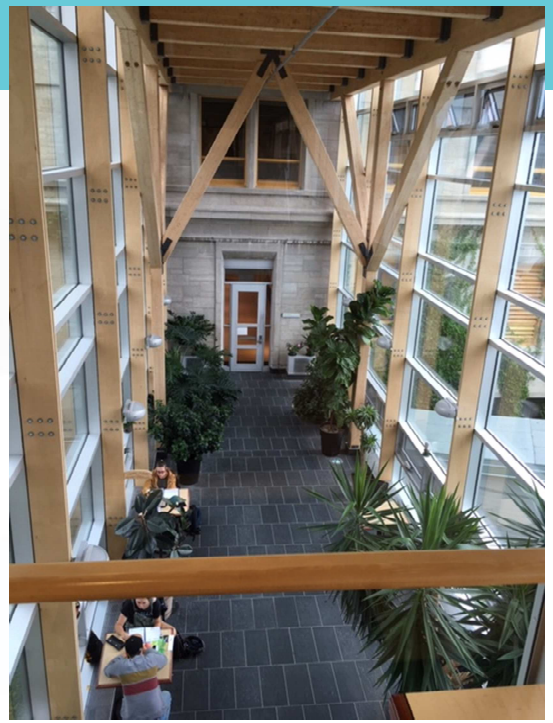
Wood construction in Canada

Challenges and solutions



Torsten Lihra, Ph.D.

Université Laval, Québec, Canada

Who am I?

- Cabinet maker compagnon in Germany
- M.Sc. and Ph.D. in Wood Science at Université Laval
- Over 20 years of work experience in the wood processing industry as an engineer and scientist
- Presently Research Professional at Université Laval as part of the NSERC Industrial Research Chair on Ecoresponsible Wood Construction (https://circerb.chaire.ulaval.ca/)

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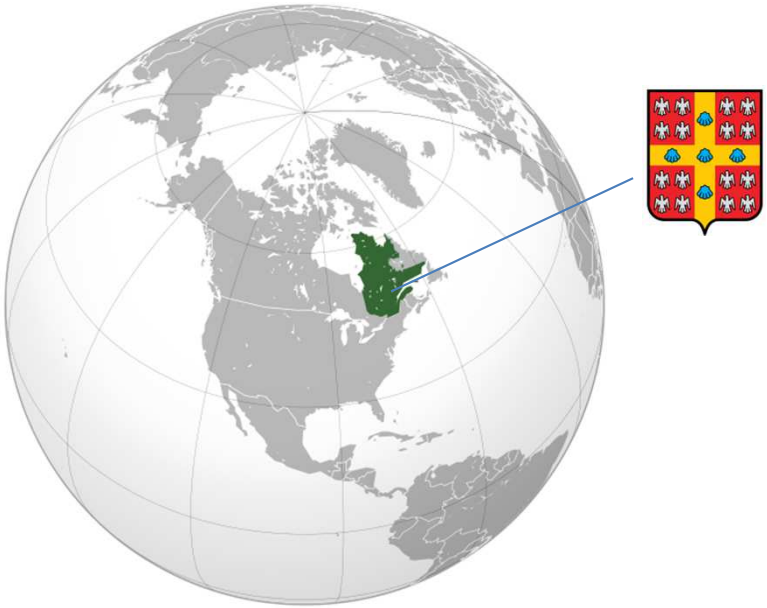
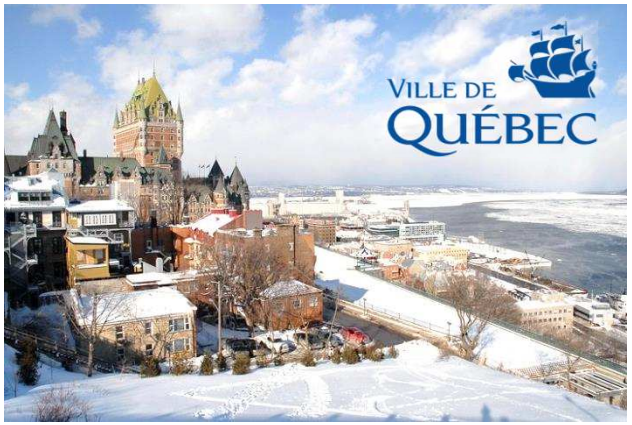
UBICACION





- Desde 1663 (~350 años)
- 48 000 estudiantes
- 3 200 personal académico
- 17 facultades

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Wood construction in Canada

Wood construction has a long history and buildings from centuries ago are still standing today.

Urnes Stave Church, Norway (c. 1150)

Horyuji Temple, Japan (c. 711)

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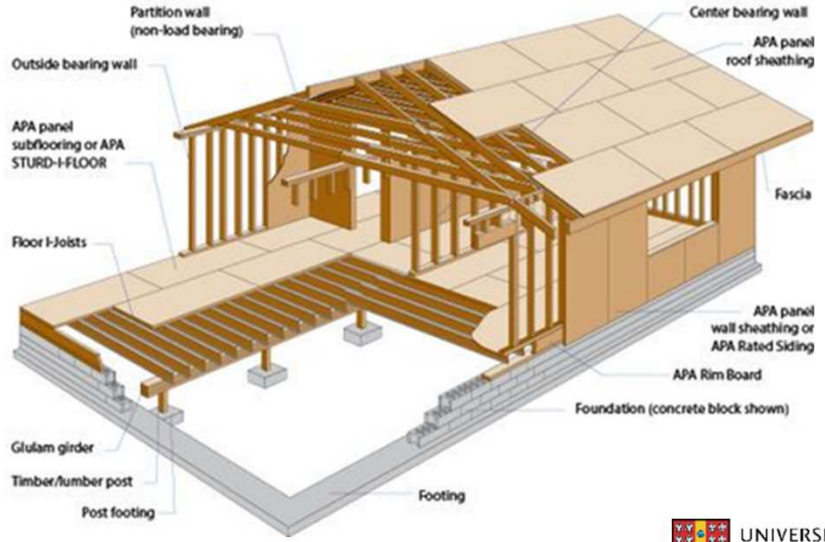
Wood construction in Canada

In Canada, permanent wood construction dates back to the arrival of European pioneers in the 17th century.

Today, over 90 % of Canada's housing park consists of wood light frame buildings.

(Source: Engineering Feed and WoodUniversity.org)



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Wood construction in Canada

Light frame wood houses are typically build on site by specialized construction companies. The skills are known and the resulting homes are energy efficient and affordable.

In Canada, this type of construction is limited to a maximum heights of 6 storeys.

(Source: Think Wood)

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Wood construction in Canada

Development of engineered wood products and pre fabrication of building components are changing the industry and pushing back the limits of wood construction!

