# Wood Design & Building®

Spring/Summer 2018 — Number 79

Six dollars

Publications Mail agreement #40063877

**Alternative Solutions**
Writing an alternative solution proposal for a tall wood building

**Romsdal Folk Museum**
Treasured landmark built using local timber technology

**Hurricane Ties**
Achieving expected uplift resistance

WOOD DESIGN & BUILDING®

# contents

**Above** and **on the cover:**
ROMSDAL FOLK MUSEUM, MOLDE, NORWAY
PHOTO CREDIT: Erik Hattrem

## On the Cover



## Departments



## Features



## Updating Codes for Tall Mass Timber Buildings

In April, the International Code Council's (ICC) Committee Action Hearings in Columbus, OH, concluded with a clear endorsement of building codes that will enable the use of mass timber technologies in buildings up to 18 stories. Though taller mass timber buildings are currently being built under various local codes, this move by the ICC ensures that model code provisions will be available to many more building officials.

"The strength and fire resistance performance of mass timber structures is well understood and supported by substantial testing and data," said Stephen DiGiovanni, P.E., Chair of the ICC's Ad Hoc Committee on Tall Wood Buildings and fire protection engineer for the Clark County (NV) Department of Building and Fire Prevention, in a press release. "As taller mass timber buildings become more widely deployed, it's important that the *International Building Code* and the entire family of I-Codes remains at the forefront of emerging construction technologies, and continues to provide building and fire code officials with the tools they need to ensure the safety of the public and first responders."

All buildings under the *International Building Code* (IBC) must meet specified fire performance standards, whether built of steel, concrete or mass timber. The 14 code provisions passed from the ICC Committee Action Hearings established new fire resistance standards and procedures for mass timber that are more rigorous than comparable steel and concrete structures.

The ICC deliberations were conducted by a board-appointed Ad Hoc Committee on Tall Wood Buildings, consisting of building officials, fire services professionals, engineers, materials providers and other industry stakeholders that worked more than two years to evaluate the code, investigate the science of mass timber, and develop consensus proposals to ensure that tall mass timber buildings meet the highest standards.

The formal adoption of the codes into the IBC is pending votes at the 2018 ICC Public Comment Hearing in October, in Richmond, VA, and a nationwide online vote by code officials in November.

We'll all be watching . . . but things are looking up!

**Theresa Rogers**
*Executive Editor*
trogers@dvtail.com

*Wood Design & Building* magazine invites you to submit your project for consideration and possible publication. We welcome contributed projects, bylined articles and letters to the editor, as well as comments or suggestions for improving our magazine. Please send your submissions to Theresa Rogers at trogers@dvtail.com.

# inspiration BOARD

## WHAT I'VE FALLEN FOR THIS MONTH...

SPONSORED BY SANSIN

### INTERNATIONAL PRIZE FOR WOOD ARCHITECTURE

Earlier this year, I had the honor of participating in the first annual International Prize for Wood Architecture awarded by the press. This brand new prize aims to reward excellence in wood architecture while establishing links between countries where wood construction is playing an increasingly important role. The editors of the following magazines also participated by each submitting three projects from their respective regions and then judging the whole.
•Lignardo/Mikado: Germany •Lignum: Switzerland
•PUU Info: Finland •Séquences Bois: France
•Trä: Sweden •Zuschnitt: Austria

The prize was awarded to Russell Acton, Principal, Acton Ostry Architects, for Brock Commons Tallwood House in April, in Dijon, France, in conjunction with the conference, Forum Bois Construction. Here are just a few of the other entrants:

ARTLAB
Photo Credit: Joel Tettamanti

PUUKUOKKA
Photo Credit: Mikko Auerniitty

LOYLY
Photo Credit: Kuvatoimisto Kuvio Oy


the BIG 95 · Tabbies 2015 Award Winner

WOOD DESIGN & BUILDING
www.wooddesignandbuilding.com
Spring/Summer 2018, Volume 20, Issue 79

**PUBLISHER** ETIENNE LALONDE elalonde@cwc.ca
**PUBLISHING MANAGER** SARAH HICKS shicks@wood-works.ca
**COMMUNICATION MANAGER** NATALIE TARINI ntarini@cwc.ca
**SPECIAL PROJECTS MANAGER** IOANA LAZEA ilazea@cwc.ca

**EXECUTIVE EDITOR** THERESA ROGERS trogers@dvtail.com
**STAFF WRITER** HERMIONE WILSON hwilson@dvtail.com
**CONTRIBUTORS** STEVE CRAFT, LUCAS EPP, ALEXANDER MCCLEAVE
**ART DIRECTOR** SHARON MACINTOSH smacintosh@dvtail.com

**ADVERTISING SALES**
**SALES MANAGER** BETH KUKKONEN bkukkonen@dvtail.com 905-886-6641 ext. 306
**SENIOR ACCOUNT EXECUTIVE** GILLIAN THOMAS gthomas@dvtail.com 905-886-6641 ext. 308
**V.P. PRODUCTION SERVICES** ROBERTA DICK robertad@dvtail.com
**PRODUCTION COORDINATOR** CRYSTAL HIMES chimes@dvtail.com

**DOVETAIL COMMUNICATIONS PRESIDENT** SUSAN A. BROWNE sbrowne@dvtail.com





**CIRCULATION**
**PUBLICATION PARTNERS** wdesign@publicationpartners.com

**SUBSCRIPTIONS**
Four issues per year for $24.00, two years for $40.00, and three years for $50.00.
Please call toll-free 1-866-559-WOOD or visit our Website to subscribe.
Subscription inquiries and customer service:
1-866-559-WOOD or email wdesign@publicationpartners.com
Send address changes to:
PUBLICATION PARTNERS
Garth Atkinson
1025 Rouge Valley Dr., Pickering, ON Canada L1V 4N8

**Published by:**
DOVETAIL COMMUNICATIONS INC.
30 East Beaver Creek Rd., Suite 202, Richmond Hill, ON Canada L4B 1J2
905-886-6640 Toll-free 1-888-232-2881 www.dvtail.com
**For:**
CANADIAN WOOD COUNCIL
99 Bank St., Suite 400, Ottawa, ON Canada K1P 6B9
1-800-463-5091 www.cwc.ca
**www.WoodDesignandBuilding.com** www.WoodDesignAwards.com
ISSN 1206-677X





Publication Mail Agreement #40063877

Printed on recycled paper
Printed in Canada

# Unique Places of Worship

## Alexander McCleave

Places of worship have long been important and symbolic buildings many of us are drawn to. Whether we visit these places to be with a group of like-minded people to sing and praise a higher power, or to be alone with our thoughts, one ideal every house of worship strives for is to provide a peaceful and welcoming environment. The incorporation of wood into these sacred buildings creates a feeling of warmth and serenity that is an appropriate backdrop for a spiritual experience.

**Belarusian Memorial Chapel** was commissioned to commemorate the 30th anniversary of the 1986 Chernobyl nuclear disaster. The design draws inspiration from the rural wooden churches in Belarus, and aims to combine their traditional architectural language with contemporary building technologies and concepts. The materials palette was restricted to wood and glass to reflect the austere and tranquil beauty of traditional wooden churches.

**Chapel of Nossa Senhora de Fatima** was inaugurated last summer for a National Scouts Activities Camp in Idanha-a-Nova, Portugal. The chapel was inspired by the scouting experience of outdoor life and used lamellar Portuguese pine to create a woodsy, natural look. The building was not meant to stand out, but rather blend into the surroundings. This creates a peaceful environment with a natural and cozy wood interior.

In a quiet Philippine fishing village, there is a vibrant and colorful little chapel called **Chapel of St. Benedict and St. Scholastica**. This chapel was constructed with a tiny budget of only $20,000 (USD). The chapel blends mahogany and amakan (woven, split bamboo) to create a truly one-of-a-kind place. The amakan weaving process creates an extremely strong panel that also gives the chapel a tropical feeling. This incorporation of different materials was inspired by the surrounding Nipa huts.

The **Burning Man** festival is an annual event that takes place in Black Rock Desert, NV. Each year, a massive temple is constructed for the 80,000 participants who come to the event. In August 2017, a group of 100 volunteers built this temple in only two weeks. The temple, constructed from Ponderosa pine from the Sierra Nevada foothills, provided a quiet, contemplative space where participants could bring mementos of people who had passed away during the previous year. By the end of the week-long event, the temple was covered in handwritten messages, objects and photos that were burned along with the structure in a cathartic ritual at the culmination of the event.


