Engineered Wood Products 101

Jeff Olson, P.E., P.Eng.
EWP Western Region (North America) Engineer
Boise Cascade - White City, OR
EWP Overview

• Prefabricated Wood I-Joists

• Structural Composite Lumber (SCL)
  • Laminated Veneer Lumber (LVL)
  • Parallel Strand Lumber (PSL)
  • Laminated Strand Lumber (LSL)
  • Oriented Strand Lumber (OSL)
EWP Overview

Other EWP Products

- Plywood
- Glued Laminated Timber (Glulam)
- Metal-Plate Wood Trusses
- Oriented Strand Board (OSB)
- Cross Laminated Timber (CLT)
Why EWP?
Logs are smaller today...

...and defects affect strength
Knots and other defects reduce resistance

Defects dispersed in EWP
Higher resistance obtained
EWP Applications

- Engineered Stud
- Engineered Beam
- Light Duty Header
- GLULAM®
- Rimboard
- Window & Door Header
- Wood I-Joists
- Stair Stringer
Wood I-Joists: History

- Developed by U.S. Forest Products Laboratory in the 1940’s
- First produced for market in late 1960’s
- Originally 2x4 flange and plywood web
Wood I-Joists: Manufacturing

- Laminated veneer lumber (LVL) or solid sawn flanges
- High grade OSB web
Wood I-Joists: Advantages

- Longer lengths (60’+)
- Dimensionally stable
- Tighter tolerances
- Higher strength
- Efficient use of natural resources
- Larger holes allowed in webs
Wood I-Joists

Multiple Series & Depths for Various Applications within Residential / High Density / Light Commercial Construction
## Wood I-Joists

Proprietary Factored Resistance Values

### Factored Resistances

**Limit States Design (CANADA)**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>9 1/4</td>
<td>4130</td>
<td>2520</td>
<td>160</td>
<td>5.2</td>
<td>2.0</td>
<td>1530</td>
<td>2360</td>
</tr>
<tr>
<td>11 1/4</td>
<td>5300</td>
<td>2770</td>
<td>265</td>
<td>6.4</td>
<td>2.3</td>
<td>1530</td>
<td>2410</td>
</tr>
<tr>
<td>14</td>
<td>6280</td>
<td>2990</td>
<td>390</td>
<td>7.6</td>
<td>2.5</td>
<td>1530</td>
<td>2530</td>
</tr>
<tr>
<td>9 1/4</td>
<td>5310</td>
<td>2730</td>
<td>180</td>
<td>5.2</td>
<td>2.2</td>
<td>1920</td>
<td>2340</td>
</tr>
<tr>
<td>11 1/4</td>
<td>6810</td>
<td>3050</td>
<td>320</td>
<td>6.5</td>
<td>2.5</td>
<td>1930</td>
<td>2640</td>
</tr>
<tr>
<td>14</td>
<td>8080</td>
<td>3330</td>
<td>470</td>
<td>7.6</td>
<td>2.7</td>
<td>1940</td>
<td>2900</td>
</tr>
<tr>
<td>16</td>
<td>9220</td>
<td>3600</td>
<td>635</td>
<td>8.7</td>
<td>2.9</td>
<td>1950</td>
<td>3140</td>
</tr>
</tbody>
</table>

1 1/2" Min. Bearing Length:
- No Web Stiffeners
- WITH Web Stiffeners

3 1/2" Min. Bearing Length:
- No Web Stiffeners
- WITH Web Stiffeners
# Wood I-Joists

## Web Holes

A 1½” round hole may be cut anywhere in the web. Provide at least 3” of clearance from other holes.

### Minimum Distance (D) from Any Support to the Centerline of the Hole

<table>
<thead>
<tr>
<th>Round Hole Diameter [in]</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>6½</th>
<th>7</th>
<th>8</th>
<th>8½</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectangular Hole Side [in]</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Any 9½” Joist</td>
<td><strong>Span [ft]</strong></td>
<td>8</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
</tr>
<tr>
<td>Round Hole Diameter [in]</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>6½</td>
<td>7</td>
<td>8</td>
<td>8½</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>Rectangular Hole Side [in]</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Any 11½” Joist</td>
<td><strong>Span [ft]</strong></td>
<td>8</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
<td>1½”</td>
</tr>
</tbody>
</table>

- Select a table row based on joist depth and the actual joist span rounded up to the nearest table span. Scan across the row to the column headed by the appropriate round hole diameter or rectangular hole side. Use the longest side of a rectangular hole. The table value is the closest that the centerline of the hole may be to the centerline of the nearest support.
Wood I-Joists

Floor Framing
Wood I-Joists

Floor Framing

F06 For load bearing wall above (stacked over wall below).

BCI® Joist blocking.