(Source: Enns Design, Toronto)

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Advantages of wood construction vs concrete and steel construction

- Environmental friendly - A natural, renewable resource
- Shorter construction time needed (prefabrication)
- Potential cost reduction (reduce labor time, on-site waste, accidents, disturbance to the site's surroundings)
- Best ratio of strength to weight
- Wood is a good thermal insulator (porosity)
- Good ''Fire'' resistance (carbon layer)

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The carbon cycle

- A growing tree is a carbon sink – it absorbs carbon from the atmosphere
- By absorbing more and more carbon it becomes a carbon stock
- A dead or decaying tree is a carbon source – it releases carbon into the atmosphere
- **Wood products prevent the carbon stock from becoming a carbon source!**

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Advantages of wood construction vs concrete and steel construction

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- Best ratio of strength to weight
- Wood is a good thermal insulator (porosity)
- Good fire resistance (carbon layer)

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Fire resistance: Carbon layer

Source: Arup, Think Wood

Source: FPInnovations

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Engineered Wood Products (EWP)

Classification:

Veneer Products: Plywood, Laminated Veneer Lumber (LVL)

Massive Timber: Glued Laminated Timber (Glulam), Cross Laminated Timber (CLT)

Strand Products: Parallel Strand Lumber (PSL), Laminated Strand Lumber (LSL), Oriented Strand Lumber (OSL), Oriented Strand Board (OSB)

Particle & Fiber Products: Particleboard, Medium Density Fiberboard (MDF),High Density Fiberboard (HDF),

Source: Xiao Dong Wang, Université Laval

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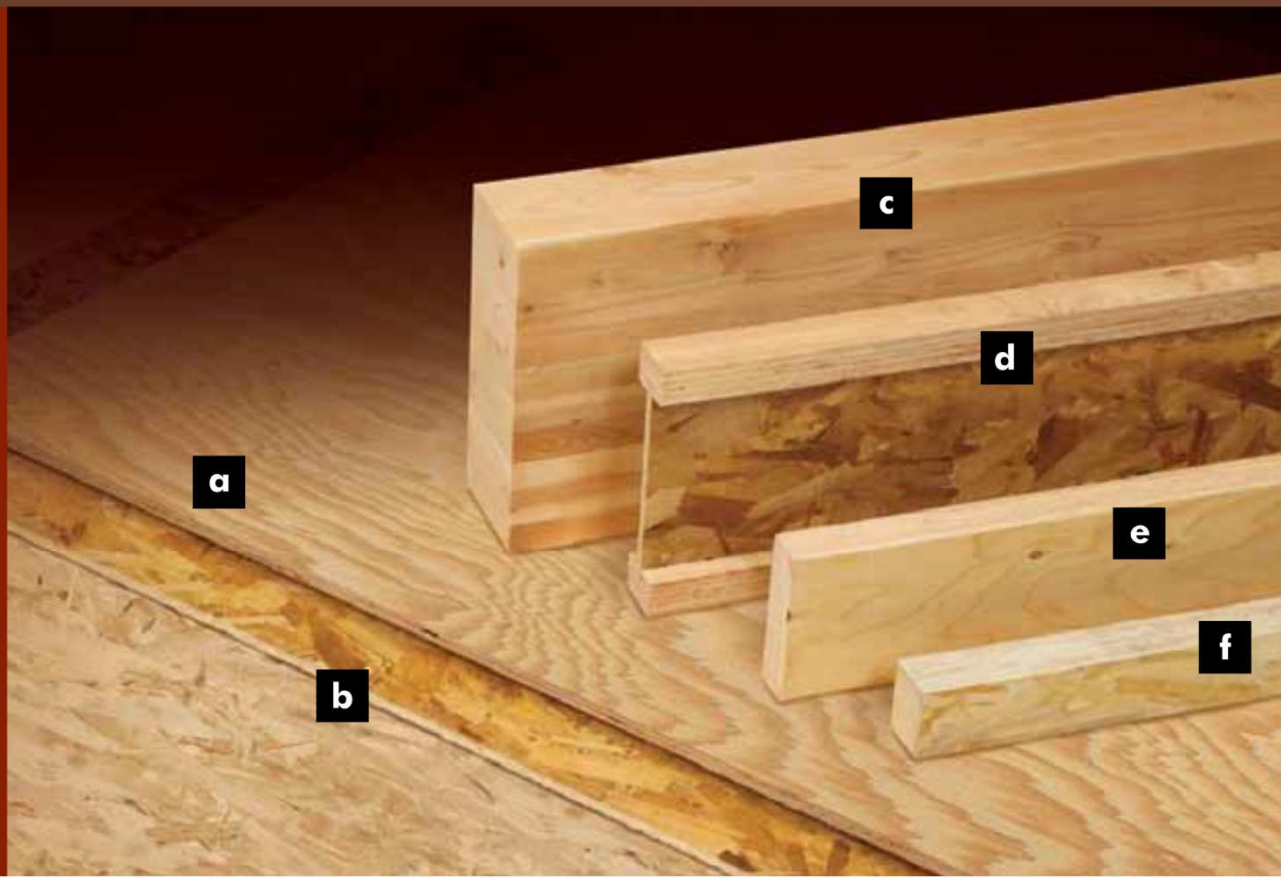
ENGINEERED WOOD PRODUCTS FOR SUPERIOR PERFORMANCE

Engineered wood products manufactured by APA members include:

- **a.** Plywood
- **b.** Oriented Strand Board (OSB)
- **c.** Glued Laminated Timber (Glulam)
- **d.** I-joist
- **e.** Laminated Veneer Lumber (LVL)
- **f.** Oriented Strand Lumber (OSL)



EWP improve wood properties

They offer: longer spans
higher and more uniform strength
flexible design

Source: Xiao Dong Wang, Université Laval

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Engineered Wood Products (EWP)

Advantages:

- Possible use of lower quality resource
- Homogeneity of properties
- Greater dimensions possible
- Better dimensional stability

Source: Xiao Dong Wang, Université Laval

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Plywood

Source: Xiao Dong Wang, Université Laval

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Oriented Strand Board (OSB)

Source: Xiao Dong Wang, Université Laval

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Structural Composite Lumber (SCL)

- Laminated Veneer Lumber **(LVL)**
- Parallel Strand Lumber **(PSL)**
- Laminated Strand Lumber **(LSL)**
- Oriented Strand Lumber **(OSL)**
- ✸ **New!** Laminated Veneer Bamboo **(LVB)**

Source: Xiao Dong Wang, Université Laval

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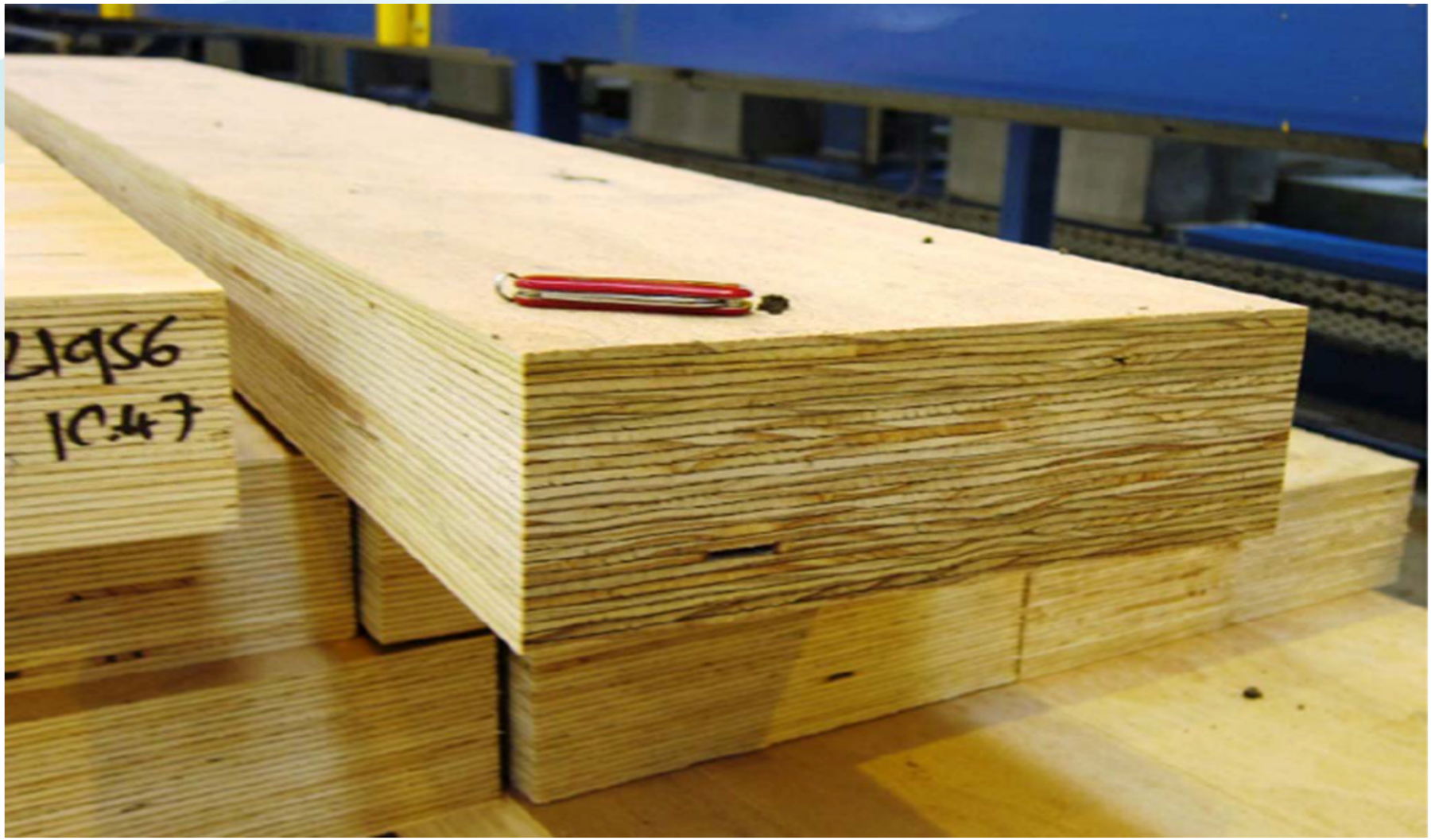
Laminated Veneer Lumber (LVL)