1


2


3


4

1. Belarusian Memorial Chapel (2017)
   Architect: Spheron Architects
   Location: London, England
   PHOTO CREDIT: Helene Binet

2. Chapel of Nossa Senhora de Fatima (2017)
   Architect: Plano Humano Arquitectos
   Location: National Scouts Activities Camp, Idanha-a-Nova, Portugal
   PHOTO CREDIT: João Morgado

3. Chapel of St. Benedict and St. Scholastica (2017)
   Architect: WTA Architecture and Design Studio
   Location: Pambujan, Philippines
   PHOTO CREDIT: Paul Quiambao

4. Burning Man Festival Temple (2017)
   Team: Marisha Farnsworth (Artist); Mark Sinclair (Structural Engineer); Steven Brummond (Project Manager/Designer); Design Team (Anastasia Victor, John Faichney, Chris Lander)
   Location: Black Rock Desert, NV
   PHOTO CREDIT: Marisha Farnsworth

Image courtesy of Acton Ostry Architects Inc.
Photographer: Michael Elkan Photography

## Brock Commons Tallwood House Wins International Press Award

Russell Acton, Principal at Acton Ostry Architects, was presented with a press award for the Brock Commons Tallwood House project as part of the International Wood Construction Press Awards, which were selected by several publication editors from around the world. Theresa Rogers, Editor of *Wood & Design Building* magazine, was part of the hand-selected jury and submitted the Brock Commons project for consideration.

Brock Commons is the tallest mass timber building in the world, home to more than 400 students on the University of British Columbia campus. It was chosen for an award because the jury felt that the project represented an architectural milestone which showcases new uses for wood in multi-storey wood construction and architecture.

Vancouver's Acton Ostry Architects designed the building in collaboration with structural engineer Fast + Epp, tall wood advisor Architekten Hermann Kaufmann of Austria, and Structurlam in Penticton BC.

"Advanced construction technologies and modern mass timber products have made tall wood construction a viable option that is gaining traction with design and construction communities who face growing pressures to reduce the carbon footprint of buildings," explains Etienne Lalonde, Vice President Market Development for the Canadian Wood Council and publisher of *Wood & Design Building* magazine. **www.wooddesignandbuilding.com**

## Bensonwood Opens New Production Facility

In late April, Bensonwood announced a new white label brand for all products produced at its new advanced building component manufacturing facility. The announcement was made at the grand opening of the new 110,000-sq.ft. production facility located in Keene, NH.

The new facility enables the efficient and precise production of high-performance and high-quality wood-based panels and structures, and will work in parallel with Bensonwood's timber frame and millwork production. The production facility scales building efficiencies by removing time and costs from building development and construction. This volume optimization lowers the environmental impact of construction by reducing waste. **www.bensonwood.com**


## Roseburg to Acquire Pembroke MDF

Oregon-based Roseburg Forest Products recently reached an agreement in principle with Pembroke MDF, Inc. to purchase Pembroke's medium density fibreboard (MDF) and molding production facilities located in northeastern Ontario.

The acquisition will be Roseburg's first international purchase and will continue the country's expansion throughout North America.

The company currently owns and operates an MDF plant in Medford, OR, which produces the company's Arreis, Medite, Medex, Permacore, and Fibrlite product lines. "The addition of the Pembroke MDF plant means Roseburg customers will have access to a broader portfolio of products from a company with a demonstrated, long-term commitment to the industry," says Jim Buffington, Roseburg's Business Director for Industrial Products.

"While this deal represents an excellent strategic opportunity for the company, it also offers Pembroke employees and suppliers the promise of stability and consistency provided by Roseburg's large manufacturing enterprise," says President and CEO Grady Mulbery. "This is a win-win for everyone involved, and we look forward to what the future will bring." **www.roseburg.com**

## AWC Hires Fire Service Manager

A new position, Manager, Fire Service Relations, with the American Wood Council (AWC) will be filled by Raymond O'Brocki, CBO. O'Brocki will create a stronger relationship between AWC and the fire service community.

The safety of first responders is AWC's priority. O'Brocki's existing relationships with fire service organizations and officials will help the AWC better understand the needs and expectations of the fire service for education and technical support on wood products, construction, and fireground considerations. One of O'Brocki's duties will be to get training materials and videos on the best practices that can help prevent construction fires in front of the right audiences.

O'Brocki served as the Construction Standards Code Enforcement Officer for Prince George's County (Maryland) Department of Permitting, Inspections and Enforcement. He had previously served in several positions for the Baltimore Fire Department.

O'Brocki is an International Code Council Certified Building Official. He received his bachelor's in jurisprudence from the University of Baltimore and his juris doctorate from the University of Baltimore School of Law. **www.awc.org**

## Austrian Timber-Hybrid Construction Specialist Awards License in Luxembourg for its Construction System

The Compagnie De Construction Luxembourgeoise SA (CDCL), based in Leudelange, has acquired the Cree license for Luxembourg.

Cree says that CDCL now has exclusive access to a completely new, digital way of planning and constructing buildings. The knowledge transfer between CDCL and Cree is already underway and a number of high-volume projects are in the development phase. "We see ourselves as pioneers, systematically implementing our company's strategy and growth trajectory," says Jean Marc Kieffer, CEO, CDCL.

Construction projects in Luxembourg will now be able to use the timber-hybrid modular construction system and knowledge platform developed by Cree GmbH. This construction method relies on timber, allowing structural columns or central service cores to be prefabricated to standardised designs, saving resources, time, noise, and money. "This modular design also allows worldwide implementation, using local resources," says Hubert Rhomberg.

Cree says general contractors and property developers such as CDCL can license the system and use it to secure a competitive advantage in their home market. **www.creebyrhomberg.com**

## Architects Chosen for New George Brown College Tall Wood Campus Buildings

Photo Credit: Moriyama and Teshima Architects

George Brown College has selected Moriyama & Teshima Architects + Action Ostry Architects to design The Arbour, its tall wood campus building on Toronto's waterfront. This moves the project one step closer to the construction of a tall wood, low carbon institutional building.

In selecting the winning design, the jury said, "The concept excelled across all aspects of the selection criteria: innovative use of wood; excellent energy use; exquisite space planning; and spaces that will have a strong resonance with students and the broader East Bayfront community."

Once built, the 174,900-sq.ft. building will be home to the college's School of Computer Technology, a new child care facility, and Canada's first Tall Wood Research Institute that will generate innovative ideas and research in low-carbon, mass timber construction.

The team's design for The Arbour features breathing rooms – using solar chimney systems to capture and harness light and air for sustainable natural ventilation. It also offers flexibility of learning spaces, enabling walls to expand and contract as well as a "Made in Canada" approach using nationally sourced mass wood components.

Construction is scheduled to begin in 2021 with a budget of $130 million. **www.georgebrown.ca**

## Washington State Helping Revolutionize How America Builds

American Wood Council (AWC) President and CEO Robert Glowinski issued a statement following Governor Jay Inslee signing SB 5450, which directs the state of Washington to enact the tall wood building code changes when adopted by the International Code Council. The move will help jump start mass timber construction in the state.

"Mass timber is a new category of wood product that will revolutionize how America builds. Beyond its aesthetic qualities, wood is among the most energy-efficient and environmentally friendly of all building materials. Wood products store carbon, keeping it out of the atmosphere indefinitely, thereby reducing a building's environmental footprint," says Glowinski.

"The entire construction industry is changing. AWC applauds Washington state for helping pioneer better places for us to live and work." **www.awc.org**

# Georgica Cove

## Limited materials palette unifies spaces and responds to local climate

**East Hampton, NY**

A couple with property on a cove overlooking the Atlantic Ocean asked for a house that would be just as comfortable for two as it would on busy weekends when the couple was entertaining their children, grandchildren and guests.

To also instill the desired sense of comfort and peace, the design needed to blend with the pastoral setting and vernacular building traditions; i.e., predominantly shingle-style homes and barns that are often added to over time. Precedent studies suggested that referencing New England-connected farms in an innovative way could achieve both goals.

The architectural style of the house was applied to subsequent buildings to unify the assembly, but partitions within provided the necessary separation between uses: house to kitchen, kitchen to shop, shop to barn. One volume was often offset or rotated from the next to provide greater access to light, air and privacy from the other functions. Following that example, the program of this house is divided into the owners' bedroom and office, eat-in kitchen and family room, formal living and dining rooms, and guest rooms.

