

Effect of Molecular Weight on Bonding Performance for Liquid Phenolic Resins

Guangbo He⁺ and Ning Yan

Faculty of Forestry, University of Toronto, Toronto, Ontario, Canada

⁺ *Wood Composites, Forintek Canada Corp., Vancouver, BC, Canada*



OUTLINE

- Background
- Objectives
- Materials and experimental methods
- Results and discussion
- Conclusions
- Acknowledgement

BACKGROUND

- **An existed weak boundary layer on wood surface, which reduces the bond strength in the wood composites.**
- **Wood is a porous material, which allows resin penetration into wood when bonded with an adhesive.**

BACKGROUND

- Flowability and wettability of resin significantly affect the bond properties
- Appropriate penetration of resin enforces the weak boundary layers
- Molecular weight and the distribution — affect the flowability and penetration of the resin into the wood surface
- Wood species may also affect resin penetration and curing and ultimately bond strength

OBJECTIVES

- To investigate the effect of molecular weight on the curing process and bonding performance associated with various wood species.
- To compare the dynamic mechanical results with static mechanical results.

MATERIALS AND EXPERIMENTAL

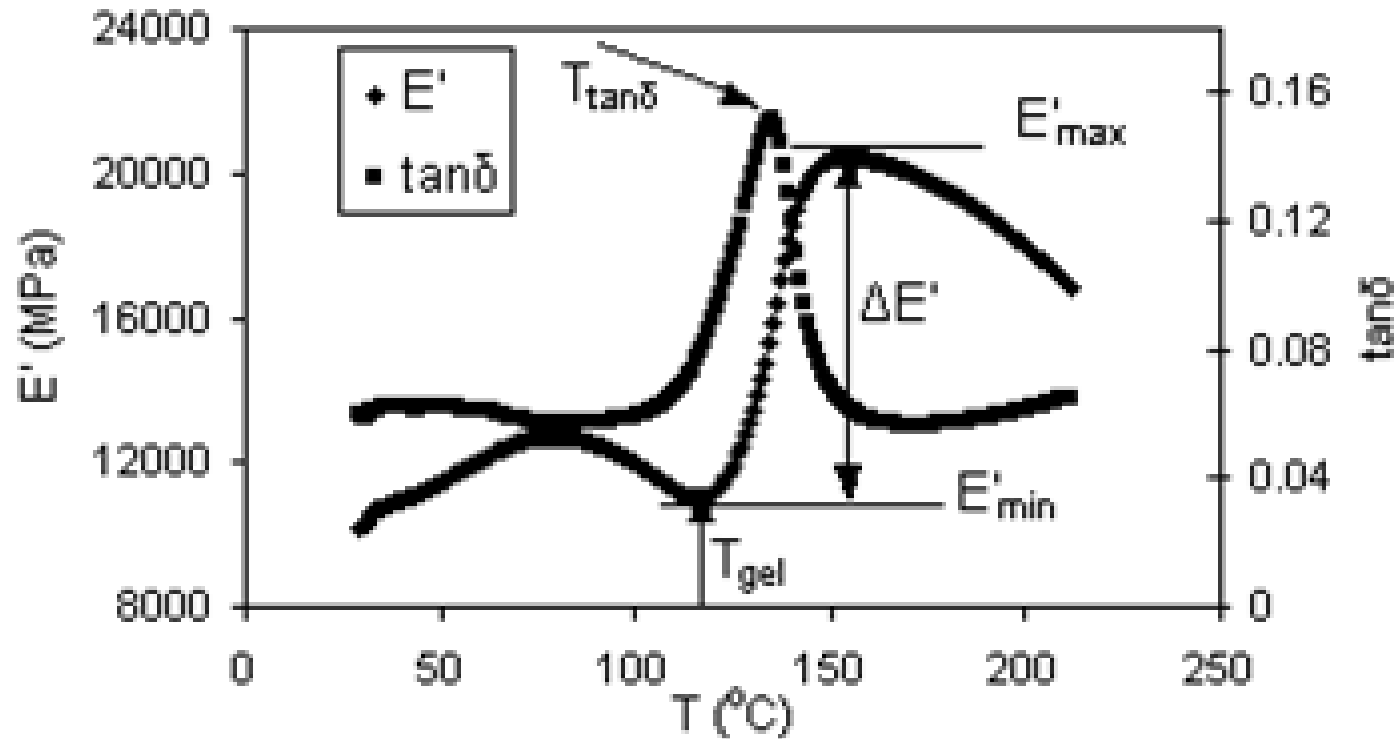
Materials

- Lab synthesized HMPF (high M) and LMPF (low M). The mixtures of HMPF/LMPF (H/L) with different ratios were used in the experiments.
- Veneers and flakes were commercial products: Aspen, red pine, southern yellow pine (SYP), white birch.