Source: Xiao Dong Wang, Université Laval

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Parallel Strand Lumber (PSL)

Source: Xiao Dong Wang, Université Laval

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Glued-Laminated Timber (Glulam)

- Lumber laminations glued together
- Structural inhomogeneity can be removed (finger joints)
- Commonly used in post and beam structures
- Large dimensions possible
- Can be curved, tapered, and cambered
- Primarily produced from Douglas Fir, Spruce and Pine

Source: Xiao Dong Wang, Université Laval

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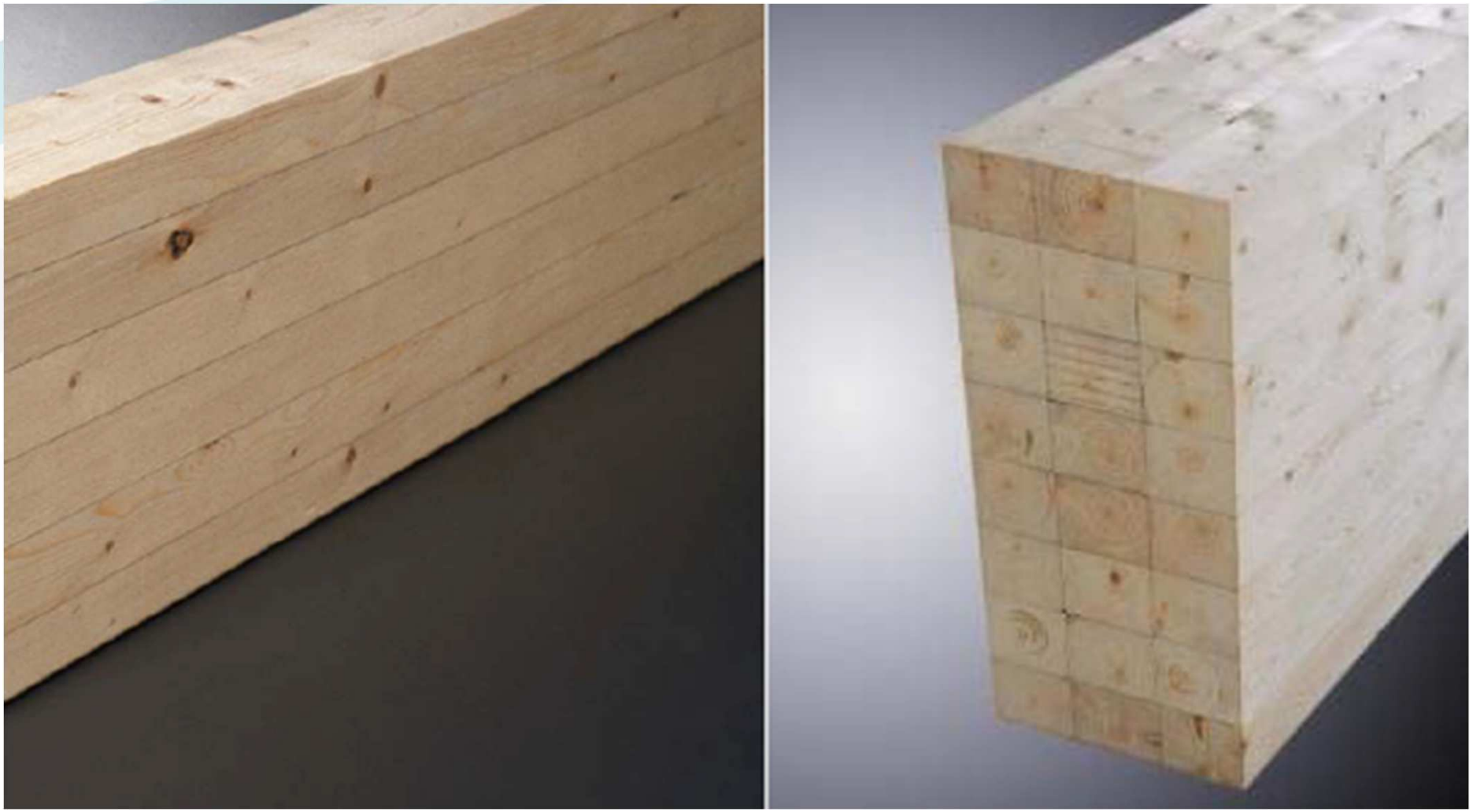
Glued-Laminated Timber (Glulam)



