



FPInnovations

Creating forest sector solutions

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Manufacturing of Cross Laminated Timber (CLT)

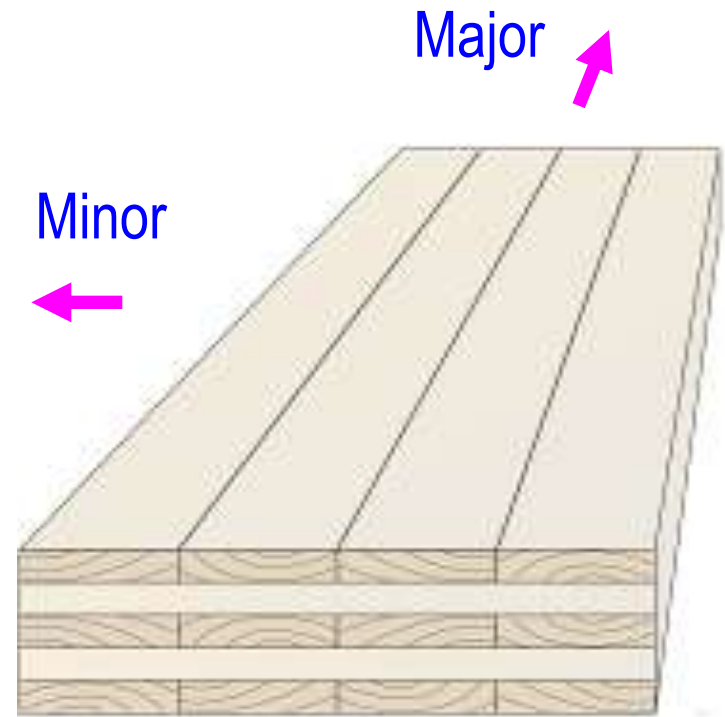
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February 8, 2011

Vancouver, B.C. Canada

Outline

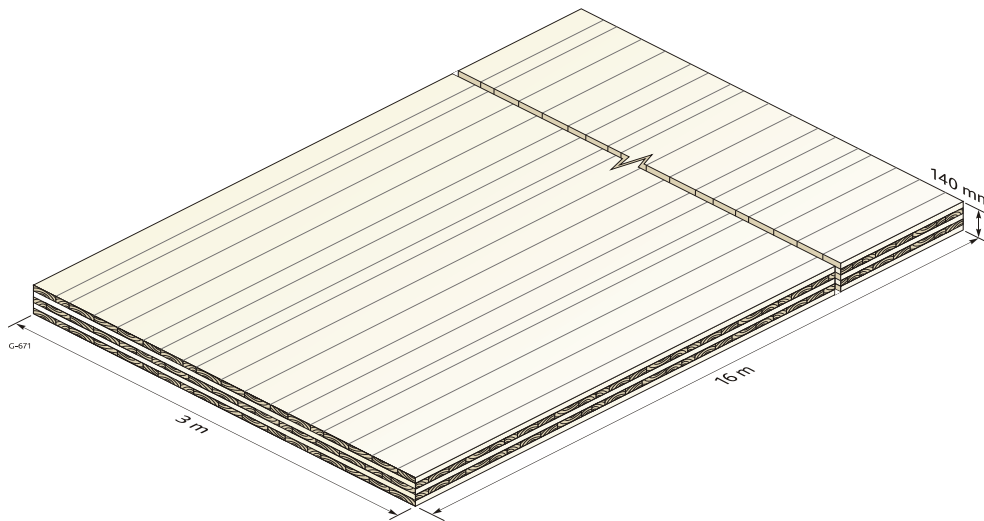
1. CLT manufacturing considerations
2. CLT raw materials
3. Typical steps of CLT manufacturing process
4. CLT bond quality assessment
5. CLT standard development at FPInnovations



CLT - 'Jumbo Plywood'

1. CLT Manufacturing Considerations

- CLT target applications
 - Floor, wall and roof
- CLT panel dimension & lay-ups
- Plant layout, equipment & qualification



2. CLT Raw Materials

■ Wood

- Structural lumber
 - No.2 &Btr - major direction
 - No.3 &Btr - minor direction
- * Refer to CSA O141 & PS 20(US)
- Wood composites (OSB, LVL...)