1. family room
2. eat-in
3. kitchen
4. pantry
5. bar
6. dining room
7. living room
8. courtyard
9. master suite 1
10. master bath 1
11. entry
12. mudroom
13. garage
14. deck

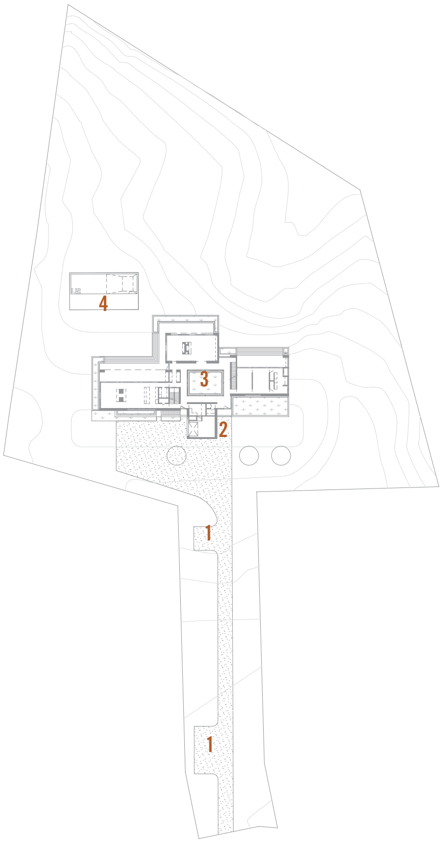
GROUND FLOOR PLAN

1. master suite 3
2. bedroom 1
3. bedroom 2
4. master suite 2

SECOND FLOOR PLAN

The spaces are arranged around a courtyard to create visual and physical connections between them, but those connections can be broken by large sliding doors. Each structure has an independent mechanical system allowing it to be shut down when unoccupied. This allows the house to expand and contract to meet changing needs. Whether the owners are alone, hosting dinner guests, or have a full house of overnight guests, the house perfectly meets their requirements.

As with connected farms, a limited palette of materials and details unifies the various spaces and responds to the local climate. The cedar shingles common to local buildings are scaled up to the size of boards to cover the roof and sidewalls. Cedar screens provide privacy and filter light. A marble plinth filled with sand elevates the house above the floodplain while also creating drywells to accept stormwater runoff. Oak floors and millwork unify the interior spaces.




1. parking
2. entry
3. building
4. pool

SITE PLAN

The design repurposes the historic typology of the connected farm to suit the timely needs of the site and the family. By acknowledging the area's history and tradition of building, the home is an evolution of this vernacular.

ARCHITECT
Bates Masi + Architects
East Hampton, NY

STRUCTURAL ENGINEER
Steven Maresca
Hampton Bays, NY

GENERAL CONTRACTOR
John Hummel and Associates Custom Builders
East Hampton, NY

PHOTOGRAPHY
Bates Masi + Architects
East Hampton, NY

# Your Masterpiece Deserves the Best Wood Protection


**FACTORY FINISHES WITH PROVEN PROTECTION AND PERFORMANCE**

From the undercoat treatment to the topcoat, Sansin's Precision Coat line of factory finishes deliver the color, durability and performance that architects, engineers and builders can count on.

SANSIN®

PrecisionCoat FACTORY FINISH

1-877-SANSIN-1
sansinfactoryfinish.com

# University of Massachusetts Olver Design Building

## Exposed mass timber structure is a teaching tool

**Amherst, MA**

The goal for the John W. Olver Design Building at the University of Massachusetts Amherst was to create an innovative and inspired building that visibly demonstrates environmentally sensitive design. The result is one of the most advanced mass timber buildings in the United States; a four-story, 87,500-sq.ft. structure that exemplifies the university's commitment to sustainability and, through generations of students who will learn within its walls, the future of the built environment.

The Design Building sets a high bar for mass timber buildings in the U.S. with a glulam timber column-and-beam frame, glulam brace frame, cross-laminated timber (CLT) shear walls, timber-concrete composite floor system, and unconventional cantilevered forms. It is wrapped in an envelope of copper-colored anodized aluminum which, combined with vertical windows, echoes the wood structure by evoking the color and pattern of regional forests.

## Architectural Design

Just as it unites three university departments, the Design Building serves as a bridge between the architectural styles of different campus buildings. It is carefully sited on a steep slope at the main campus artery, rising from three stories on the east side of the building to four on the west. In this way, its massing connects the smaller structures of historic Stockbridge Way with the brick Fine Arts Center and modern concrete structures on campus.

The steel design was more than half complete when the university decided on a wood structural system. However, knowing that a switch was possible, some smart design decisions were made early on, to select a structural grid that could accommodate either steel or mass timber, and paying close attention to floor-to-floor heights and overall building geometry. The team even created parallel schematic drawings of a mass timber building design.

Intended to house 500 students and 50 faculty, the Design Building is organized around a two-story central atrium; a flexible gathering and event space with integrated tiered seating, movable partition boards, lounge seating and cafe. Dominated by the composite zipper truss roof structure, the atrium also features a three-story, folded CLT stair, hung from a single long-span truss with thin rods that give the impression it's floating.

Facilities used by all three academic departments surround the atrium in the building's main volume. The first floor features exhibition and lecture space, laboratories, fabrication and materials testing shops,

dining and classroom space, while the second and third include studios, classrooms and offices, and the smaller fourth floor contains studios. Above the atrium is a green roof that functions as a public courtyard and outdoor learning space for students studying urban landscapes.

A curtain wall system exposes much of the building's first floor, including the timber structural system and atrium space, inviting interaction with passersby. The second story cantilevers several feet beyond the first, and the second, third and fourth stories are clad with a panelized rainscreen system.

The Design Building is Type IV Construction with a limited number of unprotected steel transfer beams in the two cantilevers and elements of the courtyard truss. Type IV Construction allows the use of exposed, solid or laminated wood members such as CLT, glulam and wood decking if certain provisions are met. For example, per IBC 2009 Section 602.4, minimum timber sizes must be used, concealed spaces are not permitted, and exterior walls must be of non-combustible materials or fire retardant-treated wood.

## Gravity Framing System

The structural gravity framing system includes glulam beams and columns supporting the timber-concrete composite floor system and CLT roof decking. Other than CLT shaft walls, walls are non-load bearing, cold-formed steel walls with standard gypsum finishes.

Common glulam floor beam sizes are 14-1/4 inches wide x 15 inches or 16-1/2 inches deep. Columns are 14-1/4 inches wide by 22-1/2 inches to 25-1/2 inches deep. Glulam members were sealed with standard factory clear-coat finishes, and members in areas of higher traffic were given an extra coating in the field. Most of the glulam members are black spruce.

The roof assembly is made from seven-ply CLT panels, with rigid insulation and sheet membrane on the exterior. Panel-to-panel connections are surface splines with plywood and self-tapping wood screws.

Typical panel-to-beam and beam-to-column connections included a variety of self-tapping wood screws, which are common on modern mass timber projects, and concealed beam hangers. In their final condition, the steel hangers are protected from fire exposure by a minimum thickness of wood.

## Education Today, Building for the Future

Completed in January 2017, the building is now home to a bustling education community. Its innovative mass timber systems are an inspiration for students, practicing design professionals, and every passerby drawn by the extraordinary sight of the zipper truss within. It is also, in many ways, the embodiment of an optimistic future.

By inspiring designers and their projects, for example, there is a good chance that the Design Building will lead to increased manufacturing of mass timber products in the eastern U.S. Attuned to this potential, the BCT program is already researching the use of local hemlock for CLT.

This article is excerpted from a case study published by WoodWorks – Wood Products Council (www.woodworks.org). WoodWorks provides free project assistance as well as education and resources related to the design of commercial and multi-family buildings in the U.S. To read the full case study, visit www.woodworks.org/publications-media/case-studies.