Source: Xiao Dong Wang, Université Laval

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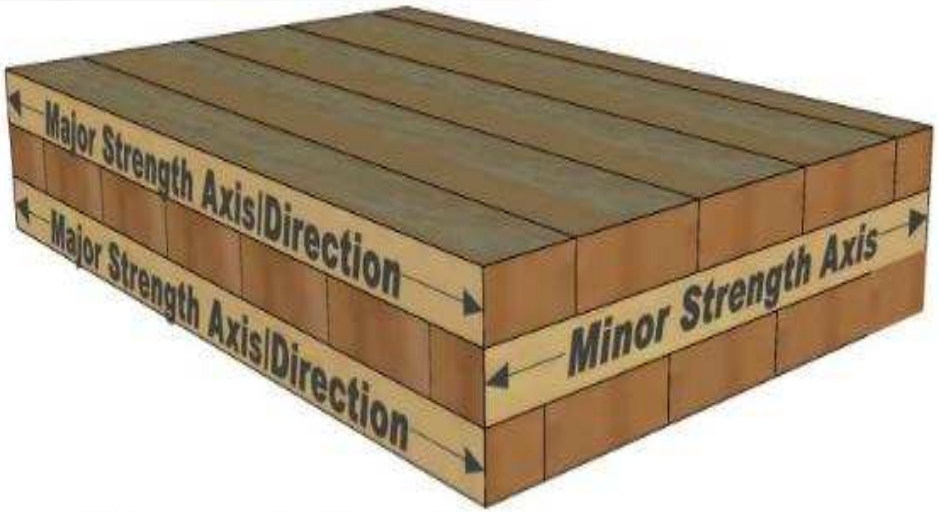
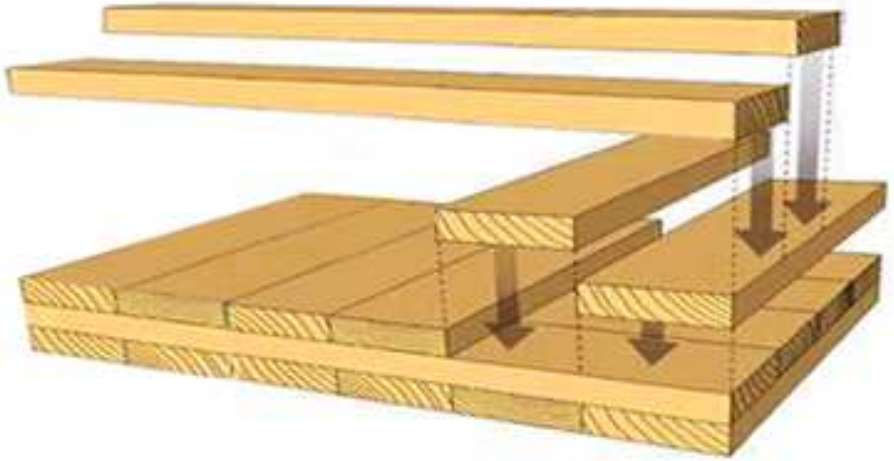
Cross Laminated Timber (CLT)

Definition of CLT





Source: Xiao Dong Wang, Université Laval

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Cross Laminated Timber (CLT)

Manufacturing Process

(1) Lumber Drying

(2) Lumber Cutting

(3) Finger Jointing

(4) Lumber Planning

(5) Gluing

(6) Assembly

Source: Xiao Dong Wang, Université Laval

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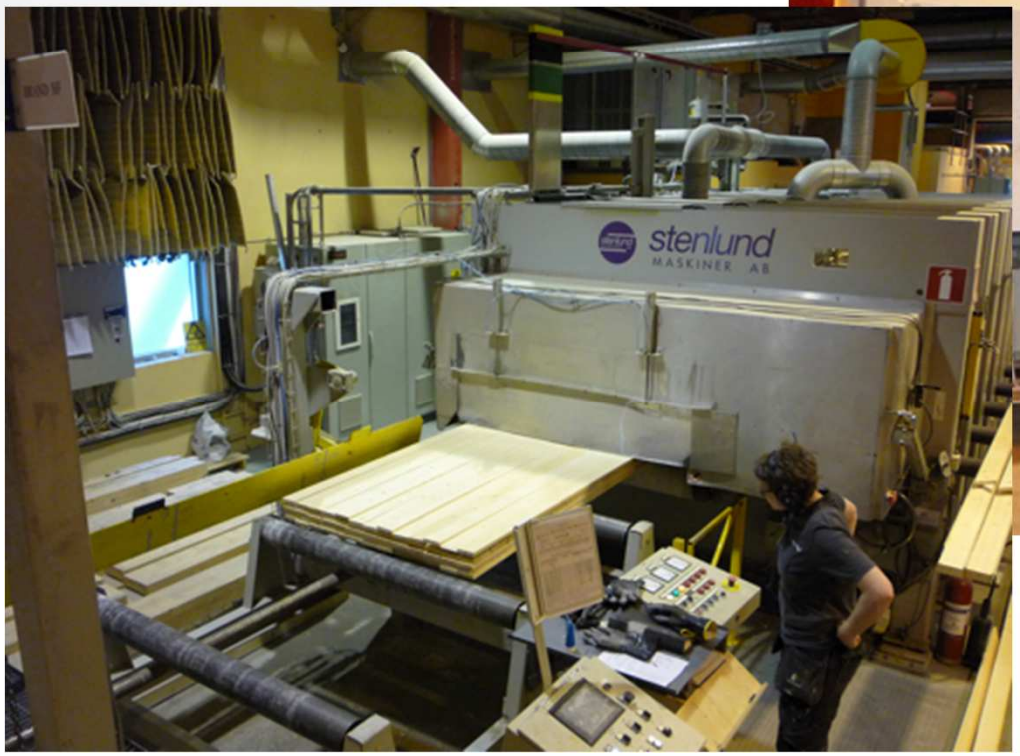
CLT Manufacturing Process

Press



Source: Xiao Dong Wang, Université Laval

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CLT Manufacturing Process

CNC Router

Source: Xiao Dong Wang, Université Laval

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Training and R&D

Smart building with wood requires multidisciplinary skills and competences at different levels:

- Technical / building level
- Bachelor degree
- Master degree
- Ph.D. degree

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Training and R&D

Industrial Research Chair on Ecoresponsible Wood Construction (CIRCERB) at Université Laval

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What is an industrial chair of the National Sciences and Engineering Research Council of Canada (NSERC)?

It is a partnership between companies of a given field and a university. This partnership, if recognized for the quality of its science, enjoys significant financial leverage from the federal government (via NSERC).

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Training and R&D: CIRCERB

Impact of the construction sector:

- 40% of energy consumption
- 25% of solid waste
- 50% of natural resources
- 39% of CO2 emissions
- 14% of drinking water

+ Bio-based materials, including wood, have a favorable position

+ A race to the highest wood building is triggered

+ Supportive government efforts

Source : ATHENA Institute and Natural Resources Canada

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Training and R&D: CIRCERB

Addressing the knowledge gap at the University level through multidisciplinary training and research

- Architecture
- Wood engineering
- Civil engineering
- Mechanical engineering
- Industrial engineering
- Environmental engineering
- Chemistry
- Law
- Actuarial science
- Industrial design
- Administration

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Training and R&D: CIRCERB

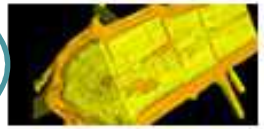
CIRCERB works in closely with its industry and government partners and has a tight relationship with FPInnovations, a Canadian privately owned non for profit research center.

FPInnovations®

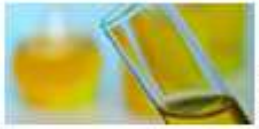
FPInnovations Research Programs

BIOMATERIALS

ADVANCED BUILDING SYSTEMS



RESOURCE ASSESSMENT



BIOREFINERY AND ENERGY

FOREST OPERATIONS

PIT - PERFORMANCE INNOVATION TRANSPORT

MARKET PULP

PRIMARY WOOD PRODUCTS MANUFACTURING

WILDFIRE OPERATIONS

PAPER, PACKAGING AND CONSUMER PRODUCTS

SECONDARY WOOD PRODUCTS MANUFACTURING

ENVIRONMENT AND SUSTAINABILITY

VALUE MAXIMIZATION AND DECISION SUPPORT

BUSINESS INTELLEGENCE

MEMBER RELATIONS & TECHNOLOGY TRANSFER

Source: FPInnovations

Training and R&D: CIRCERB

Some numbers:
Budget over 5 years: **7 724 118 CAN$** (research and infrastructure)
15 industry partners and 5 universities involved:
65 projects carried out or under way (M.Sc., Ph.D., Post-Ph.D.)
35 research and in-company **internships**
14 international interns
54 scientific **articles**, published, submitted or under way
146 scientific presentations and posters
1 patent, 2 others under way