Generic CLT



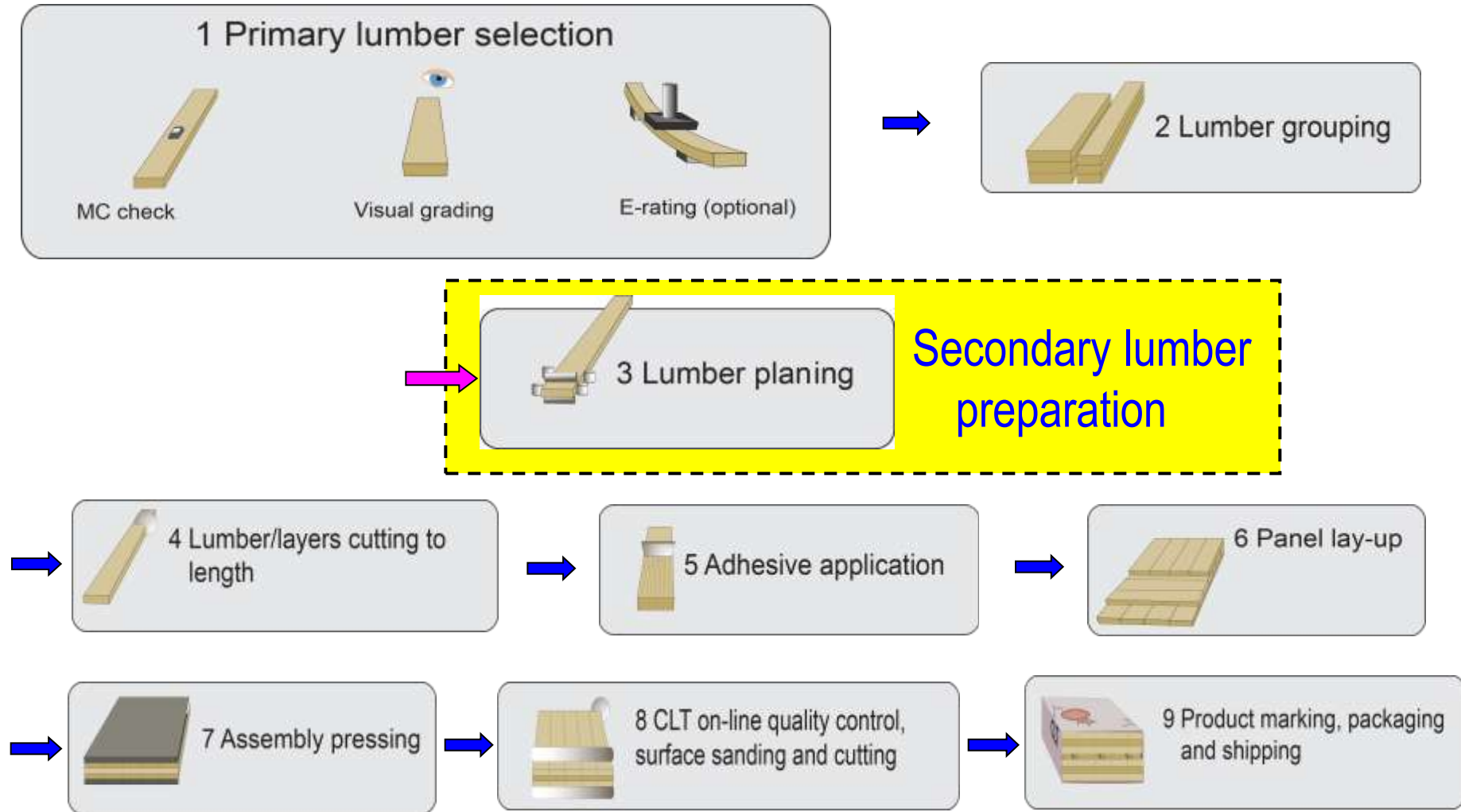
Hybrid CLT

■ Adhesives

- Phenolic type (PRF)
- Emulsion polymer isocyanate (EPI)
- One-component polyurethane (PUR)
- ...

