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Engineered Strand Lumber (ESL)

Challenges and Opportunities

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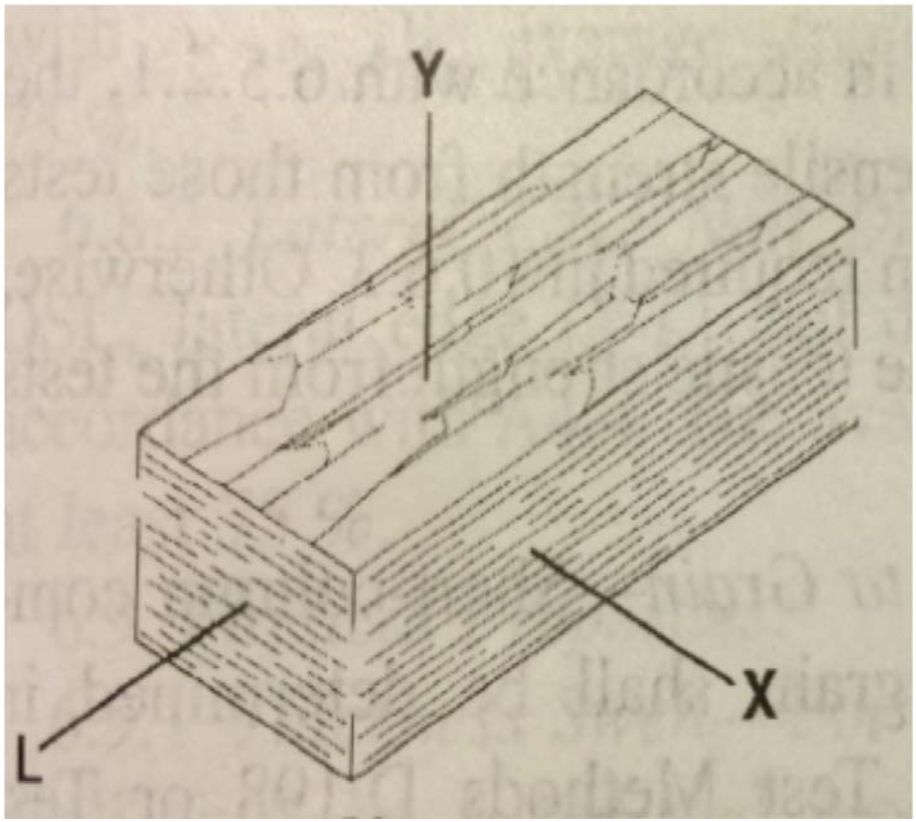
Anisotropic Materials



PSL
LSL
OSL

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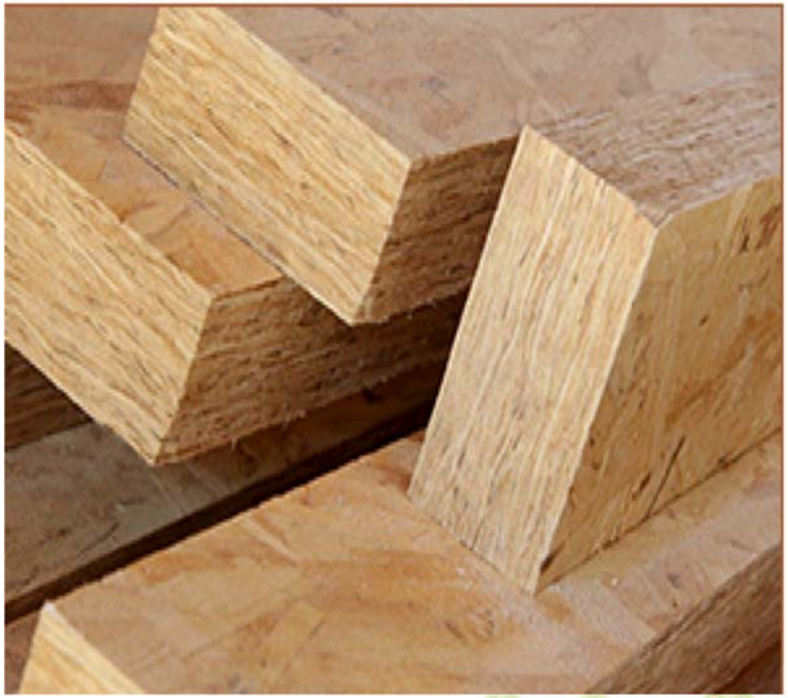
PSL vs. LSL