## PROJECT FACTS

**Size**
87,500 sq.ft./four stories

**Total cost**
$52 million

**Completed**
January 2017

CLIENT
University of Massachusetts Building Authority
Amherst, MA

ARCHITECT
Leers Weinzapfel Associates
Boston, MA

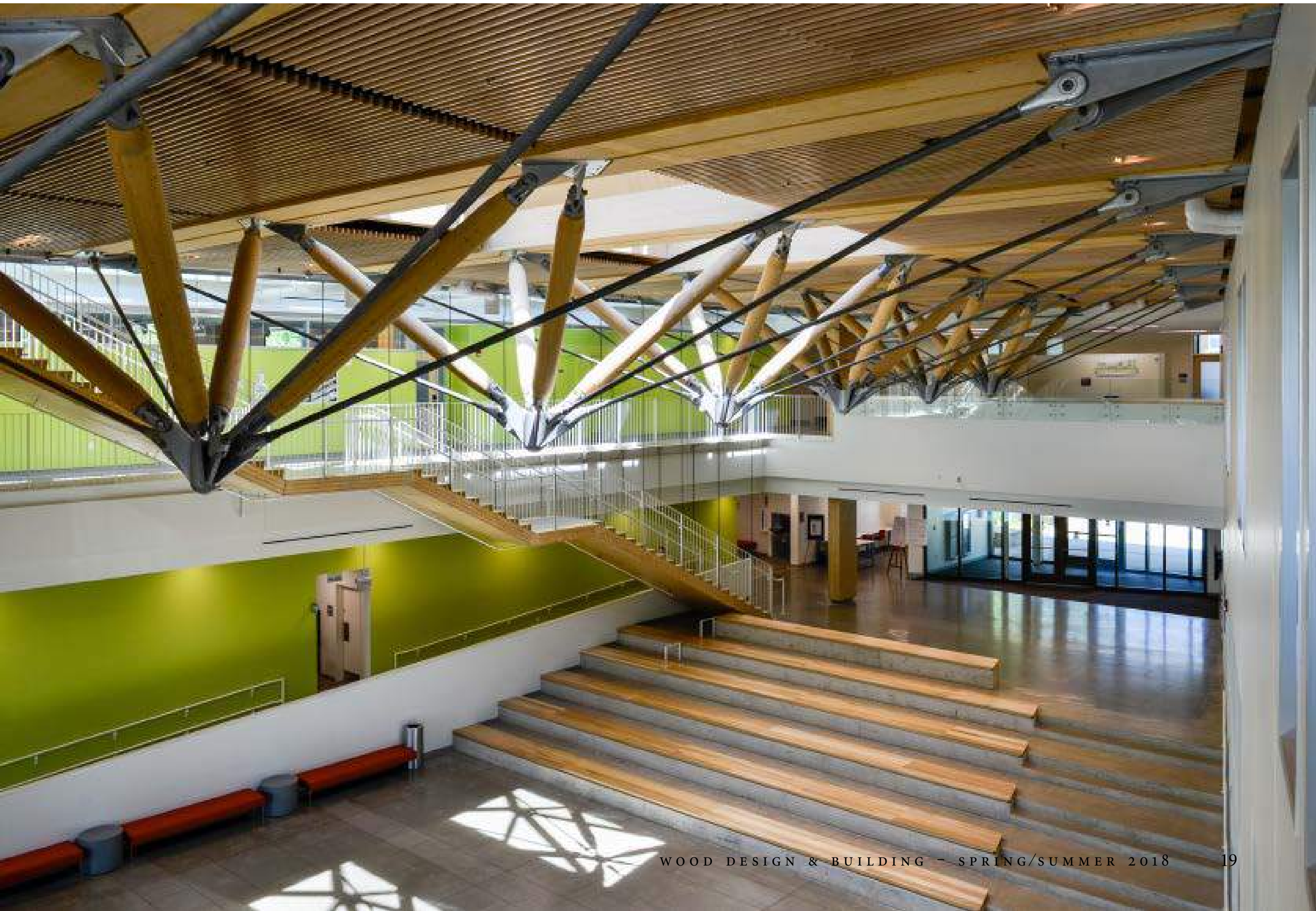
STRUCTURAL ENGINEERS
Equilibrium Consulting
Vancouver, BC

Simpson Gumpertz & Heger (EOR)
Boston, MA

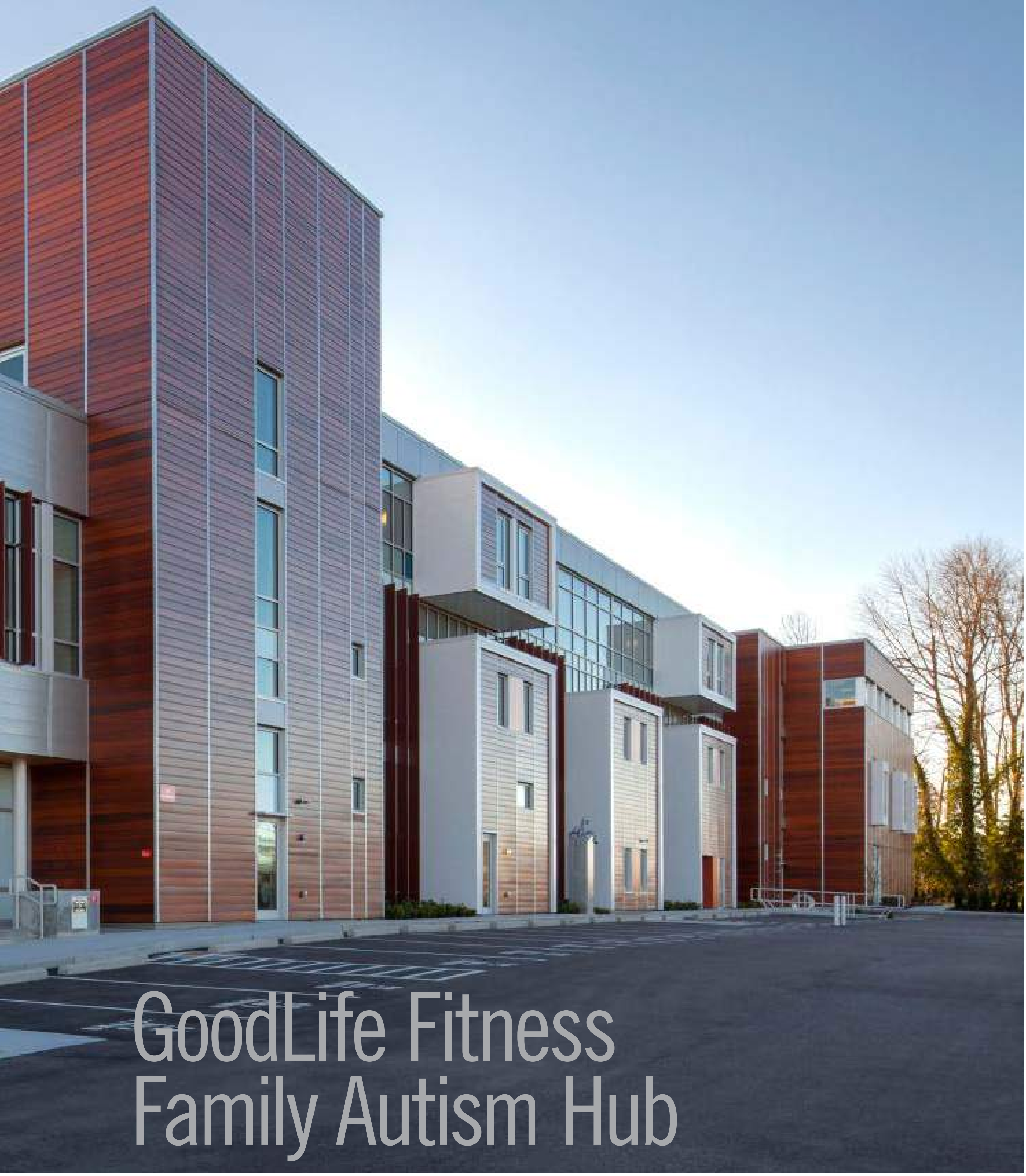
CONSTRUCTION MANAGER
Suffolk
Boston, MA

TIMBER SUPPLIER
Nordic Structures
Montreal, QC

PHOTOGRAPHY
Alexander Schreyer – University of Massachusetts
Amherst, MA




3688



# GoodLife Fitness Family Autism Hub

## Wood creates a nurturing place for people living with Autism Spectrum Disorder

**Richmond, BC**

Located in Richmond, BC, the GoodLife Fitness Family Autism Hub is designed to address the challenges faced by those living with Autism Spectrum Disorder (ASD). It is a provincial knowledge center that incorporates state-of- the-art resources for research, education, treatment and support for ASD individuals and their families.

There are few precedents and very little research on the effects of the built environment on people living with ASD. Early design research and consultation with autism experts stressed that the building should be warm, approachable and inviting. The primary goal was to develop a nurturing and supportive environment; the need to minimize stimuli was a constant theme in the literature and research.

In addition to social sustainability, the Hub is committed to reducing the building's impact on the physical environment. The design team embraced the province's *Wood First Act*, a decision that informed every aspect of the design, from principal structure to cladding and interior finishes. To meet the building's program requirements, a three-story post and beam glulam structure was developed. This structure is expressed throughout the building wherever possible and contributes to a warm, inviting environment. An economical and versatile hybrid system of TJI joists and engineered wood products helps minimize cost.

The main three-story mass of the building is oriented in a north-south direction, with subsidiary massing oriented east-west to create courtyards facing the adjacent Fraser River. This linear concept allowed the program components on all three floors to be accessible from fully glazed corridors that run along the west side of the building. The corridors provide both daylight and views, as well as an acoustic buffer from the traffic noise along a nearby busy roadway. Spaces along the corridors offer a variety of seating areas, play spaces and calming spaces. Playful elements of color and texture animate the space. The exposed NLT floor structure along the corridor helps define this main circulation spine.

All materials were selected for their durability, functionality, aesthetics and low environmental footprint. With a high priority placed on locally sourced materials containing recycled content, wood was an obvious choice.