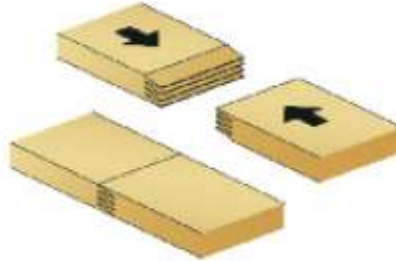
- * Meet CSA O112.10
- * Refer to manufacturer's specifications

3. Typical Steps of CLT Manufacturing Process

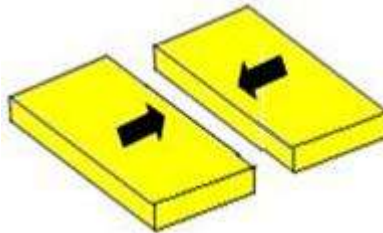


Secondary Lumber Preparation

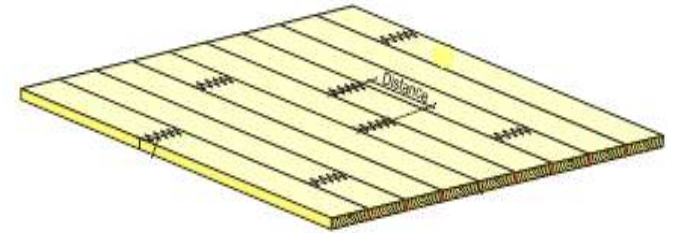
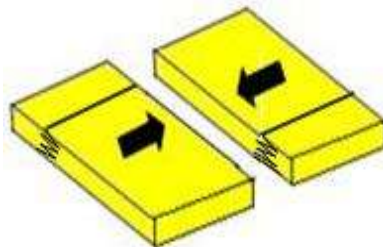
Option 1: End-joining



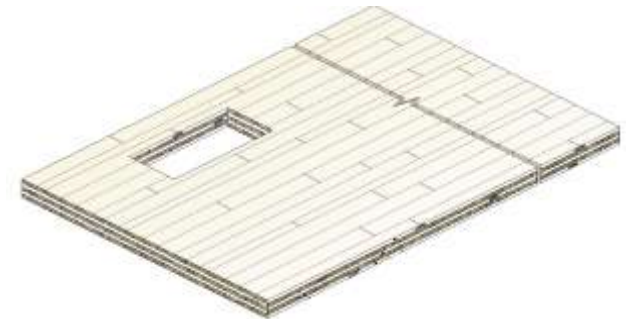
Option 2: Edge-gluing



Option 3: End-joining +
Edge-gluing



CLT Layer



CLT Panel

3.1 Lumber Procurement

- 2x lumber / 1x board
- S4S / S1S1E (rough sawn)
- KD - HT (19% MC or less)

- Unpack lumber stocks and sticker lumber



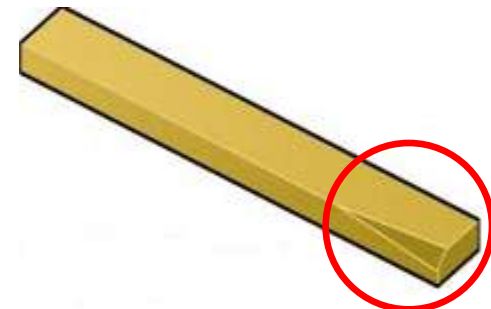
Air-drying



Kiln-drying

3.2 Lumber Quality Control

- MC target: $12 \pm 2\%$
- Visual grading - NLGA rules
 - Limits on wane / shake
 - Restrictions on warp (crook, twist...) and decay...
- E-rating (optional)