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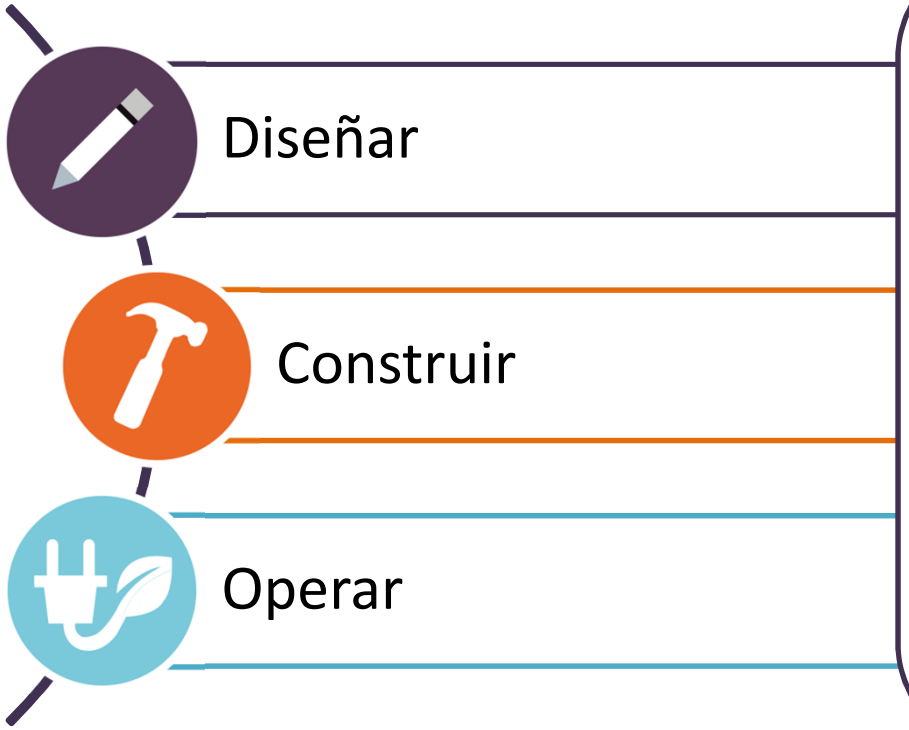
ACADÉMICA

3 EJES DE INVESTIGACIÓN

7 TEMAS



- Diseño integrado
- ACV y Ecodiseño

- Materiales
- Sistema de construcción
- Logistica

- Durabilidad
- Eficiencia

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Training and R&D: CIRCERB

Examples of research and development projects carried out at CIRCERB

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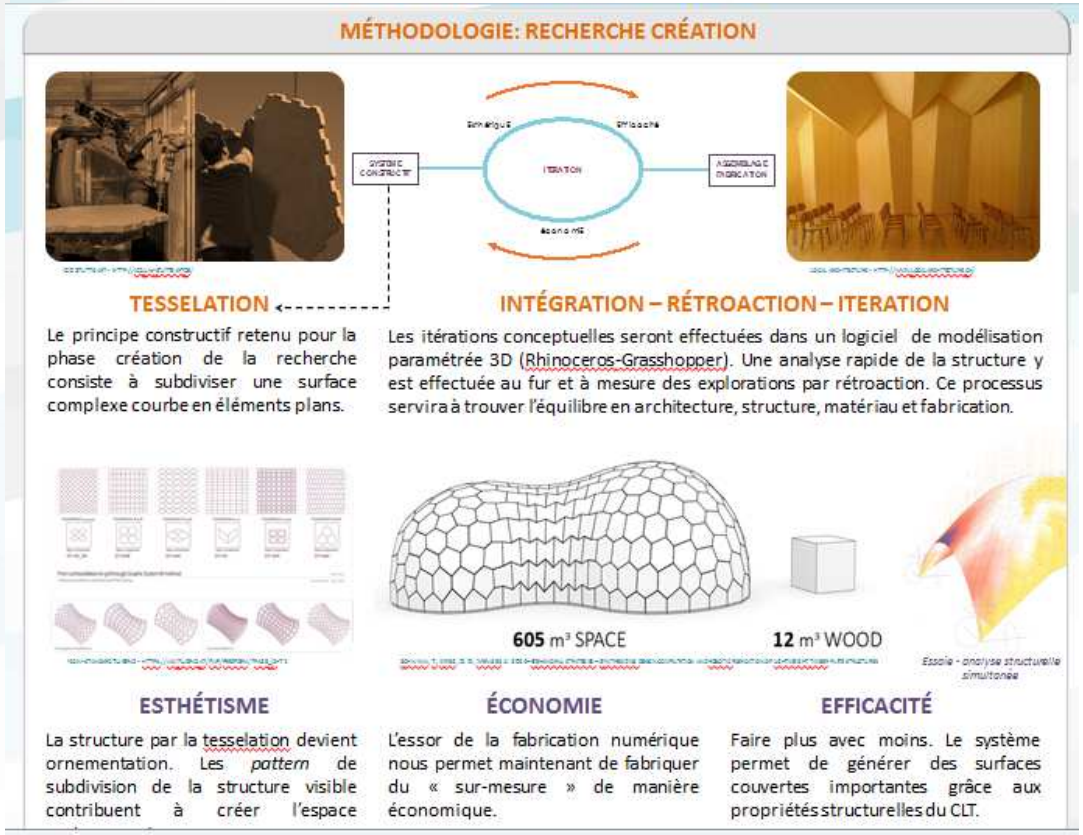
DISEÑO INTEGRADO

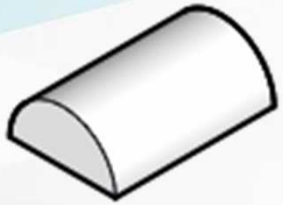
Concepcion y préfabricaion numérica 3D en CLT



Wood and biomimicry: Design of wooden grid shells

Shape

F1



Simple curve

F2

Double curve

F3

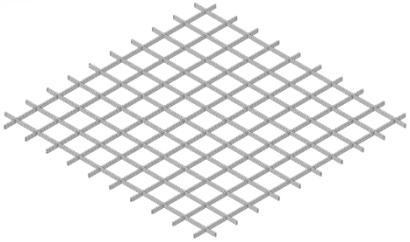
Freeform

F4

Fold

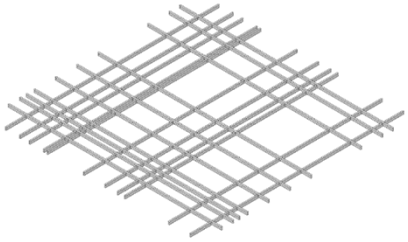
Structure

S1



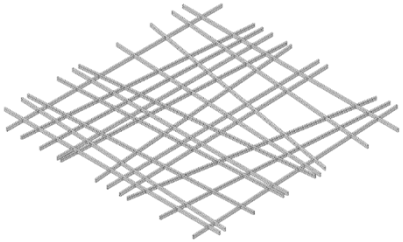
Equidistant

S2



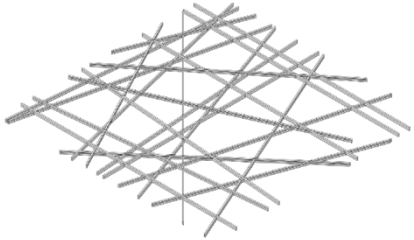
Orthogonal

S3



Deviation

S4



Intersection

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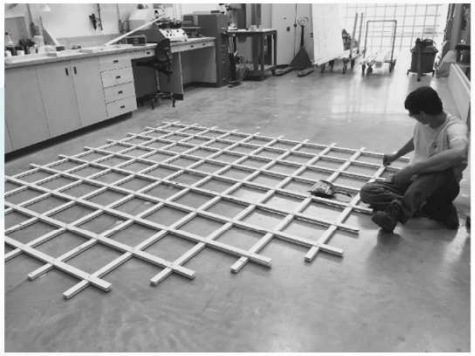
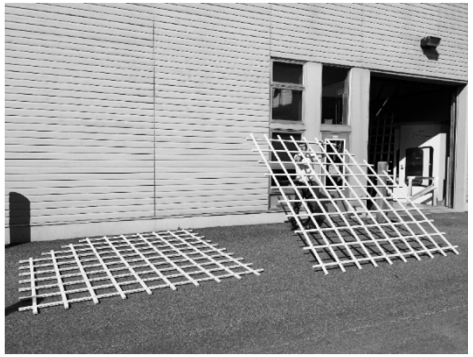
Fabrication



