CLT Benefits

- Generate economic opportunities
- Reduce CO$_2$ emissions, fossil fuel consumption, increase energy efficiency
- Increase the use of renewable materials
- Create high value-added uses for wood.
- Increase the economic value of forestlands
- Architectural freedom
- Faster, cleaner construction
- Potential incremental volume 5BBF
NOTABLE PROJECTS IN NORTH AMERICA
Brock Commons Phase 1

- University of British Columbia Point Grey campus
- Student residence
- 18 stories, 173 ft (53 m)
- 162,700 ft² (15,115 m²)
- LEED Gold certification
- In construction (scheduled 2017)
T3-Hines

- Minneapolis, Minnesota.
- 7 stories, 85 ft (26 m).
- 220 000 ft² (20 400 m²)
- High-end office space.
- Post and beam with NLT.
- Under Construction.

http://goo.gl/BsRW5t

Franklin Elementary School

- Franklin, West Virginia.
- 300 students.
- Carbon stored: 1,014 tons.
- Completed January 2015.
Candlewood Hotel

- Redstone, Alabama.
- 4 stories, 58 000 ft²
- 92 rooms.
- Army’s privatized lodging.
- Completed 2014.

http://goo.gl/t1Gv/M

LendLease
HARDWOOD CLT
Birch CLT - Austria

- Hasslacher Norica Timber / TU Graz
- Birch (Betula pendula)
- $\rho_{12\%\text{MC}} = 594 \text{ kg/m}^3 \ (37 \text{ lb/ft}^3)$
- $n=20$, 5-ply, x-section ~24x8 in, MUF
- Tested according EN 1995-1-1
  - MOE = 15,524 MPa (COV=4.3%)
  - MOR = 38 MPa (COV=11.6%)
  - Tensile strength of joints 55.7 MPa
  - Compressive strength $\perp$ =5.8 MPa$^2$
Birch CLT House, Austria
Beech CLT - Switzerland

- Bern University of Applied Sciences
- European beech (*Fagus sylvatica*)
- \( \rho = 690 \text{ kg/m}^3 \) (43 lb/ft\(^3\))
- \( n=13, 120 \text{ mm (4\(\frac{3}{4}\) in), layers=vary} \)
- Values higher than spruce CLT, especially rolling shear (~5x), bending (1.7x) and compression perpendicular to grain (~5x).

Franke, S.: Mechanical properties of beech CLT. CD-ROM Proceedings of the World Conference on Timber Engineering (WCTE 2016), August 22-25, 2016, Vienna, Austria, Eds.: J. Eberhardsteiner, W. Winter, A. Fadai, M. Pöll, Publisher: Vienna University of Technology, Austria
Yellow-Poplar CLT - USA

• VT, WVU
• 6/4 #2 Common Yellow-poplar
• SG = 0.48-0.50
• n = 24, 72x12x4.2 in, 3-ply, PF
• Tested according PRG320
• Bending stiffness and strength, and resistance to delamination exceeded required values
• Forms adequately strong and durable adhesive bonds

Hybrid Poplar CLT - USA

- Oregon State University
- FSC-certified plantation hybrid poplar (Pacific Albus)
- SG = 0.347, No.2&Btr
- n=10, 100x16x3¼ in, 3-ply, PF
- Tested for PRG-320 compliance
- Met/exceeded shear and bending strength for CLT. Did not meet stiffness (MOE) needed

HARDWOOD CLT IN THE U.S.
MAJOR ISSUES
“This standard provides requirements and test methods for qualification and quality assurance for performance rated cross-laminated timber (CLT) intended for use in construction applications.”

ANSI/APA PRG 320-2012
Standard for Performance-Rated Cross-Laminated Timber
• Any **softwood** recognized by ALSC
• Species: $SG \geq 0.35$
  1 per layer
• Grades: #2&btr (/), #3&btr (⊥)
• MC: $12 \pm 3\%$
• Most hardwoods have $SG > 0.35$
• Hardwoods typically dried to low MCs
PRG320 - Material Considerations

• Layer thickness: $5/8'' \leq t \leq 2''$

• Width of pieces:
  – Parallel layers $w \geq 1.75 \times t$ (major strength)
  – Perpendicular layers $w \geq 3.5 \times t$ (minor strength)

• For dimension lumber, this excludes:
  – Parallel: 2x2, 2x3; Perpendicular: 1x2, 1x3, 2x2, 2x3, 2x4

• Hardwoods commonly sawn to 1” thickness

http://www.cedarlan.ie/
Material Considerations

- Shrinkage (hardwoods ~30% higher)
- Adhesion issues
- Mechanical properties
Cost Considerations

• Softwood lumber price: $314
  – #2&btr West SPF, KD (09.09.2016*)

• Hardwood lumber prices: $510
  – #2Com 4/4 poplar, KD (08.26.2016**)

• Wood is ~50% of CLT mfg. costs (glue is 10%)

• Europe: spruce CLT ~$700/m³; beech ~$3,200/m³

• CLT in general costs 10-15% more than steel/concrete
  – However, structural frame is <20% of total building cost

* Random Lengths
** Hardwood Market Report
Hardwood CLT - Procurement Issues

• Is there enough wood to sustain a hardwood CLT industry?
• Average western dimension mill capacity ~180MMBF
• Considering width-thickness ratios, process factors, and lumber prices, some sizes and grades are favored.
• One large CLT plant (~24MMBF**) needs access to ~5 average dimension mills’ supplies.
• However, average hardwood sawmill capacity ~6.7MMBF*
  – How much of mill’s output suitable for CLT?

Summary

- Research/testing indicates that hardwood CLT for structural use is **technically feasible**
- Hardwood CLT, in general, has **better strength properties**.
  - Potential for smaller cross-sections, longer spans
- Major issues: **cost, procurement, gluing, grading**
- Inclusion in **ANSI/APA PRG320**
- Maybe **specific** uses; e.g., high loads, long spans, hybrids
- **Industry support** and long-term commitment needed!
Thanks!