F08 Solid block all posts from above to bearing below.

F10 Backer block (minimum 12" wide). Nail with 10 - 3" (10d) nails.

Joist Hanger

Filler block. Nail with 10 - 3" (10d) nails.

Backer block required where top flange joist hanger load exceeds 250 lbs. Install tight to top flange.
Wood I-Joists – Web Stiffeners

- Increases reaction resistance
- Provides lateral support for specific hangers
Engineered Rimboard

- Typical Rimboard Thickness
  - 1 1/8” – 1 1/4” OSB
  - 1 1/4” - 1 1/2” LVL
- Vertical load and lateral nail resistance for diaphragms
- Dimension lumber should never be used as rim board with wood I-Joists
Floor Diaphragm
Full scale testing to establish equivalency to 2x dimension lumber
Diaphragm Testing

Failure of sheathing

Flange thickness not limiting factor
Wood I-Joists

Roof Framing
Bottom flange needs to be fully supported
Roof Framing

Ridge Nailer NOT allowed with I-Joist rafters
**Roof Framing**

I-Joist Hip & Valley Rafters

- Structural hips and valleys required
- Slopeable/Skewable hangers with web stiffeners required
Wood I-Joist Fire Assemblies

- 1-hour floor/ceiling assembly based on CAN/ULC-S101 / ASTM E-119 fire test.
- Most common assembly requires two layers of fire-rated gypsum board
- Larger joists assemblies may include one layer 5/8” type C gypsum board with mineral wool between bottom flanges
Fire Resistance Assembly Testing
Fire Resistance Assembly Testing
• Certification defined in NBCC
• Assemblies listed by agency accredited by Standards Council of Canada (SCC)
• Example agencies: Intertek, ULC, PFS Corporation
### One-Hour Fire Resistance Rated Floor and Roof Assemblies

#### Two Layers 5/8" Type X Gypsum Wallboard - BCI® and AJS® Joists

#### BASE ASSEMBLY

<table>
<thead>
<tr>
<th>Component</th>
<th>Material Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor Topping (Optional)</td>
<td>Reference sound ratings if applicable</td>
</tr>
<tr>
<td>Floor Sheathing</td>
<td>Min. 25/32 inch (18 mm) T&amp;G Sheathing</td>
</tr>
<tr>
<td>Insulation (Optional)</td>
<td>Glass Fiber Insulation</td>
</tr>
<tr>
<td>Structural Members</td>
<td>Reference sound ratings if applicable</td>
</tr>
<tr>
<td>Resilient Channels (Optional)</td>
<td>Min. 0.019 inch (0.6mm) Galvanized Resilient Channel</td>
</tr>
<tr>
<td>Ceiling</td>
<td>(2) Layers of 5/8 in (18mm) Type X Gypsum Wallboard</td>
</tr>
</tbody>
</table>

A modified contact construction adhesive must be applied to the top of the joists prior to placing sheathing. The sheets shall be installed with their long edge perpendicular to the joists with end joists centered over the top flange of joists and staggered one joist spacing with adjacent sheets. Floor sheathing must be installed per code requirements.

Maximum 24 inch (610 mm) on center spacing. Minimum flange dimensions of 1½ inch (38mm) thick by 1½ inch (38mm) wide.

Attached perpendicular to the bottom flange of the joist with 1¼ inch (32mm) Type 8 drywall screws. Channels are spaced a maximum of 16 inches (406mm), 24 inches (610mm) on center when I-joists are spaced a maximum of 16 inches on center.
Fire Assembly Sound Ratings

- Sound Transmission Class (STC)
- Impact Insulation Class (IIC)
- Important Components
  - Floor Covering
  - Resilient Channels
Laminated Veneer Lumber (LVL)

- Developed prior to WWII, originally for airplane propellers
- Produced originally for wood I-Joist flanges in early 1970's
Birch LVL used throughout the "Spruce Goose"
LVL: Manufacturing

Similar to plywood, but wood grain oriented in single direction along beam length
LVL: Advantages

- Dimensionally Stable
- No Camber
- High Strength
  - Defects are dispersed (knots, slope of grain)
  - COV 10-15% (solid sawn = 25-40%)
  - 4800 – 6270 psi Bending, 1.7 – 2.0 x 10^6 psi MOE
• Different grades possible depending upon mix of veneer
• Product may be ripped to a shallower depth and retain same specified strength values
Strand Lumber

- **Parallel Strand Lumber (PSL)**
  - Long strips of veneer glued together
  - Developed in Canada late 70’s – early 80’s