Assembling

Nodes

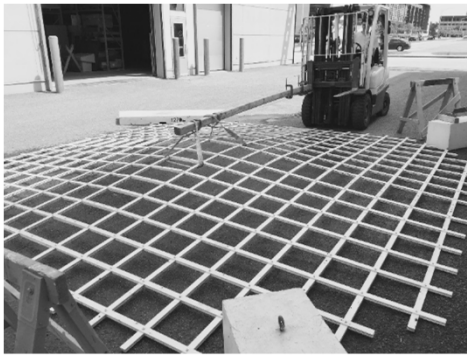


Sections

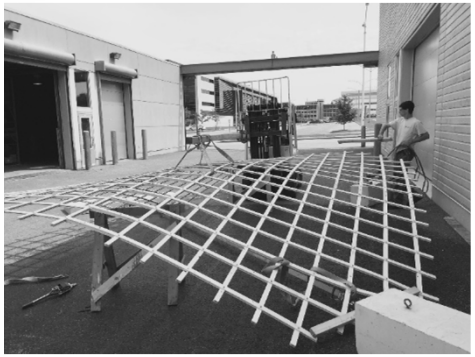
Connections

Watering

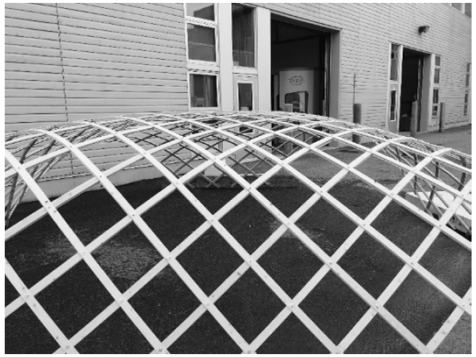
Link



Erection



Deformation



Final shape

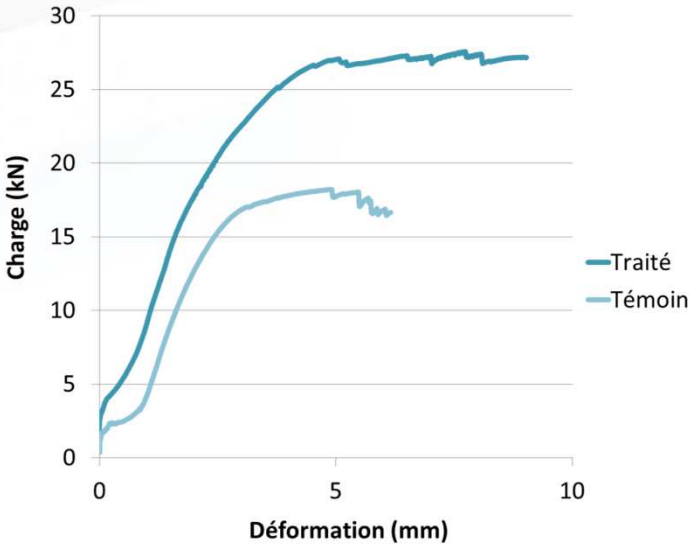
Bolt

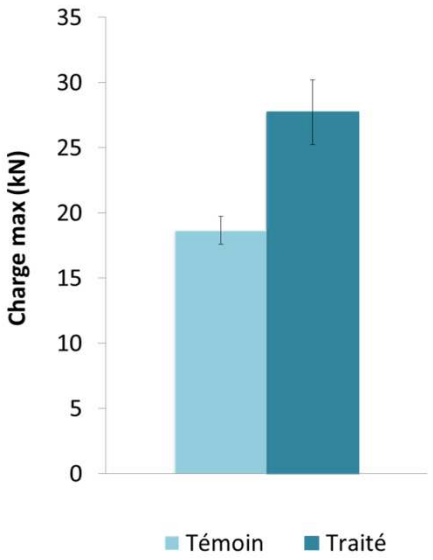
Ambience

SISTEMA DE CONSTRUCCIÓN

Patente pendiente

❶ Le traitement du bois par imprégnation a permis d'obtenir une amélioration de 49% de la charge maximale avant rupture en compression latérale d'un assemblage boulonné par rapport au bois non traité.





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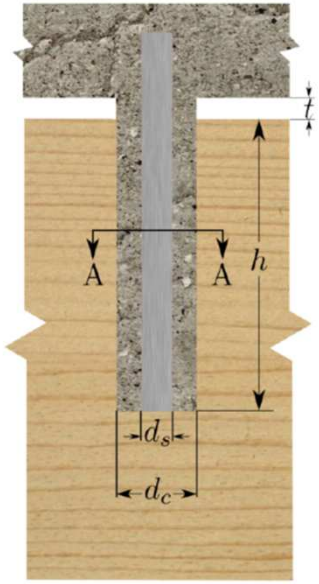
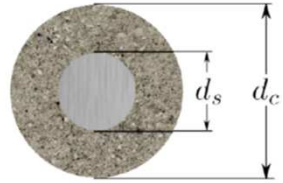
SISTEMA DE CONSTRUCCIÓN

Patente pendiente

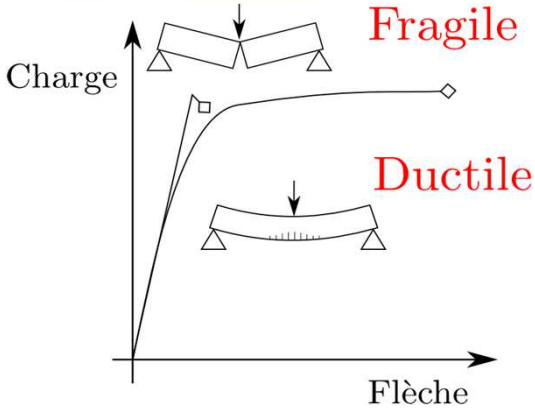
❶ **<u>Un connecteur composite</u>** en béton fibro-renforcé (préfabriqué), avec ou sans cœur de métal, qui sert à assurer une action collaborante entre une poutre de bois et une dalle de béton.