Wane



3.3 Lumber Grouping

- Achieve panel design capacity
- Ensure good visual appearance
- Group lumber for major/minor directions based on
 - Lumber MC and visual characteristics
 - In combination of lumber MOE, if E-rating is used



3.4 Lumber Planing

- Activate or refresh wood surfaces to reduce oxidation for effective bonding
- Reduce thickness variation of laminations
- Remove about
 - 0.15 in from the width
 - 0.10 in from the thickness



Surfaced at 4 sides

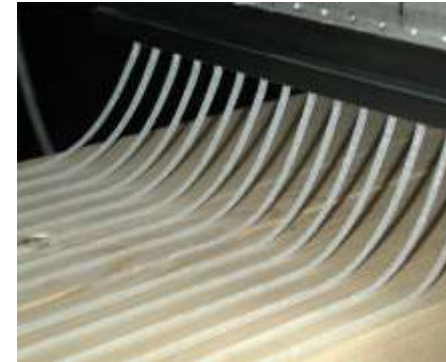


Surfaced at 2 sides

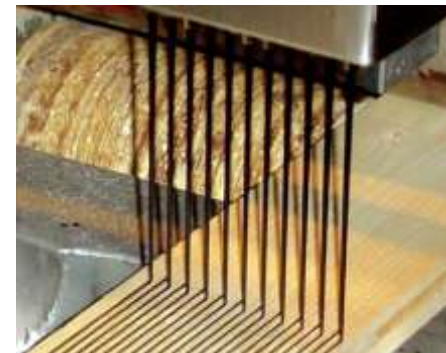
3.5 Adhesive Applications

- Apply parallel lines of adhesives using a through-feed system
- Application rate and assembly time are adhesive-dependent
 - ✓ Target for PUR:
100-180 g/m² &
45 min maximum

Extruder heads



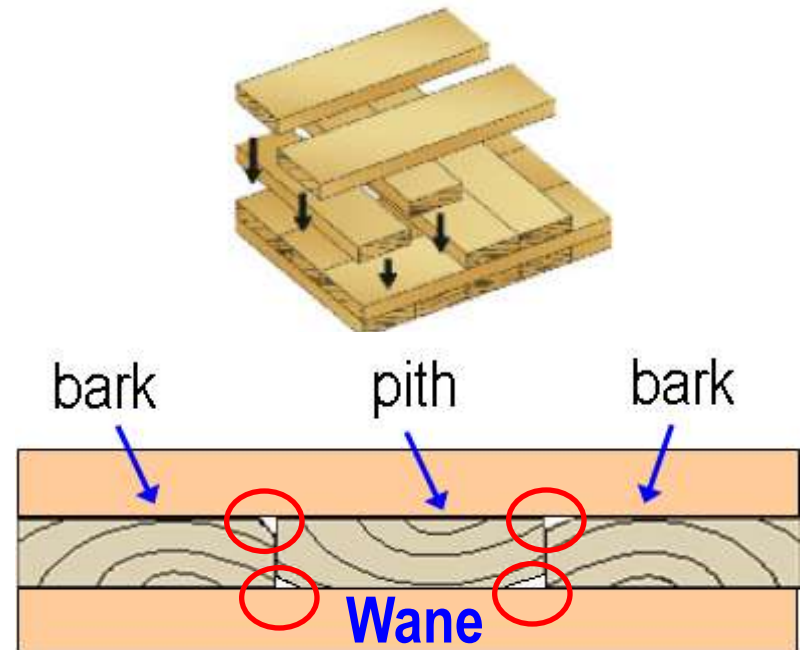
PUR, light color



PRF, dark color

3.6 Panel Lay-up

- Similar to plywood (a crisscross pattern)
- Orient laminations such that bark and pith faces of adjacent pieces alternate
 - disperse wane for a minimum effective bond area (80%)
 - reduce tendency of panel warp



3.7 Assembly Pressing

- Ambient temperature is 15°C or above
- Applied pressure and pressing time are species / adhesive -dependent
- If no edge-gluing, apply a 40-80 psi side pressure to minimize potential gaps in the main layers