PSL

- Parallel strand lumber

LSL

- Laminated strand lumber



PSL vs. LSL

- PSL has
  - Higher MOE and MOR because it has
    - Smaller strand orientation angles
    - Higher strand length-to-strand thickness ratio
    - Higher strand quality
  - Higher production cost because veneer is more expensive than strands

PSL vs. LSL

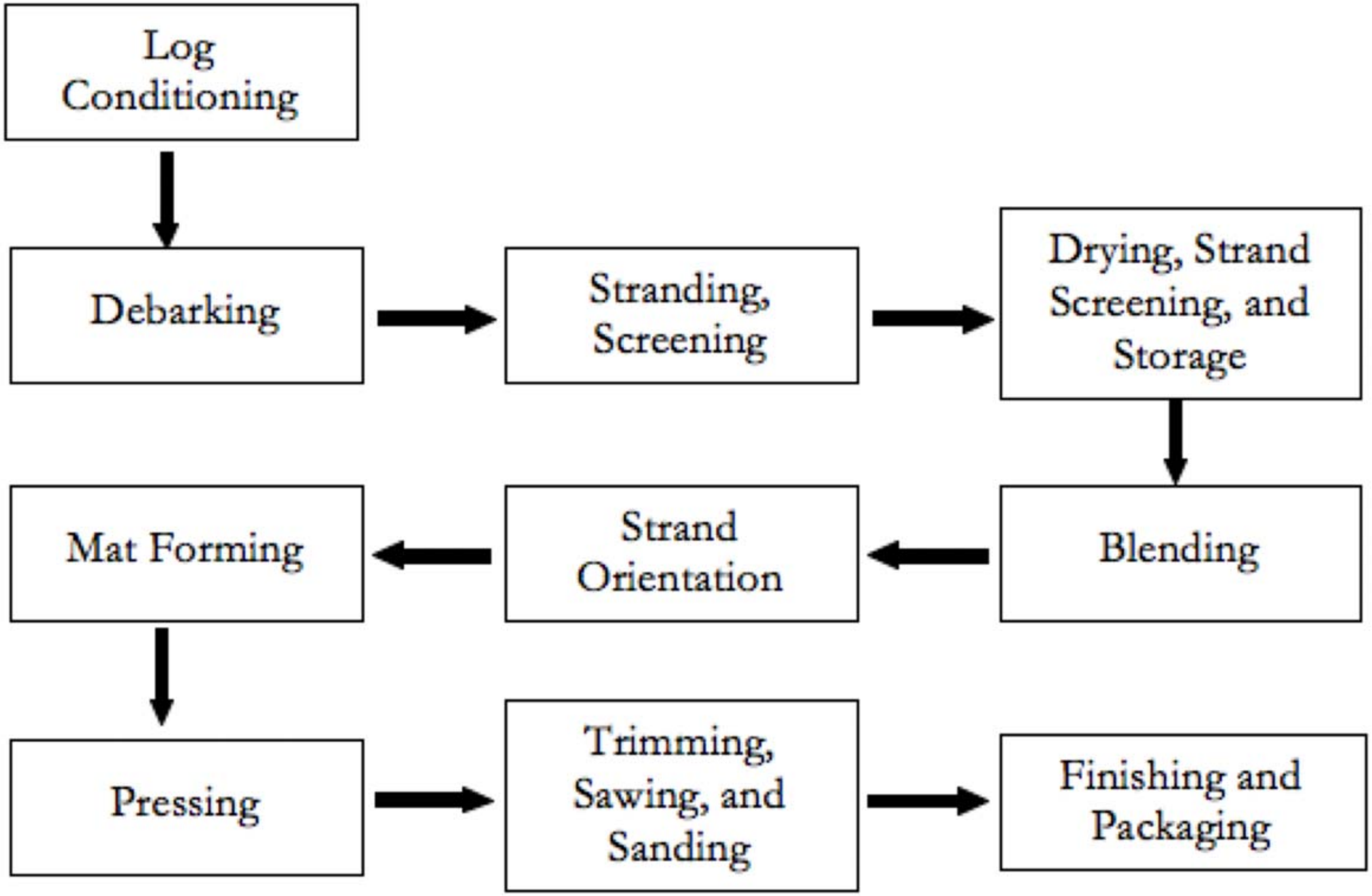
Both products have small market up to date because