1. entry
2. reception
3. gift shop
4. workroom
5. resource centre
6. library
7. PAFN information centre
8. meeting rooms
9. kitchen
10. pre-school space
11. consultant meeting rooms
12. music room
13. therapy rooms
14. family courtyard
15. outdoor play area
16. parking

FIRST FLOOR PLAN

The exterior materials are primarily stained cedar siding and metal panels. These materials are used, alone and in combination, to express program components and reduce the apparent scale of the massing. The western red cedar is finished with a clear sealer to maintain the natural warmth of the wood and provide visual richness. The security fences and bicycle enclosures are also constructed of western red cedar.

Beyond the expressed wood structure, interior finishes include linear wood ceilings, wood acoustic wall panels, and extensive millwork. These are all designed and detailed to create a modern, expressive architecture and a nurturing place for people living with ASD.

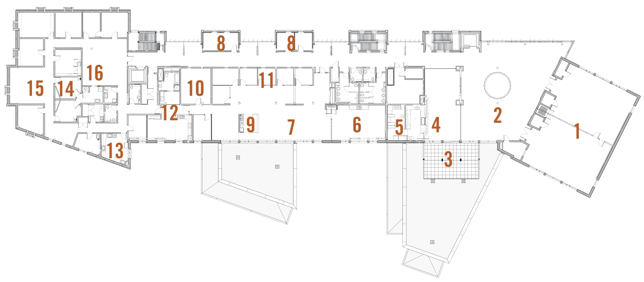
CLIENT
Pacific Autism Family Centre Foundation
Vancouver, BC

ARCHITECT
NSDA Architects
Vancouver, BC

STRUCTURAL ENGINEER
Fast + Epp
Vancouver, BC

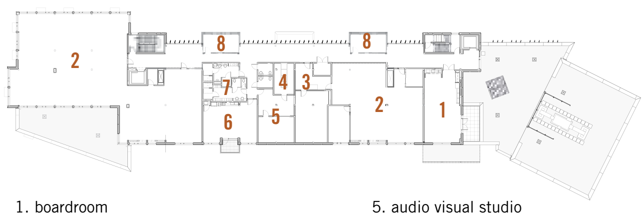
GENERAL CONTRACTOR
Ventana Construction Corp.
Burnaby, BC

PHOTOGRAPHY
Derek Lepper Photography
Vancouver, BC



1. multi-purpose auditorium
2. auditorium lobby
3. covered patio
4. cafe
5. servery
6. life span classroom
7. life span social centre
8. meeting rooms
9. kitchenette
10. digital room
11. consultant meeting rooms
12. life skills suite
13. laboratory
14. dental room
15. research/clinical assessment area
16. reception/nurse

SECOND FLOOR PLAN



1. boardroom
2. general office
3. copier/work room
4. server room
5. audio visual studio
6. staff room
7. staff lockers
8. meeting rooms

THIRD FLOOR PLAN

# Romsdal Folk Museum

Pine architectural form combines region's folk culture and characteristic landscape in a larger composition

**Molde, Norway**

The Romsdal Folk Museum is an architectural attraction and a treasured landmark that embodies the history and identity of the entire region. The architect's intention is for the structure to signal its meaning and function through its architectural expression and use of local materials. The scale of the building refers to the urbanity and morphology of the town. The 37,673-sq.ft. project has an open and progressive layout that makes diverse utilization possible.

The museum design is rooted in rationality and sustainability and the plan geometry is deceptively simple. The characteristic angled shapes are limited to the roof and the external wall, making the circulation and internal organization clear and flexible. The public areas are clearly separated from the administration wing on both the ground and first floor.

Exhibition rooms, the auditorium and the library are all placed on the ground floor to increase flexibility and user experience. The transparency of the reception room permits supporting internal and external activities. Large sliding doors separate the permanent and temporary exhibition areas, giving the curators the ability to easily combine or separate the spaces. The archives and workshops are located on the basement level, with the vertical circulation of large items facilitated by a large elevator.

Pine is the primary building material. The terrain required the use of some concrete, however, its use was restricted to the foundation. Exterior walls and ceilings are covered with pine treated with a bio-based oil.

Varied openings filter the daylight in such way that the internal space is enriched by gradations and translucency. However, the main exhibition rooms are black boxes, giving the curators total control of artificial lighting in these areas. All the glazing units have high-performance glass and, in some locations, the glass is enhanced with silk-printed colors and patterns.

The Romsdal Folk Museum strategically employs several low-tech building solutions. It embodies the national policy in Norway to aim for a more sustainable future. The museum is built using Norwegian timber technology and acts as a hub for cultural development.

In this building, the people of Molde, as well as visitors and tourists, are given the opportunity to connect and to build a wider community. The museum hosts not only exhibits about Norwegian culture but also concerts, workshops and lectures.

The architectural form brings together the region's folk culture and the area's characteristic landscape in a larger composition. The range of perspectives and activities ensures a broad audience, with the museum becoming a living center for the exploration of the region's history, contemporary culture, and future.

CLIENT
Stiftelsen Romsdalsmuseet
Molde, Norway

ARCHITECT
Reiulf Ramstad Arkitekter
Oslo, Norway

STRUCTURAL ENGINEER
Norconsult
Sandvika, Norway

GENERAL CONTRACTOR
Rødberg Bygg AS
Molde, Noway

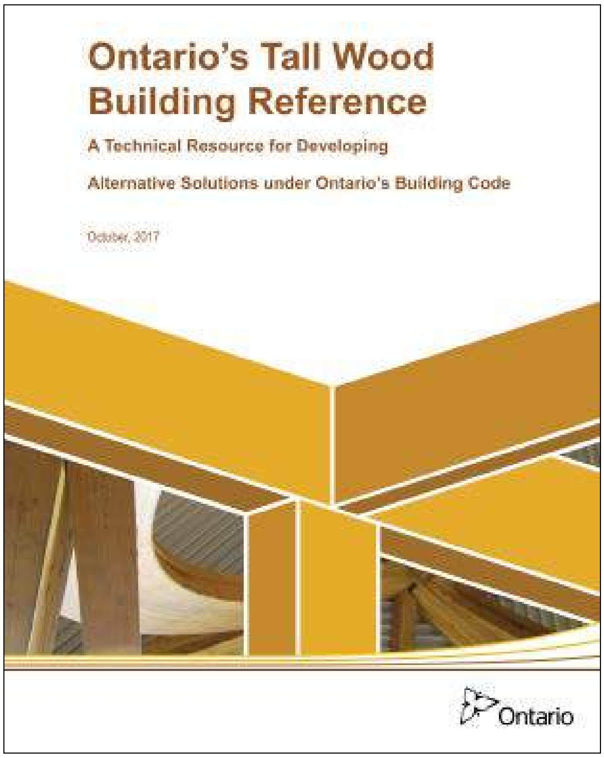
TIMBER SUPPLIERS
Splitkon Norge
Amot, Norway

Martinsons Byggsystem KB
Sweden

PHOTOGRAPHY
Reiulf Ramstad Arkitekter, Erik Hattrem, Søren Harder Nielsen

# Alternative Solutions for TALL WOOD BUILDINGS

**Steve Craft**




Editor's Note: *Ontario's Tall Wood Building Reference* was released in November 2017 by the provincial government. The publication was written as a technical resource to be used by building officials, architects, engineers, developers, and builders, and provides information to assist them as they consider tall wood building construction. Though the document is Ontario-focused, it can serve as a valuable guide to other jurisdictions regarding code requirements and developing wood buildings higher than six stories.

In recent years, tall mass timber buildings have become more prevalent, with dozens either erected or under construction around the world. Developers, architects, governments and the wood products industry are increasingly interested in designing and constructing these unique and progressive buildings.

Although mass timber buildings taller than six stories are currently not permitted under the prescriptive building code requirements, building code committees in Canada are working on revisions to the code requirements to allow tall wood buildings to be constructed. However, until those changes occur, tall mass timber buildings can only be designed and approved using an alternative solutions approach.

The term "mass timber" refers to large timber components such as glued-laminated timber (glulam) or other structural composite lumber (SCL) beams and columns, and cross-laminated timber (CLT) or laminated veneer lumber (LVL) panels. Due to their large cross-sectional area and the relatively slow rate of charring when exposed to fire, these structural wood products tend to have a significant amount of inherent fire resistance.

In order to better understand how these products perform in fire and how they impact the fire dynamics within a mass timber building, many fire research tests have been conducted in recent years in Canada and around the world.

In an effort to support the wood industry in Ontario and contribute to the knowledge base for tall wood buildings, the Ontario Ministry of Natural Resources and Forestry recently published *Ontario's Tall Wood Building Reference*. This reference is written primarily for the Chief Building Official (CBO) of a municipality who may receive

Although mass timber buildings taller than six stories are currently not permitted under the prescriptive building code requirements, building code committees in Canada are working on revisions to the code requirements to allow tall wood buildings to be constructed.

an alternative solution proposal for a tall wood building. It is also a valuable tool for developers and architects who are interested in better understanding the various considerations that may go into the development of an alternative solution when seeking approval from a CBO to construct a tall mass timber building.