- **Laminated Strand Lumber (LSL)**
  - 12” long strands

- **Oriented Strand Lumber (OSL)**
  - 3” – 6” long strands
<table>
<thead>
<tr>
<th>Product</th>
<th>Bending</th>
<th>Shear</th>
<th>MOE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doug Fir SS Grade</td>
<td>2830</td>
<td>220</td>
<td>1.7 x 10^6</td>
</tr>
<tr>
<td>24F-E DF Glulam</td>
<td>4435</td>
<td>290</td>
<td>1.9 x 10^6</td>
</tr>
<tr>
<td>LSL</td>
<td>4300</td>
<td>575</td>
<td>1.3 – 1.6 x 10^6</td>
</tr>
<tr>
<td>PSL</td>
<td>5360</td>
<td>540</td>
<td>2.0 or 2.2 x 10^6</td>
</tr>
<tr>
<td>LVL</td>
<td>4800 - 6280</td>
<td>530 – 580</td>
<td>1.7 – 2.0 x 10^6</td>
</tr>
</tbody>
</table>
SCL Connections

- Multiple 1 3/4” ply beams must be connected properly for load to be distributed evenly
- Higher grade SCL typical equivalent to DF specific gravity
SCL Studs & Columns
SCL Tall Walls

Diagram showing the structural components of a wall, including:
- Uniform Load
- Header
- Window
- Sill Anchor
- Column tributary width
- Stud tributary width
- Solid Blkg.
- Blocking
- Top of Floor
- Wall Height
- Opening

Image of a real-world application of the diagram showing a wooden framework with beams and supports.
SCL Stud Shear Walls

- **US Test Criteria**: AC 202 (ICC-ES)
- **Minimum nail spacing requirements to ensure ductile failure**
- **EWP industry has funded a test program with cyclic testing at FPInnovations via CCMC**
SCL Design Issues

Holes in SCL—Refer to Manufacturer’s Product Literature

NOTES
1. Square and rectangular holes are not permitted.
2. Round holes may be drilled or cut with a hole saw anywhere within the shaded area of the beam.
3. The horizontal distance between adjacent holes must be at least two times the size of the larger hole.
4. Do not drill more than three access holes in any four foot long section of beam.
5. The maximum round hole diameter permitted is:

<table>
<thead>
<tr>
<th>Beam Depth</th>
<th>Max. Hole Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 1/4&quot;</td>
<td>3/4&quot;</td>
</tr>
<tr>
<td>7 1/4&quot;</td>
<td>1&quot;</td>
</tr>
<tr>
<td>Greater than 7 1/4&quot;</td>
<td>2&quot;</td>
</tr>
</tbody>
</table>

6. These limitations apply to holes drilled for plumbing or wiring access only. The size and location of holes drilled for fasteners are under the regulations of the CSA O90-09 Engineering Design in Wood.
7. Beams deflect under load. Size holes to provide clearance where required.
8. This hole chart is valid for beams supporting uniform load only. For beams supporting concentrated loads or for beams with larger holes, contact Boise Cascade CEWP Engineering.
SCL Holes
SCL Fire Design

• SCL has the same char rate as timber & glulam

• Methodology prescribed in NBCC 2010 D-2.11.1 can be applied to SCL

• Simple design procedure based on NRC research, permits the designer to quickly calculate the endurance time of a wood member exposed to standard fire based upon:
  • the size of wood beam or column
  • percent of maximum allowable design load applied.

All Adhesives are Exterior Grade (water proof)

• Phenol Formaldehyde
  • Used in plywood for 60+ years
  • Heat or microwave cured
  • Insoluble after cured
  • Emissions are un-measurabale
  • Not Urea Formaldehyde (used in particleboard, emission problems in 1980’s)

• Isocyanate
  • High strength
  • Extremely useful for I-Joists (web to flange, web to web joints)
EWP Design Values

- ASTM - American Society For Testing and Materials, recognized in NBCC as non-Canadian accepted standard organization
- Consensus organization for the development of uniform testing of products.
- Members include industry, manufacturing, designers, scientists, code officials, etc.
- Committee D 07 covers wood products
EWP Design Values

- Wood I-Joists covered by ASTM D5055
- SCL covered by ASTM D 5456
  - Provides design and material considerations
  - Provides qualification requirements
  - Independent third-party inspection, in-house quality assurance, periodic re-evaluation.
EWP Design Values

- All design values are based on the lower 5th percent of the test results.
- Modulus of elasticity is based on the mean of test results.

Design values based on a factor of safety placed on the 95% tolerance limit with 75% confidence for a normal distribution.