- PSL is expensive and needs to stay in niche markets.
- LSL is a relatively lower quality structural composite lumber but has great potential to be substantially enhanced in terms of price and performance.

Main Driving forces for Development of LSL

- Making valuable large size products from small logs;
- Producing more reliable composite lumber with lower variation in properties (i.e., higher design values than sawn lumber).

Process of Making LSL



Criteria for Structural LSL

- High design value
  - High mechanical properties
  - Low variation in properties
- Durable
  - High bonding strength (dry and wet conditions)
  - High creep resistance

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What is the Best LSL

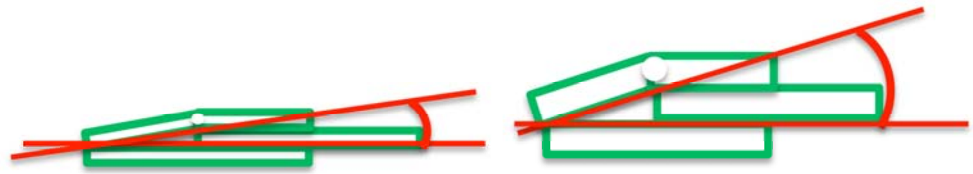
- It is the lowest cost product that can comply with the requirements for its applications.

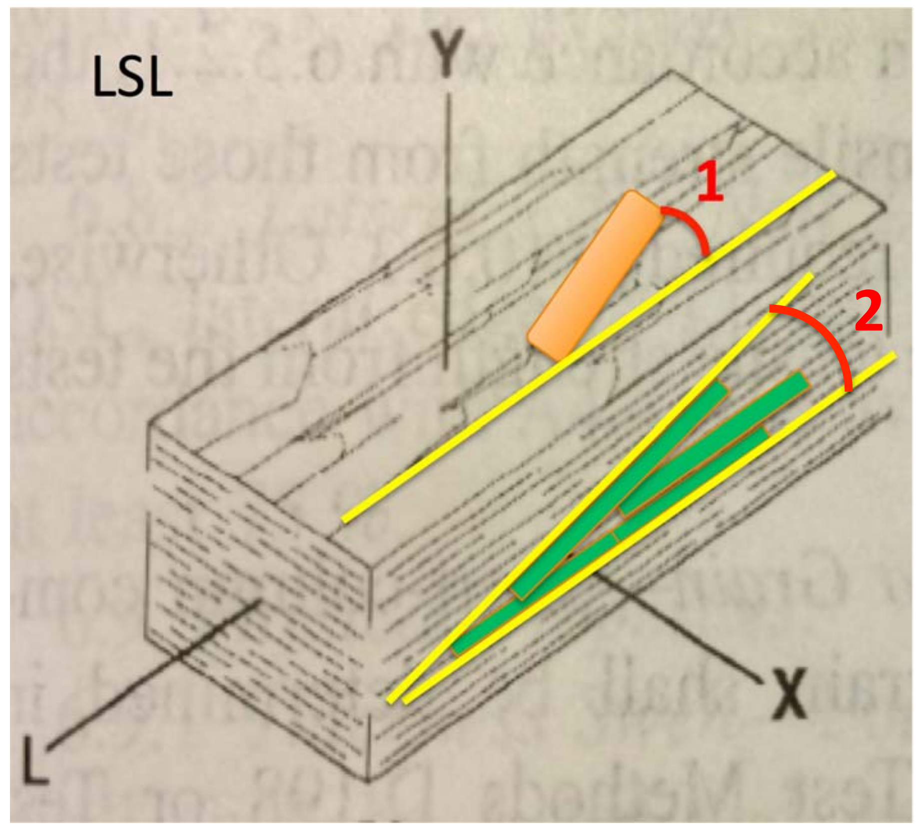
Predominant Variables Affecting MOE and MOR of LSL

