture content above 20%, drying took longer than 9 months, leaving the CLT panels at risk of developing fungal decay.

Breathable insulation materials (with no separate high resistance vapor control layer) can help reduce trapped moisture and the risk of fungal decay. When CLT panels are able to dry from their wet face, drying times may be fast enough to avoid fungal decay.

Conclusions

For any CLT project, design teams need to develop systems and methods tailored to the location and climate to effectively manage moisture. The type and combination of protective measures may not be the same for all building types. Moisture management will be of less concern for small, simple buildings as their quicker schedules limit exposure to wet weather conditions. Conversely, large buildings with longer construction periods and extended exposure to wet weather conditions may require a more robust moisture management plan.

Nonetheless, any CLT project should consider a site moisture management plan that clearly outlines the roles and responsibilities of project team members. The management plan should consider mitigation measures, moisture content monitoring, and key thresholds when further action should be taken to reduce wetting. Read More→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