To understand how a building permit can be issued for a building that does not meet the prescriptive requirements of the building code, it is necessary to understand how building codes in Canada work. The regulation of building construction is a provincial responsibility under the Canadian Constitution. However, to support harmonization between provinces, the National Building Code of Canada (NBCC) is developed under the direction of the Canadian Commission on Building and Fire Codes as one of five national model codes. Some provinces adopt the NBCC as published, while other provinces and territories make minor or, in some cases, major changes. Enforcement of the provincial codes is typically undertaken by a municipality's CBO.

In Ontario, a majority of the model NBCC is adopted, along with other Ontario-specific changes (e.g. to mid-rise combustible construction provisions), and is published as the Ontario Building Code (OBC). Compliance with the OBC can be demonstrated in one of two ways; by complying with the applicable acceptable solutions in Division B, or by using alternative solutions that achieve the levels of performance required of the applicable acceptable solutions relating to the objectives and functional statements. This means that the acceptable solutions in Division B of the OBC establish the performance level required with respect to the applicable objectives and functional statements.

Brock Commons – Tallwood House
Photo provided courtesy of Acton Ostry Architects Inc.
© Michael Elkan Photography

Based on this, if a designer wishes to submit an "alternative solution," the designer must first establish the level of performance required based on the Division B acceptable solution. This is the primary difference between an objective-based code and a performance-based code, the latter of which would explicitly establish the performance criteria. With an objective-based code, the designer must determine the level of required performance, quantitatively, based on the expected performance of the acceptable solution.

Once the performance levels are established based on the performance of a design compliant with the acceptable solution, as specified in Division B, the alternative solution can be evaluated to determine the performance level provided. The OBC requires that the performance level of the alternative solution be equal to or greater than the performance level of the acceptable solution.

Alternative solution submissions can take many forms, from simple trade-offs to complex fire safety engineering analyses. Alternative solutions for tall wood buildings are likely to be on the more complex end of the spectrum.

Often, the primary strategy in developing an alternative solution for the use of a mass timber building where noncombustible construction is otherwise required is to follow all the requirements for a noncombustible building, except for the use of mass timber structural members and assemblies. Then, mitigating features are introduced, where considered necessary, to meet the performance level established by the acceptable solution of non-combustible structural elements. These mitigating features may include encapsulation of the mass timber and the addition of sprinkler system components intended to increase the reliability of the system, such as an on-site water tank or multiple risers. The impact of these mitigating features can then be evaluated using a risk analysis in order to compare the acceptable solution to the alternative solution.

The alternative solution for a mass timber high-rise building would most likely need to address several aspects related to the combustible structure. These may include the structural fire resistance rating of the mass timber structure, which for a building over 6 storeys would be required to be a minimum of two hours. While testing is one way to demonstrate performance, tall mass timber buildings will in many cases be designed for fire resistance based on engineering principles related to the charring properties of the wood structure.

Should a fire occur, the combustible nature of the mass timber structure and the impact the combustible structure may have on the fire growth, intensity and duration must also be considered. This contribution to the fire development will depend on the different scenarios considered, such as in the case where sprinklers fail to control the fire and the fire department is unable to respond, as well as the specific design of the building.

When a CBO has the appropriate competence and experience, they may choose to review and evaluate the proposed alternative solution themselves. However, in many cases, an Alternative Solution for a tall wood building may be beyond the level of in-house expertise of a CBO. In these cases, a third-party review can become an important resource used by CBOs to evaluate complex alternative solutions.

There are efforts in Canada to allow for tall mass timber buildings under the prescriptive requirements in the respective building codes. This would possibly reduce the need for alternative solutions for tall mass timber buildings once adopted in the near future. However, many of the buildings being designed and built today go beyond what is being considered in the current revisions to the buildings code and, therefore, designers will continue to require alternative solutions since the buildings may be taller, or the architects would like more exposed wood, or the buildings may be designed for different occupancies than those permitted by the acceptable solutions in the code. For more information on alternative solutions for tall wood buildings, download *Ontario's Tall Wood Building Reference* at www.ontario.ca/page/building-with-wood.

Steve Craft, PhD, P.Eng., is Principal, CHM Fire Consultants Ltd.

RIGIDPLY RAFTERS INC.

**WWW.RIGIDPLY.COM**

Rigidply Rafters Inc. Engineers and manufacturing capabilities can help turn your vision into reality. *Let the natural beauty of wood* - **Glue-Laminated Timbers** - *bring the performance, stability, and charm to your project.*

**701 E. Linden Street, Richland PA 17087 • 717.866.6580 • 717.866.7237**
**1283 Joni Miller Road, Oakland MD 21550 • 301.334.3977 • 301.334.9289**

**WWW.RIGIDPLY.COM**

# DOWEL LAMINATED TIMBER

## A new mass timber product in North America

**Lucas Epp**

A range of wood species is achievable with DLT. Spruce-Pine-Fir, Douglas fir, Western red cedar, and Alaskan yellow cedar panels are shown here.

### INTRODUCTION

Use of mass timber as a structural system is on the rise in North America. Replacing traditional structural systems such as concrete and steel, these prefabricated solid wood panels create a construction method that is fast, clean, and sustainable – not to mention aesthetically pleasing. With recent projects like the 220,000-sq. ft. T3 office buildings in Minneapolis and Atlanta, the cost-competitiveness of mass timber is now being shown at scale.

Dowel Laminated Timber (DLT), known as *dübelholz* (literally "dowelled wood") in Europe, is a structurally efficient and economic mass timber panel which can be used for floor, wall, and roof structures. In many ways, it is similar to Nail Laminated Timber (NLT), but without the nails. DLT panels are the only 100 per cent mass timber product – in concept they involve no glue or nails.

### HISTORY OF MASS TIMBER

Before describing DLT in detail, it is important to understand NLT – the oldest mass timber product, which has been in use in heavy timber structures for over 150 years. Examples exist in the warehouse districts of many cities. Large industrial buildings like the 500,000-sq.ft., eight-story Butler Building (Minneapolis, built in 1906) used solid-sawn posts and beams with NLT floor panels to create a robust structural frame.

NLT is created from dimensional lumber stacked on edge – nominal 3", 4", 6", 8", 10", or 12" boards which are laminated and fastened together with nails. Plywood or OSB sheathing is often added to the top side to provide a structural diaphragm. This system became prevalent, leading the National Lumber Manufacturers Association to create Heavy Timber Mill Construction Buildings in 1916, an illustrated guide to structural and fire detailing of these heavy timber structures.

Heavy timber construction fell out of main stream use with the industrial revolution and the rise of steel and concrete as primary building materials.

However, this is starting to change as the construction industry realizes the importance of sustainable construction. Wood is the only primary structural material that is renewable and grows naturally.

Julius Natterer, a famous Swiss timber engineer, re-introduced the concept of NLT (known as brettstapel, literally "stacked elements") to Europe in the 1970s. Natterer saw NLT as a mass timber product that could be produced by anyone, and encouraged manufacturing throughout Europe. However, the nails inside NLT meant that CNC machining of these panels was impossible, and manufacture by hand was laborious.

### HISTORY OF DOWEL LAMINATED TIMBER

In the early 1990s, DLT/*dübelholz* was developed by Alois Tschopp (Tschopp Holzbau) with Pirmin Jung in Switzerland. They saw this product as a superior

## DLT IN NORTH AMERICA

In 2017, StructureCraft installed the first DLT production plant in North America. This high capacity, fully automated DLT machinery line is the fastest and largest capacity worldwide, and is intended to introduce a new cost-competitive mass timber product to the rapidly growing market in North America.

## DLT MANUFACTURING

DLT panels are made from softwood lumber boards stacked like the boards of NLT, but friction-fit together with hardwood dowels instead of nails. The dowels hold each board side-by-side, forming a stiffer and stronger connection than the nails in NLT. Each board lamination in a DLT panel is finger-jointed, creating a stiffer and stronger panel than NLT as it eliminates the board splices and butt-joints which are characteristic of NLT.

DLT panels may be processed using CNC machinery, unlike NLT panels (due to the nails). This creates a high tolerance panel which can also contain pre-integrated electrical conduit and other service runs.

product to NLT/*brettstapel* in every way – it used only wood, it was CNC machinable, and production of the panel was possible with automated machinery. They proceeded to create the first automated machinery line for DLT.

In Europe, DLT is a well-known and well used mass timber product. Although both products were developed around the same time, CLT has developed a larger market share in Europe, as the big glulam manufacturers saw CLT as a glued product which would be easy to expand into. DLT remained the realm of smaller manufacturers – the largest manufacturer produces around 15,000m$^3$/year. Interestingly however DLT is often cheaper than CLT in Europe, and is gaining more interest, due to DLT being 100 per cent wood.