- Strand orientation angles,
- Strand length-to-thickness ratio,
- Density and its vertical density profile,
- Resin content

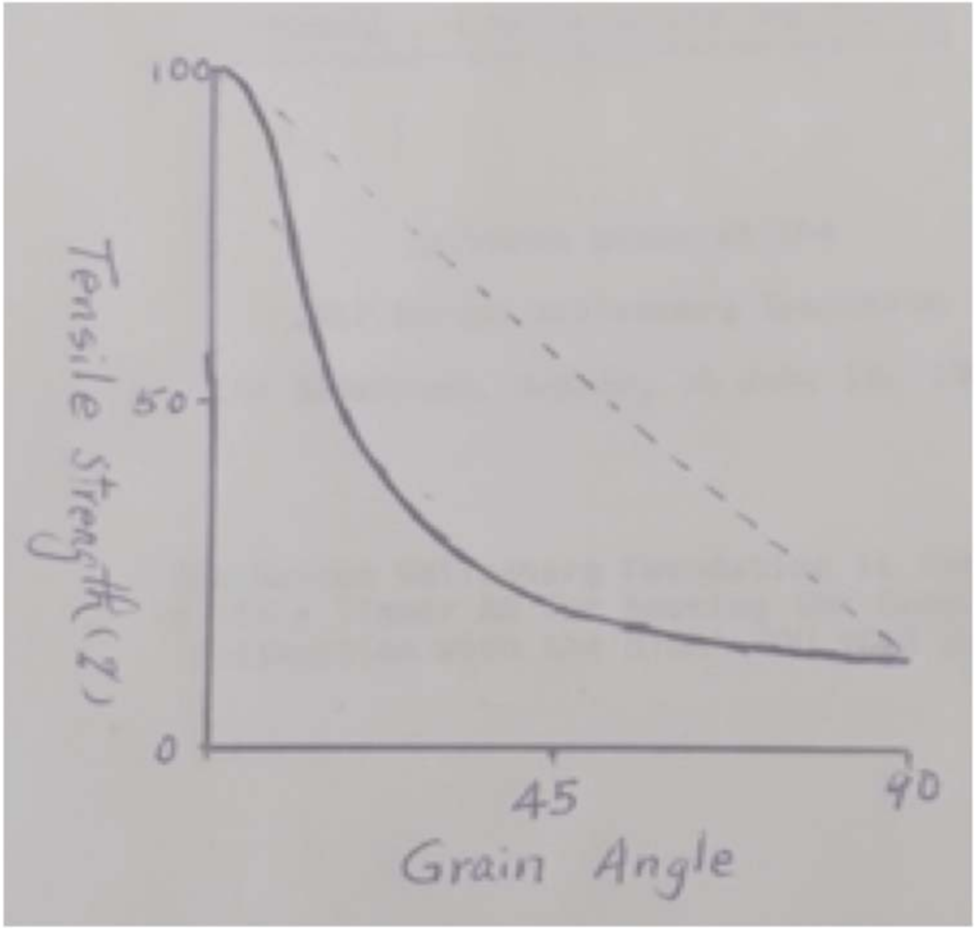
Strand Orientation Angles

- There are two different kinds of strand orientation angles.
  - ***Angle 1*** -- strand orientation angle in Y-plane in relation to longitudinal (L) axis
  - ***Angle 2*** -- strand bending angle in X-plane in relation to longitudinal (L) axis





Effect of Orientation Angle



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Grain angle in Thickness

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How to Achieve Small Strand Orientation Angles

- Reducing strand orientation angle 1 via selecting right orientators and setting them correctly:
  - High strand length-to-alignment gap ratio.
  - Short strand free-fall distance.
  - Minimum air turbulence in orientator area.
- Reducing strand orientation angle 2 via using thin strands. This could be essential to the development of high performance LSL.