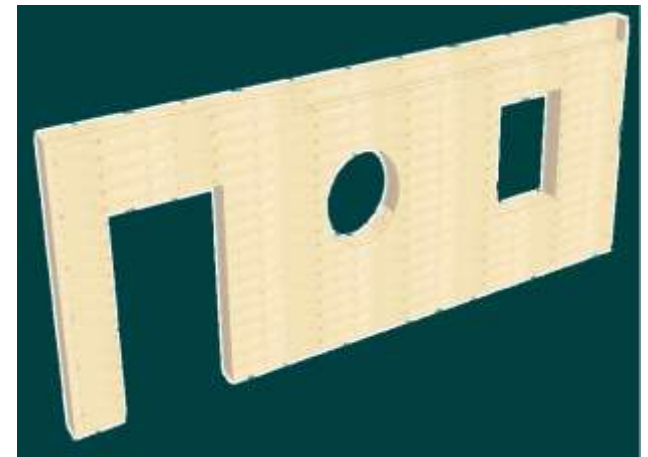
Vertical pressure only



With side pressure

3.8 CLT Quality Control, Cutting & Marking

- Perform visual grading
(optional: surface sanding)
- Cut out openings for windows /doors with CNC machine
- Mark CLT panels
 - Plant's logo & code
 - Species, lamination grade and thickness...