Recent larger and taller wood buildings in Europe have used DLT as floor and wall panels (E3, Berlin). There are more than 15 manufacturers of DLT in Europe, primarily located in Switzerland, Germany and Austria.

Above and this photo: E3 Berlin, a seven-story mixed use building uses DLT for floors and walls.

DLT press at StructureCrafts's new facility in Abbotsford, BC.

### Panelized Building Elements

DLT panels are prefabricated in sizes of up to 12 feet wide and 60 feet long. Each panel is put through a panel planer to ensure a dimensionally accurate and planed surface. Prefabricated panels can be factory finished with sealers or stains.

### Finish and Geometric Possibilities

DLT is a versatile product, and naturally lends itself to creating unique aesthetics on the exposed face of the panel. Each of the laminations are run through a profile molder, meaning many different profiles are achievable, from notches and reveals to flowing curves.

Curved DLT panels can be created by milling custom profiles into each lamination, creating a flexible panel which, like an accordion, can accommodate curves perpendicular to the span direction of the panel. The radius for these curves is limited only by the bending stiffness of the dowels, which are located centrally in the panel. These panels are created initially flat and then curved into shape on site.

Fluted panels (e.g. 2x4-2x6-2x4) can create a unique soffit aesthetic if exposed, and allow the running of electrical conduits or sprinklers in the gaps.

Unique to DLT as a mass timber product, acoustic profiles can be integrated directly into the bottom surface of a panel. This can help a designer achieve acoustic objectives while keeping the wood exposed and allowing for a wide variety of surface finishes.

Any wood species incorporated in the International Building Code (IBC) and referenced National Design Specification (NDS) for Wood Construction can be used in DLT, as only specified strength and stiffness for each lamination is required. Full-scale panel testing is not required to determine structural performance – a significant advantage to DLT as a product.

## STRUCTURAL PERFORMANCE

As a floor or roof deck, DLT is a highly efficient structural panel. Similar to NLT or GLT (glulam on flat), all of the wood fiber runs in the direction of the span. This provides the most efficient use of material for floor and roof systems which are typically one-way spanning between beams or walls.

From a structural perspective, each individual lamination spans between supports, meaning calculation of the panel stiffness and capacity is simple. The structural design of each lamination in a panel is covered by CSA O86 and the NDS and applicable grading rules. Structurally finger-jointed lumber is used for spans longer than 20 feet, meaning no reduction in strength or stiffness is required for longer panels. This is a big advantage over traditional NLT where butt joints in laminations require a 20 to 30 per cent reduction in panel strength and stiffness (refer to *Nail Laminated Timber Design Guide*, Table 4.1 and IBC 2015 2306.1.4).

T3 Minneapolis office building.

The Uniform Building Code (predecessor to the IBC) has recognized laminated decking since 1927, and the NBC since its first publication in 1941. The requirement for minimum fastening of the boards together ensures that the panel acts as an element and not individual boards. The 3/4" diameter hardwood dowels in DLT can create the same interlayer shear capacity between boards as the original 20 penny nail requirement specified in the IBC.

Machine stress rated lumber can be used to increase strength and stiffness of the panel.

## Diaphragms and Shear Walls

Plywood or OSB sheathing atop the panel gives shear capacity to DLT panels for use as structural diaphragms in floors and walls. The sheathing also allows for simple nailed connections between panels with strips of plywood. The shear capacity of the sheathing applied overtop the DLT panels can be calculated like a typical nailed plywood diaphragm per CSA O86 11.5 or Special Design Provisions for Wind and Seismic (SDPWS) 4.2.7.1.

## Bearing Walls

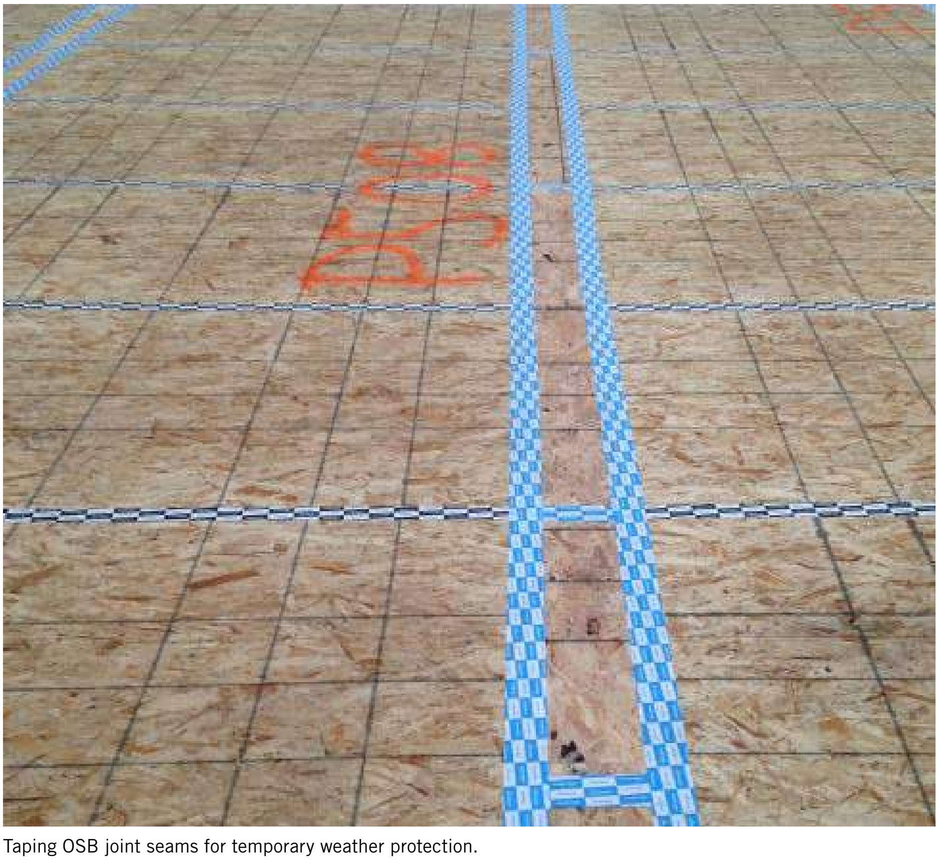
DLT panels can be used as structural bearing walls with the DLT exposed on both sides, or sheathed one or both sides as a shear wall.

## Two-Way Spans

Smaller two-way spans or weak-axis cantilevers (up to two- to three-foot cantilevers or four- to six-foot simple spans) can be achieved in DLT panels by using screw reinforcement inside the panel. Screw reinforcement for a weak-axis cantilever can be designed using a strut-and-tie truss analogy to design angled shear and compression screws, and using the plywood sheathing as a tension flange.

Larger minor axis cantilevers can be achieved using steel or wood outriggers set atop or notched into the top of the panel.

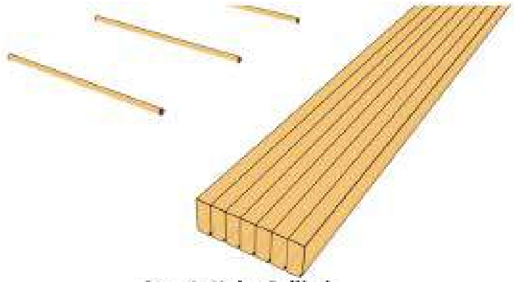
Connection detail at wall/floor panel interface.



Taping OSB joint seams for temporary weather protection.

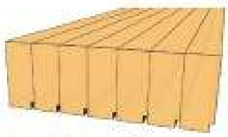
## HOW DLT IS MADE

**Step 1: Boards Pressed**
The first package of lamellas is automatically fed into the DLT machine and then hydraulically pressed vertically and horizontally to ensure a flat panel, and remove any gaps between boards.

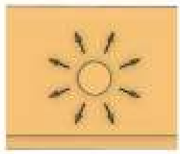


**Step 2: Holes Drilled**
A drilling aggregate drills 3/4" diameter holes into the wide face of the lamellas with a custom-designed drill bit.

**Step 3: Dowels Inserted**
The 3/4" diameter hardwood dowels are hydraulically pressed into the holes.



**Step 4: Process Repeat**
Additional packages of lamellas are pushed into the DLT press and doweled into the previous packages until a full width panel is created



**Step 5: Moisture Equilibrium**
As the drier dowel comes into moisture equilibrium with the surrounding lumber, it expands, creating a tight friction fit between the two materials.

### Detailing for Moisture

When detailing DLT panels, designers need to account for moisture movement – wood expands perpendicular to grain when as moisture content increases. Incorporation of small gaps between panels deals effectively with this issue. The T3 Minneapolis structure had a floor plate which was 220 feet wide, and which experienced both snow and rain during winter construction. The gap between panels effectively dealt with expansion of the panels during construction, and there were no issues with moisture damage or remedial works required. The key is in detailing for the movement, and letting panels dry out after they get wet.