❷ **<u>Un modèle de calcul fiable</u>** qui permet de concevoir le connecteur *sur mesure* (choix du nombre et de la dimension du connecteur) pour assurer la ductilité de la structure, ex. d'une poutre de portée et charge donnée





Coupe A-A



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RADIANT WALLS BASED ON COMPOSITE PANELS HYBRID WOOD AND INORGANIC MATERIAL

RESULTS

Front of rupture of a wood–cement particleboard cut with a saw

New panel (PCBS) *without finishing paper* offers to us the advantages over gypsum board *with finishing paper* :

- Thermal capacity : 28% higher
- Mechanical properties
  - MOR : Similar in paper fibre direction and 214% higher in perpendicular to paper fibre direction
  - Screw withdrawal : 51% higher
- Physical properties:
  - water absorption : similar after 24h and non-swelling in water
  - Density : similar (0,68±0,02)

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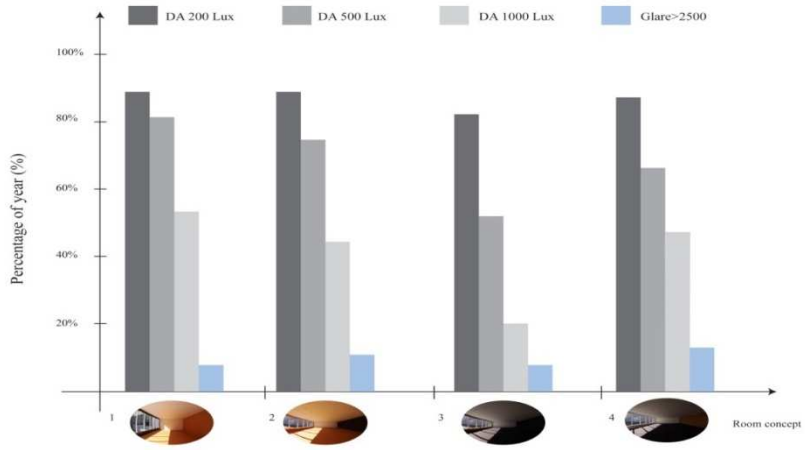
DURABILIDAD /EFICIENCIA

Analyzing 50%-55% Wood Application

	Images	Ecotect simiulation	DF	DA
Room concept 1	 50%		3.5 Average value	200 lux 87% 500 lux 66% 1000 lux 26% 2500 lux 6%
Room concept 2	 55%		4.5 Average value	200 lux 90% 500 lux 76% 1000 lux 46% 2500 lux 7.5%
Room concept 3	 55%		5.4 Average value	200 lux 90% 500 lux 82% 1000 lux 60% 2500 lux 9%
Room concept 4	 55%		3 Average	



- **<u>Impacto del madera sobre el consumo d'energia</u>** y el comodidad visual en un medio ambiente arquitectonico

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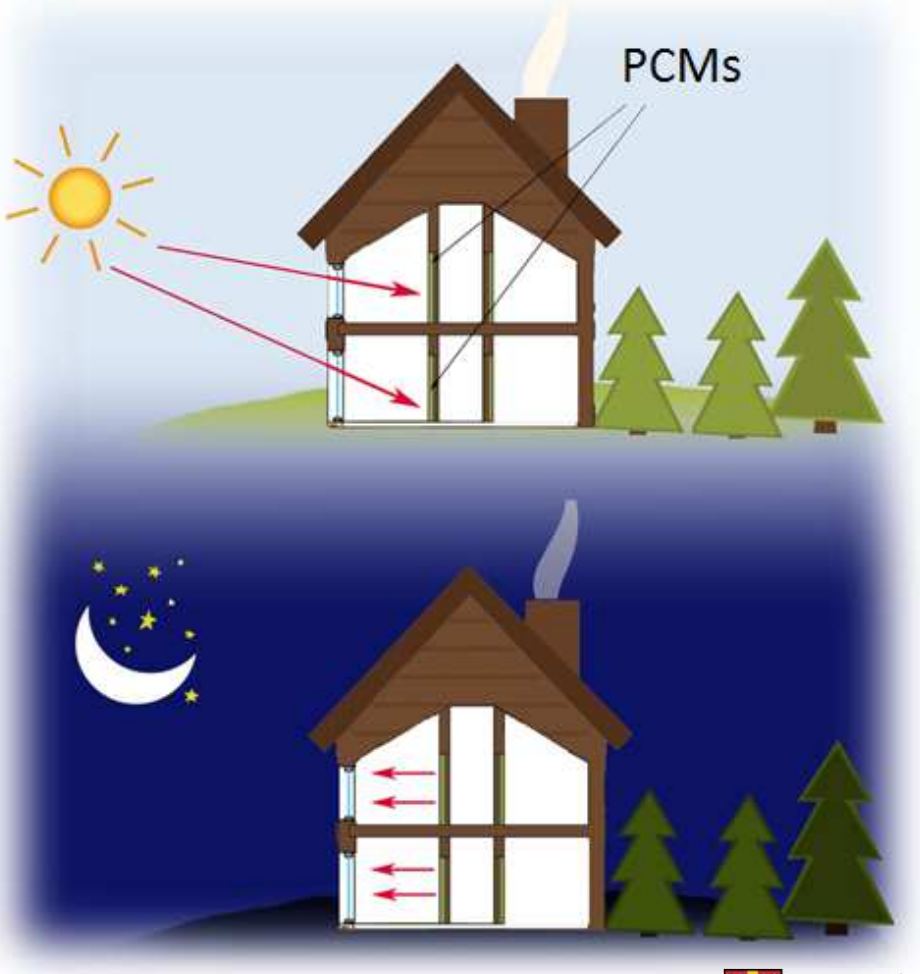
High thermal mass wood components containing biobased Phase Changing Materials (PCMs)

Problem : Lightweight timber-frame buildings have a low thermal inertia. Enhancing the thermal mass could reduce the energy consumption and improve thermal comfort.



Phase-Change Materials: A Phase-Change Material (PCM) is a substance with a high heat of fusion capable of storing and releasing large amounts of energy by a transition of phase, more often with the liquid / solid transition.

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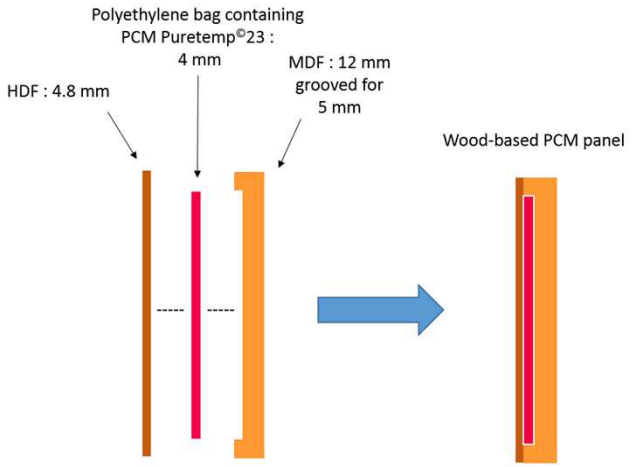
- **Objective 1 :** Manufacturing wood-based panels loaded with bio-based PCMs

Results : A maximum of 57,1 J/g of heat can be stored in a panel with a melting point of 23°C

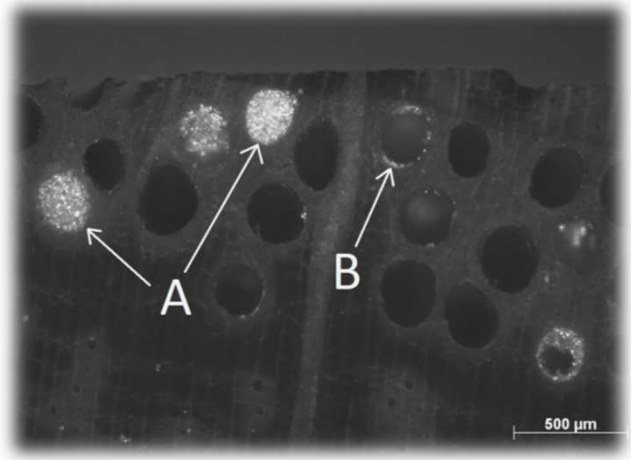


- **Objective 2** : Assessing the efficiency of the panels for a timber-frame construction, in Québec climate with two-timber frame test-huts in Laval University Campus, Québec city

Results : PCM panels can reduce heating consumption by 9% in March, 10 % in April and 41 % in May and reduce overheating up to 2°C in summer

- **Objective 3** : Impregnation of Engineered Wood Flooring layers with PCM microcapsules

Results : Thermal mass of red oak boards have been enhanced by 76,9 %



Characterization and analysis of fire risks of green roof systems

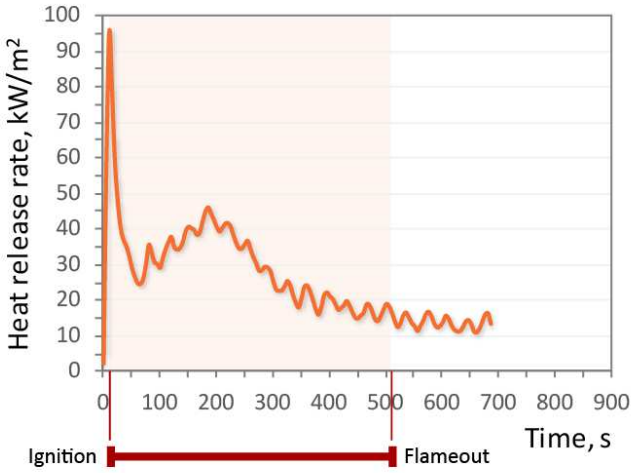
Main objective:

To deepen the knowledge about green roof systems in terms of fire safety.