5% of test values are below this point

95% of test values are above this point
Wood I-Joist Testing
One of 20+ possible shear/reaction failure modes
EWP Evaluation Reports

- Evaluation Services evaluate product based on testing standards provided by ASTM
  - Canada: CCMC
  - US: International Code Council (ICC)
- Some criteria is based on Wood I-Joist Manufacturers Association (WIJMA) guidelines.
- Evaluation Services evaluate products for conformance ASTM standards and building codes
EWP Evaluation Reports

CCMC Evaluation Reports

(appendix to the building code)

Evaluation Report
CCMC 13300-R

BCI® Joists

1. Opinion
It is the opinion of the Canadian Construction Materials Centre (CCMC) that "BCI® Joists" when used as joists in accordance with the conditions and limitations stated in Section 3 of this Report, complies with the National Building Code of Canada (NBC) 2005:

- Clause 1.2.1.1.1(a), Division A, as an acceptable solution (i.e. CAN/CSA-O86-01(S1-05)). "Engineering Design in Wood," for I-joint qualification) required by Division B in:
  - Sentence 4.3.1.1(1); and
- Clause 1.2.1.1.1(b), Division A, as an alternative solution (i.e. floor joists) that achieves at least the minimum level of performance required by Division B in the areas defined by the objectives and functional statements attributed to the following applicable acceptable solution:
  - Sentences 9.23.4.2.(2).

This opinion is based on CCMC’s evaluation of the technical evidence in Section 4.1 provided by the Report holder.

Ruling No. 09-03-201 (13300-R), authorizing the use of this product in Ontario, subject to the terms and conditions contained in the Ruling, was made by the Minister of Municipal Affairs and Housing on 04 March, 2009 (revised 05 May, 2009) pursuant to s.29 of the Building Code Act, 1992 (see Ruling for terms and conditions). This Ruling is subject to periodic revisions and updates.

2. Description
"BCI® Joists" is a prefabricated wood I-Joist available in ten series. Five series are manufactured with western species wood and five series are manufactured with southern species wood. The I-Joist is made from laminated veneer lumber (LVL) flanges with an oriented strandboard (OSB) web. The flanges are made from laminating veneers of Douglas fir, Southern Yellow Pine, Western Hemlock and Eucalyptus (see CCMC 12472-R). The top and bottom flanges are available in depths ranging from 35 mm to 38 mm and widths ranging from 35 mm to 89 mm. The web consists of 9.5-mm-thick OSB in 1.219-mm segments. The flange width, depth and grade are listed in Table 1.
**EWP Product Support**

- Manufacturers have product engineering support staff to consult
- Product Technical Notes available from manufacturers and testing agencies
- Product Warranties

---

**Lifetime Guaranteed Quality and Performance**

Boise Cascade warrants its BCI® Joists and Versa-Lam®
Products to comply with our specifications and to be free from
defects in materials and workmanship. Further, we guarantee that
these products, when correctly installed and used, will meet or
exceed our specifications for the life of the structure.
EWP Product Support

Product Literature

BCI® SPECIFIER GUIDE
ENGINEERED WOOD PRODUCTS
WESTERN CANADA

CCMC Report Number 13302-R

High Performance Floor & Roof Systems
EWP Product Repairs
EWP Product Repairs
EWP Product Repairs

- Consult manufacturer for repairs
- Testing conducted to verify common repairs
- Repair to restore original design values of undamaged joist
References: EWP Websites

- Canadian Wood Council: [www.cwc.ca](http://www.cwc.ca)
- Wood I-Joist Manufactures Association (WIJMA): [www.i-joist.org](http://www.i-joist.org)
- American Wood Council: [www.awc.org](http://www.awc.org)
- APA – Engineered Wood Association: [www.apawood.org](http://www.apawood.org)
- US Forest Products Laboratory: [www.fpl.fs.fed.us](http://www.fpl.fs.fed.us)
Thank you for your time today

Jeff Olson, P.E., P.Eng.
Boise Cascade - White City, OR
jeffolson@bc.com
Canadian Wood Council
G063
Engineered Wood Primer: EWP 101
CALWSF_05

Jeff Olson, P.E., P.Eng.
December 13, 2012
Credit(s) earned on completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

This course is registered with AIA CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.
This seminar will discuss the true performance of Engineered Wood Products (EWP) in terms of Fire performance, shrinkage and the lateral design of wall and floor systems.
Learning Objectives

At the end of this course, participants will be able to:

1. Participants will see test results on the performance of different Engineered Wood Products and their optimal use in various building applications.
2. Participants will learn about Fire Performance, Shrinkage, Lateral Design of wall and floor systems in regards to Engineered Wood Products
3. Participants will discuss the reliability and determination of Engineered Wood Products mechanical properties
4. Participants will be shown examples of how Engineered Wood Products can be incorporated into commercial and residential buildings that will meet building and fire codes.
This concludes The American Institute of Architects Continuing Education Systems Course

Canadian Wood Council
Wood WORKS! Alberta

www.cwc.ca
www.wood-works.org