Use of OSB sheathing with a pre-applied moisture-resistant top coating and taped joints is a newer solution to this issue. Along with providing a path for the water to move off the floor plate, this strategy provides significant protection from moisture, and greatly reduces expansion of the panels.

If a gap is provided between panels, it can be filled in afterwards with lumber, or retained to create a visual delineation between panels – as it was on the T3 building. From a fire design perspective, the gap between panels is not an issue if a continuous topping layer or plywood spline is provided. Similar to a plywood spline between CLT panels, this continuous layer prevents air movement between floors, thus ensuring char development remains unidirectional (NLT Guide 3.3.2). The local authority having jurisdiction (AHJ) for the T3 building accepted permanent gaps between NLT panels for this reason.

## FIRE PERFORMANCE

DLT can be used in all types of combustible construction. From a fire perspective, DLT behaves the same or better than NLT.

Both the National Building Code of Canada (NBCC) and the IBC recognize NLT and provide guidance for both structural and fire design. No product-specific standard is required, as the structural design of each lamination element is covered by the building codes. It is resistant to fire, and has long met the requirements of heavy timber in North American building codes. NLT can be used in all types of combustible construction.

The fire resistance of mass timber panels is now widely proven – the char developed during a fire creates a self-protection layer. Research recently completed by FPInnovations showed that a 2 x 8 NLT floor panel with concrete topping can achieve a three-hour fire resistance rating under full load (Osborne, 2015).

The inherent fire performance of mass timber removes the need for intumescent coatings and dropped ceilings that would be required for a steel structure, allowing the wood to be exposed as a permanent soffit.

## ACOUSTICS

As with all mass timber systems, it is important to address acoustic separation between mass timber walls and floors, which can be achieved through appropriate detailing. Acoustic mat should be used in floor buildups with no dropped ceiling.

## VIBRATION AND TIMBER-CONCRETE COMPOSITES WITH DLT

The stiffness of mass timber panels is important in long-span floor systems, and as can be seen in Table 1, consideration of floor vibrations often govern the required panel thickness.

A concrete topping is often required for acoustic performance, and this topping can be made composite with DLT panels to increase the panel stiffness. In Europe, many different techniques of creating composite action between the DLT and the concrete topping are used, including:

- Fully threaded screws inclined in the direction of the shear flow
- Milled notches in the DLT panel, continuous perpendicular to the direction of the span
- Use of fluted DLT, with the flutes turned up so the concrete topping flows between the higher laminations

Residence using DLT for walls, roof, and floors.

## SUMMARY

Dowel Laminated Timber takes mass timber construction one step further to create a 100 per cent wood panel which can be CNC machined and incorporate acoustic treatment into an exposed wood soffit. Due to its efficiency, aesthetics, and cost effectiveness, DLT will help lead the push towards wood construction.

DLT also extends the range of mass timber options available in North America, and supports the trend towards prefabrication as the future of building construction.

## REFERENCES


- Binational Softwood Lumber Council. 2017. Nail Laminated Timber – U.S. and Canadian Design and Construction Guide v1.0.
- E3 Berlin, www.proholz.at/zuschnitt/33/lueckenfueller-mit-distanz
- Osborne, Linday (FPInnovations). 2015. "Fire Resistance of Long Span Composite Wood-Concrete Floor Systems"


Lucas Epp, P.Eng., leads the engineering department at StructureCraft and has also co-authored industry guidelines including the recently published NLT Design and Construction Guide. He can be reached at lepp@structurecraft.com or (604) 313-2526.

# Hurricane Ties

**Stephen MacDougall**

## Hurricane ties will hold a roof on, right?


Detached and outward leaning top of side support wall.


Hurricane ties securing roof truss to top plate but not wall studs below.

When steel straps, commonly referred to as hurricane ties, are installed on a building, they are expected to secure the roof in place against wind uplift forces. Unfortunately, depending how hurricane ties are used, they may not provide the expected uplift resistance.

Recently, the entire roof of a three-year-old barn equipped with hurricane ties in southern Ontario lifted up off the top of the exterior walls during a spring wind storm. Fortunately for the workers inside the barn at the time, although the roof completely separated from the supporting walls, the roof trusses only dropped down a few feet thanks to stacks of straw bales inside the building which prevented the barn from completely collapsing.

At the time of the failure, neighboring buildings were not damaged and the maximum wind gust speed of 96km/h recorded by a nearby weather station did not exceed the Code-required wind load the barn should have been designed to withstand. The barn's hurricane ties were intended to secure the roof to the top of the walls and prevent exactly what occurred. So what happened?

The barn was rectangular in shape, measuring 120 ft. long by 60 ft. wide with 16-ft. tall walls and a gable-style roof with a pitch of about 4/12. The barn included cast-in-place concrete perimeter foundation walls and 2 x 6 wood studs spaced at 24 in. on center with metal cladding forming the exterior walls. The roof included pre-fabricated wood roof trusses spaced at 48 in. on center with a clear span across the width of the barn. Each of the roof trusses was secured to the top of the exterior walls with a "twist strap" style hurricane tie on each side.

As it turned out, the hurricane ties were all found intact and had indeed prevented the roof trusses from separating from the double 2 x 6 plate along the top of the exterior walls. The failure that allowed the roof to lift up occurred at the nailed connection between the exterior wall studs and the top plate. In this case, the hurricane ties secured the roof trusses to the top plate, but did not extend down to bridge the connection between the top plate and the studs below.

The failed connection between the top plate and the wall studs consisted of nails installed vertically though the top plate into the end grain at the top of the wall studs. This type of construction is common when stud walls are constructed on the ground and then raised up into place. The wall did not include sheathing (OSB, plywood, etc.), which may have also helped secure the top plate to the studs. Instead, strips of 1 x 4 strapping were used to secure the light gauge exterior metal cladding to the walls. Because the nails forming the failed connection were installed into the end grain of the studs, they would have provided limited withdrawal resistance. Additionally, the nails used had smooth shanks and were significantly thinner than traditional common or spiral nails of the same length (most likely installed with a nail gun), factors that further reduced their withdrawal resistance.

A design review of the failed connection found that the withdrawal resistance of the nails provided less than 60 per cent of the hurricane tie uplift capacity stated by the manufacturer and was well below the design wind uplift force required by the Ontario Building Code for this barn. Upon review of the original construction drawings, it was found that the hurricane ties were specified as securing the trusses to the top plate only and no details were given regarding how the top plate was to have been secured to the wall studs.

In this case, the building was damaged beyond repair, however, the damage likely could have been reduced or even prevented had alternative hurricane ties been used. A variety of hurricane ties and straps are available which can be installed to extend from the roof framing down past the top plate and secured to the top of the wall studs. These larger hurricane ties would have significantly increased the uplift resistance of the roof with only a nominal cost increase at the time of construction.

It should be noted that due to the relatively light weight of the structure compared to its size, the base of the exterior walls may have also been subject to damage from wind uplift had the connection at the top plate not failed first. The bottom plate of the walls was bolted to the foundation, however, similar to the top of the walls, the nailed connection between the studs and bottom plate included limited withdrawal resistance. As a result, the base of the walls is another area where hurricane ties may have been required to secure the base of the wall studs and ensure the wind uplift forces were adequately transferred into the foundation.

Although farm buildings such as this may be more susceptible to wind damage due to their size and relatively light weight, hurricane ties are beginning to be used more commonly in all types of wood framed buildings including houses where designing for wind uplift may not strictly be required by local codes. Some Ontario municipalities now offer rebate programs for the installation of hurricane ties, citing the increased occurrence of damaging winds and tornadoes. Regardless of the building application, care needs to be taken when designing and constructing a wood-framed building to resist wind uplift and ensure that the structure is truly secured in place as intended.

Separation of roof trusses and top plate from wall studs.

Stephen MacDougall is a Professional Engineer with Brown & Beattie Ltd. specializing in the inspection and assessment of structurally damaged buildings. He and his colleagues have been working closely with insurance companies investigating a wide variety of buildings damaged by events such as fires, explosions, vehicle impacts, wind, and snow loading.

# Wood WARE

Homegrown Trailers, established in January 2016, produces sustainable, handcrafted travel trailers, primarily out of wood. Based in Kirkland, WA, the company manufactures, sells and rents its artisan travel trailers. Each of the two models are solar-powered and combine the beauty and simplicity of a tiny house with the mobility and lifestyle of a camper. Both campers deliver a compact, environmentally conscious, healthy living space, with a cedar lining that can be stained or left natural. The company's goal is to help people connect with nature and find adventure on the road, in a trailer that provides a comfortable and natural feel.

**www.homegrowntrailers.com**