Density and Vertical Density Profile

- Mechanic properties increase with increasing product density.
- Sharp vertical density provides higher flat-wise but lower edgewise bending properties.
- Uniform vertical density provide higher tension, compression and shear properties and equal bending properties in edgewise and flat-wise directions.

Strand length-to-thickness Ratio

- Minimum 150:1 by definition of ASTM, preferably 200:1 or higher.

Resin

- MOE and MOR increase as resin content is increased.
- Resin cost increases with increasing resin content.

How to Achieve High Performance LSL at Low Cost

To enhance mechanical properties

- Small strand orientation angles in length in both X- and Y-plane, i.e., small Angle 1 and angle 2;
- High strand length-to-thickness ratio;
- High bond strength: Sufficient resin content and density level.

How to Achieve High Performance LSL at Low Cost

To lower production cost

- High conversion ratio of LSL/wood (log) input by volume.
- High production throughput.

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Key Guideline of Making LSL Up to Date

- A consensus in the industry and academia -- long strands will provide small strand orientation angle and thus achieving high specific MPE and MOR.
- Unfortunately, this guideline has been proved not able to provide small strand orientation angles up to date.

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Assessment of Using Long Strands

- Not practicable to align long strands to yield small strand orientation Angle 1 due to slow alignment speed.
- Necessary to use relatively thick strands when long strands are used. Otherwise, long and thin strands are hard to be kept straight and processed. As a result, Angle 2 is large.

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Assessment of Using Long Strands

- Difficult to make uniform product because fewer strands are used to make unit product;
- As a result, the current LSL needs to be re-engineered so that high performance, low cost LSL can be produced.

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Challenges and Opportunities

- Re-engineer LSL to increase market share via:
  - Increasing the quality of LSL enough to compete with LVL for many applications via enhancing strand orientation;
  - Reducing production cost so it can compete with sawn lumber in price, yet have more predictable performance.

Unorthodox Approach

- Since the use of long strands could not meet the expectation of making low cost, high performance LSL, we cannot expect a substantial improvement for the current LSL made of long strands without drastic changes in design and setup of former and strand orientator.

Unorthodox Approach

- It is time to think approaches, e.g.,
  - Using shorter and thinner strands than those used in the current LSL manufacturing;
  - Improving current strand orientator or developing better strand orientators.

Why Use Shorter Strands

- It is feasible to align relatively short strands and reduce the free-fall distance of the aligned strands to provide small strand orientation Angle 1 at a reasonable fast alignment speed.
- It is possible to use thin strands to reduce the strand bending Angle 2.

Why Use Shorter Strands

- Relatively shorter and thinner strands provide higher number of strands per unit product and reduce the variability of LSL.
- Increase the yield of usable strands.

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Same Strand length-to-Alignment Gap

	Longer Strands	Shorter Strands
Alignment Speed	Slower (-)	Faster (+)
Angle 1	=	=
Achievable Angle 1	Larger (-)	Smaller (+)
Use of Thinner Strands	More Difficult (-)	Easier (+)
Achievable Angle 2	Larger (-)	Smaller (+)
Product Variation	Higher (-)	Lower (+)
Product/Log by volume	Lower (-)	Higher (+)

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Summary

- Relatively shorter strands have more advantages over longer strands for making LSL.
- As long as the strand orientation angles in length are small and the ratio of strand length to thickness is high, higher performance LSL can be made from short strand than from long strands at lower cost.

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