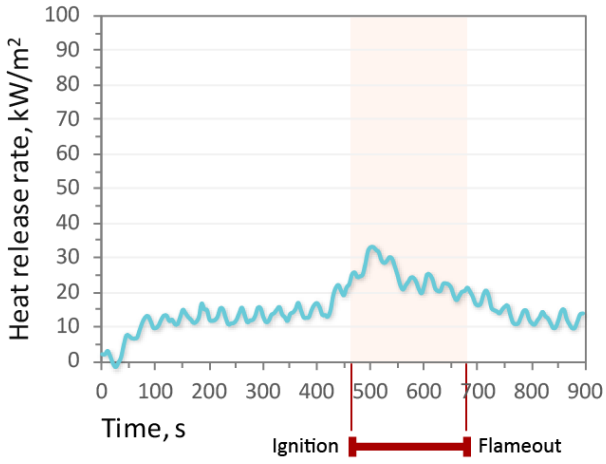
Flammability characteristics

Green roof soil (20% of organic matter)

0% of moisture content



30% of moisture content



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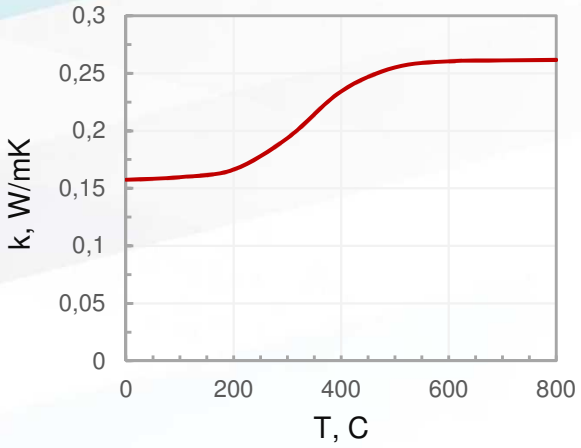
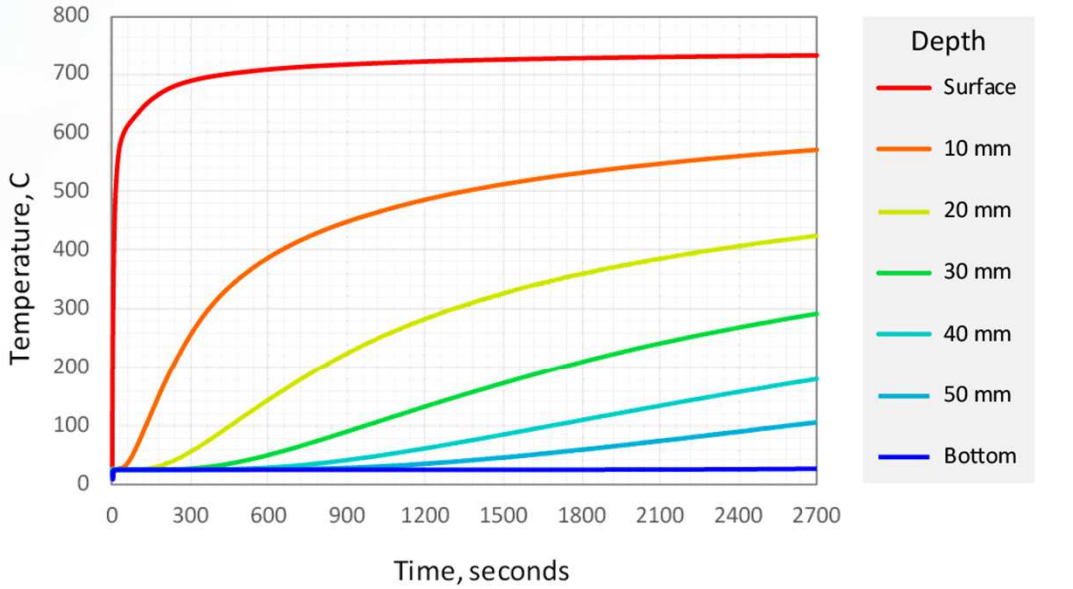
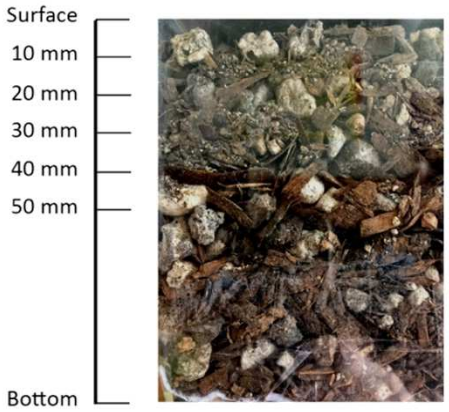
Heat transfer analysis through the soil layer

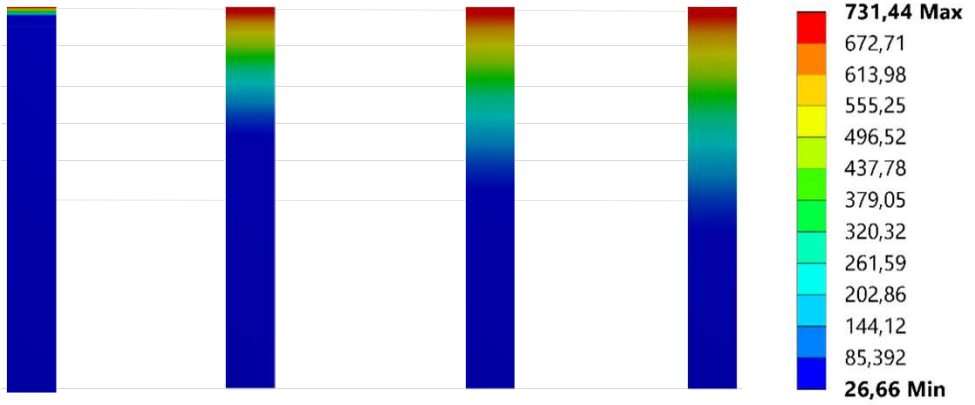
Thermal conductivity



Heating load: 50 kW/m^2 applied to surface







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Training and R&D: CIRCERB

- CIRCERB starts its second mandate for the next 5 years
- Over 50 research projects (Master, Ph.D., Post doc)
- Possibility of internships at any level
- CIRCERB pays grants to its students
- International collaboration is part of our vision
- Candidates from Uruguay are very welcome!!!

… our winter is not so bad after all!

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How much trees do you need to build this:

Murray Grove

Waugh Thistleton Architects, London, UK (2009)