CLT - Research and Testing at UBC

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University of BC
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Cross Laminated Timber (CLT)

- Multi-layer plate elements with 3 up to 9 layers
- Crosswise orientated boards, laths or planks (of relatively low quality)
- Bonding between layers primarily on the wide surfaces only
- Maximum dimensions: Length = 16 m, Width = 5 m, Thickness = 0.5 m
Properties of CLT

- Good thermal insulation
- High indoor environment quality
- Reduced in plane swelling and shrinkage: 0.02% per 1% MC (spruce: 0.24%/%) 
- Gaps and grooves can be used reduce drying stresses
How CLT is Designed in Europe

In Europe: Properties for CLT are stipulated in technical approvals of product from individual companies. These technical approvals are to be used together with the European or national codes for timber structures.

Examples of available European CLT technical approvals

Binder Holzbausysteme GmbH (A) Z-9.1-413 / ETA-06/0009
Lignotrend AG (CH) Z-9.1-555
Stora Enso Timber OY LTD (FIN) Z-9.1-559
Haas Fertigbau GmbH (GER) Z-9.1-680
KLH Massivholz GmbH (A) ETA-06/0138
CLT – European Status Quo

- European Cross laminated timber (CLT) has moved from a niche market since mid 1990’s to a mass produced product.

- Production is projected to double (600,000 m³) or triple (1,000,000 m³) by 2015.
CLT seems to be a maturing structural product in Europe. Why do we need more research and studies at UBC? Can we not just adapt European solutions and technologies?
In N. America CLT must compete with concrete and steel as building material. Its success will depend on performance and pricing; this is governed by production method, installation schemes and resource characteristics.

In Europe, the cost of the wood substrate is approximate 50% of the cost of CLT.

19 mm thick C16 or C24 grade structural timber (European White Spruce) is used in European CLT.
Pressing Technologies

- Mechanical press (1000 kPa)
- Nailing system (Aluminum)
- Vacuum press (~80 kPa)
Source: BC Ministry of Forests
Mountain Pine Beetle Epidemic

- The socio/economical impact of the MPB infestation is obviously huge.
- From environmental point of view, if we do not use the wood in a timely manner, BC forest will become a carbon source not a carbon sink!
Mountain Pine Beetle Epidemic

- The MPB wood should be used as a value-added product and carbon storage base – building products.
- Where is the market for the wood?
  - North American Residential market?
  - Oversea?
  - Commercial / nonresidential market
Current Canadian Availability

Pilot plant scale production - CST Innovations

- Panel dimensions (max.): thickness 140 mm, width 1.4 m, length 7.9 m.
  Typical panel dimensions:
  - 3-ply, 89 mm (35mm-19mm-35mm)
  - 3-ply, 105 mm (35mm-35mm-35mm)
  - 5-ply, 140 mm (35mm-19mm-35mm-19mm-35mm)
  (plans to increase to 200 mm thickness- no firm available date)

- Adhesive: Polyurethane

- Wood species: SPF, KD-HT, #2& btr. Equivalent (MPB lumber)
Near Future Canadian Availability

- Structurlam, Penticton BC
- Nordic Engineered Wood, Quebec
UBC Research on CLT

- Study to make the CLT using BC wood based on available technology
  - Glue
  - Species
  - Grade
  - Surface quality
  - MC

- Studied the structural performance of as floor or roof plates – Computer model and experiments (J. Chen)

- Studied the structural performance of as beams (I. Bejtka - KIT)
European Tests on Shear Bond

Karlsruhe Institute of Technology

Technical University of Graz
Comparison of strength values

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Maximum</th>
<th>Minimum</th>
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</thead>
<tbody>
<tr>
<td>Blaß and Görlacher (53)</td>
<td>3.70</td>
<td>3.95</td>
<td>3.20</td>
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<td>Jeitler (81)</td>
<td>3.45</td>
<td>4.13</td>
<td>3.00</td>
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Comparison of stiffness values

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<th>Average</th>
<th>Maximum</th>
<th>Minimum</th>
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<tr>
<td>Blaß and Görlacher (26)</td>
<td>5.02</td>
<td>6.38</td>
<td>2.70</td>
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<tr>
<td>Jeitler (81)</td>
<td>2.70</td>
<td>4.55</td>
<td>3.45</td>
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</tbody>
</table>
UBC Tests on Shear Bond