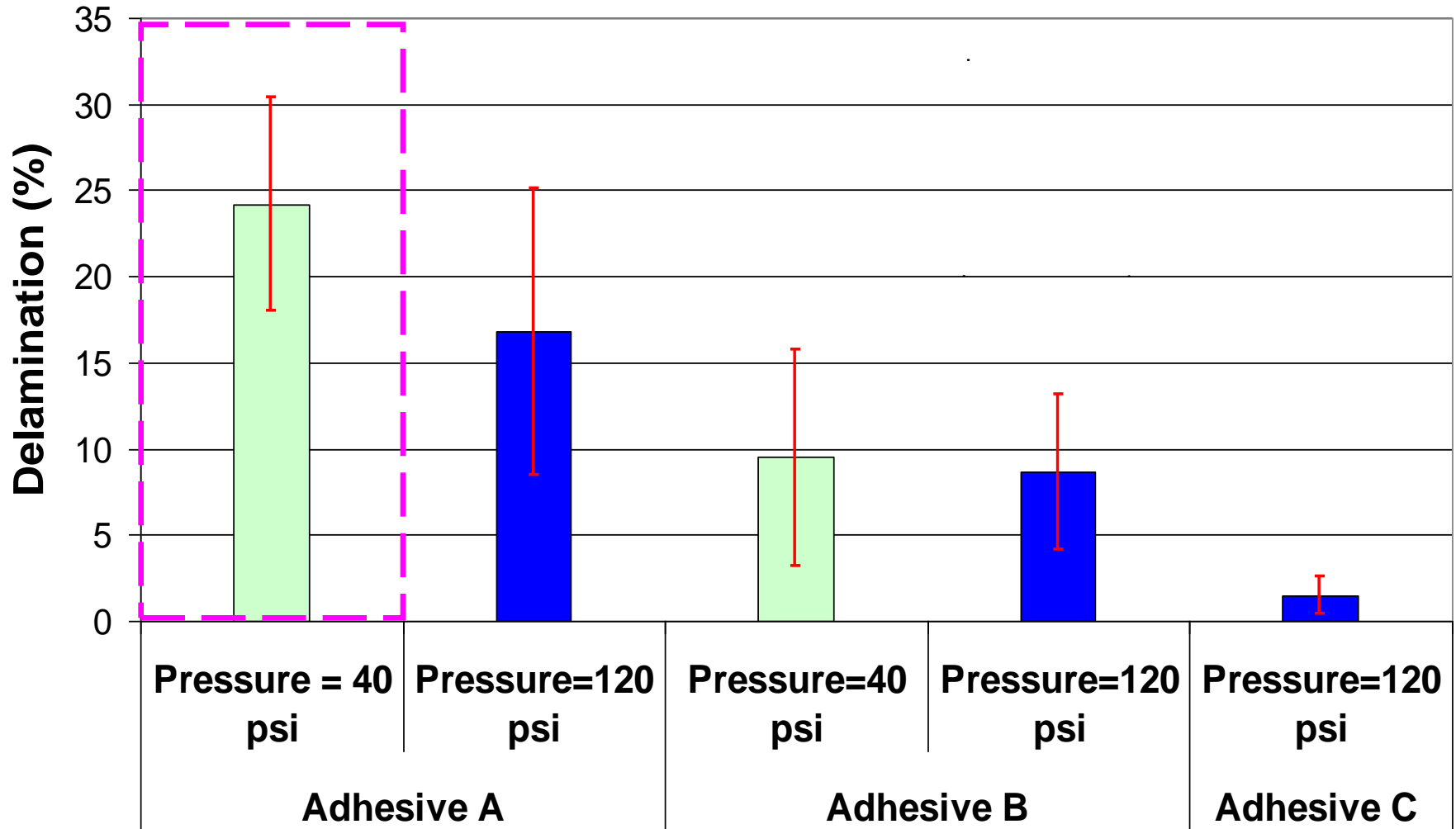


4. CLT Bond Quality Assessment

- Made 2 x 2 -ft CLT
 - 3 lay-ups: 3, 5 and 7-ply
 - 3 adhesives: A, B and C
 - 2 pressures: 40 and 120 psi
- Performed delamination test (CSA O112-06)
 - Cylindrical specimen (d = 3.5 -in)



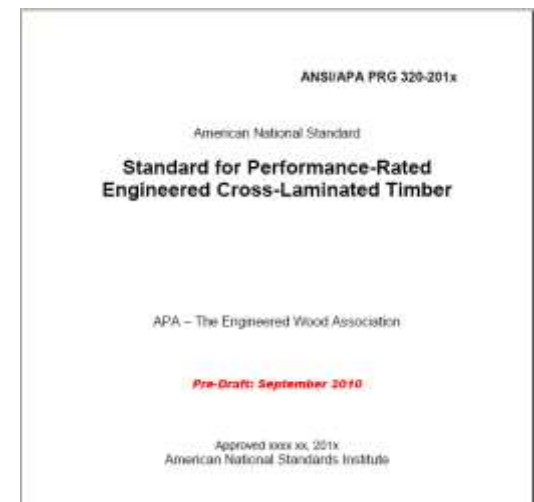
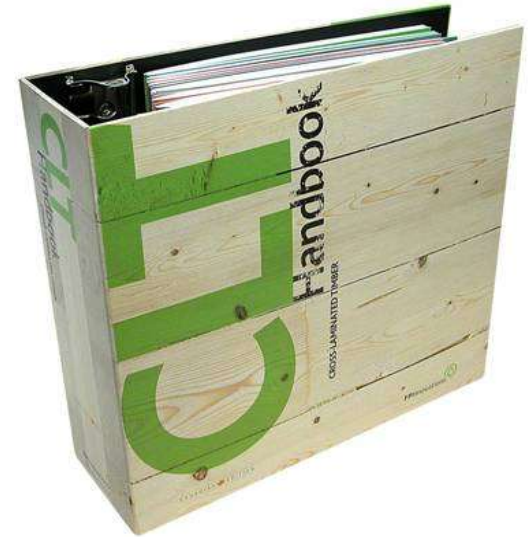
CLT Delamination Resistance



5. CLT Standard Development at FPInnovations

- Developed seed documents for
 - CLT Plant Qualification Standard
 - CLT Product Standard

- CLT North American Standard is under development at APA



Summary

- ✓ CLT manufacturing steps were introduced
- ✓ FPInnovations developed draft CLT plant qualification / product standards based on pilot plant tests
- ✓ FPInnovations passed the standards to APA for a North American CLT standard