Pressure levels: 0.1, 0.3, 0.6 MPa
Two types of Adhesives: PRF and PU
Two Species: SPF and SPF/Western Hemlock
Shear Strength and Stiffness
UBC Tests on Shear Bond
UBC Research on Design of CLT Buildings

- Design CLT buildings using available information (J. Wang)
- Compare the environmental footprint of a Concrete and a CLT office building (A. Robertson)
Design of a 4 Storey Mid-rise Professional Office Building
Design of a 20 Story Hybrid CLT Concrete Building

J. Wang and RJC
Original Concept by F. Lam, CC Yao and A. Boniface
20 Story Hybrid CLT Concrete Building
Life Cycle Comparison of Reinforced Concrete or CLT in an Office Building

Case study building; Discovery Parks, Burnaby, BC
(Bunting Coady Architects)

Preliminary results UBC Adam Robertson MASc Study
LCA Comparison of Concrete & Timber Office Buildings

Global Warming Potential
Acidification
Eutrophication
Fossil Fuel Depletion
Water Intake
Ecological Toxicity
Human Health
Ozone Depletion
Smog

(Normalized as a percentage)

Concrete Building
Timber Building

Preliminary Results UBC Adam Robertson MASc Study
Embodied Energy of Office Building Construction Materials

Preliminary results UBC Adam Robertson MASc Study
Global Warming Potential of CLT by Life Cycle Stage

- Raw Material Acquisition: 64
- Manufacturing: 37
- Transportation: 14
- Use: -753

Preliminary results UBC Adam Robertson MASc Study
CLT to Beam Connection with Self Tapping Wood Screws
FEM Analysis of a Small Demonstration Building

M. Katz's I-house - J. Chen
# NSERC Strategic Network Newbuilds (2011 to 2016)

<table>
<thead>
<tr>
<th>Project Cluster &amp; No.</th>
<th>Year</th>
<th>Title</th>
<th>PI</th>
<th>University</th>
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<tbody>
<tr>
<td>C1-1 (1)</td>
<td>1,2</td>
<td>Characterizing planar shear modulus and strength of CLT</td>
<td>Gong</td>
<td>UNB</td>
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<tr>
<td>C1-2 (3)</td>
<td>3,4,5</td>
<td>CLT product design method based on flexural properties and use of modal testing method</td>
<td>Chui/Gong</td>
<td>UNB</td>
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<tr>
<td>C1-4 (4)</td>
<td>4,5</td>
<td>Development of NDT technique for CLT QC evaluation and control</td>
<td>Chui</td>
<td>UNB</td>
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<td>C2-2 (5)</td>
<td>2,3</td>
<td>Seismic response of CLT mid-rise system</td>
<td>Lam/Haukaas</td>
<td>UBC</td>
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<td>2,3,4</td>
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<td>C3-1 (6)</td>
<td>1,2</td>
<td>Stiffness and strength of CLT diaphragms (in-plane loading)</td>
<td>Lam/Haukaas</td>
<td>UBC</td>
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<td>C3-2 (7)</td>
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<td>Manufacturing Parameters on CLT Floor Performance to resist out-of-plane loading</td>
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<td>UBC</td>
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<td>1,2 &amp; 3,4</td>
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<td>C3-2</td>
<td>3,4,5</td>
<td>Stability of CLT wall under vertical load</td>
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<td>UBC</td>
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<td>C3-3 (11)</td>
<td>3,4,5</td>
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<td>C4-1 (13)</td>
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<td>Force transfer around openings in CLT buildings(lateral load)</td>
<td>Lam/Haukaas</td>
<td>UBC</td>
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<tr>
<td>C4-2 (14)</td>
<td>1,2</td>
<td>Innovative CLT Building Systems – Localized Rolling Shear Reinforcement and Post-tensioned CLT system</td>
<td>Lam/Haukaas</td>
<td>UBC</td>
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<td>C5-1 (17)</td>
<td>2,3 &amp; 4,5</td>
<td>Connection design in CLT</td>
<td>Salenikovich/Smith</td>
<td>Laval/UNB</td>
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</table>
Supporting Agencies and Companies

- BC Forest Innovation Investment
- NSERC
- NRCAN Value to Wood Program

- CST Innovations
- Canfor Corp.
- Coast Forest Products Association
- RJC Consulting Engineers

- TU Graz, AU
- Karlsruhe Institute of Technology, GE
- Ivalsa, IT
Thank you for your attention