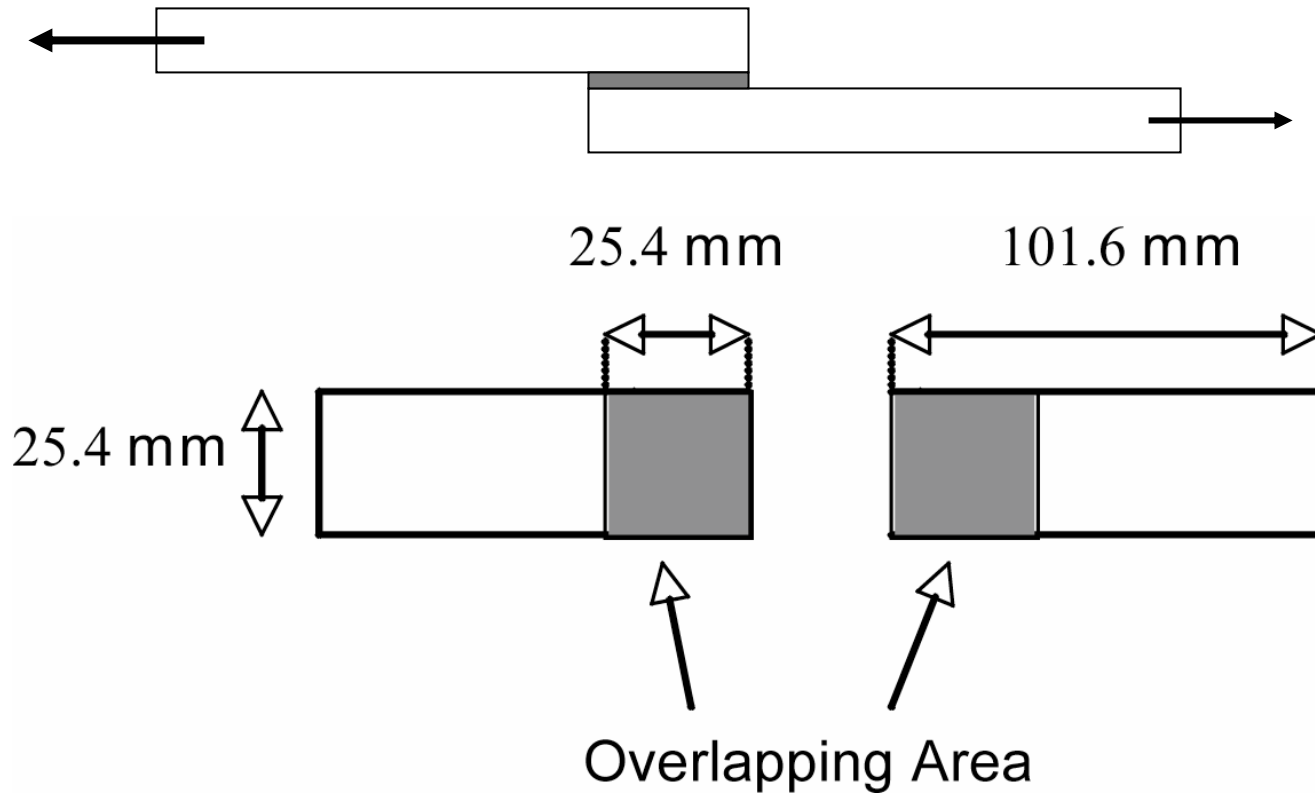
Molecular weight and properties of the synthesized phenolic resins

Resins	Mn	Mw	Ip	pH	Solid content (%)
LMPF	212	303	1.42	10.89	47.5
HMPF	821	1657	2.02	11.14	50.9

Dynamic mechanical analysis (DMA)



Lap-shear test



Hot-press time: 180 s

Hot-press temperature: 180 °C

Lab OSB panel making and test

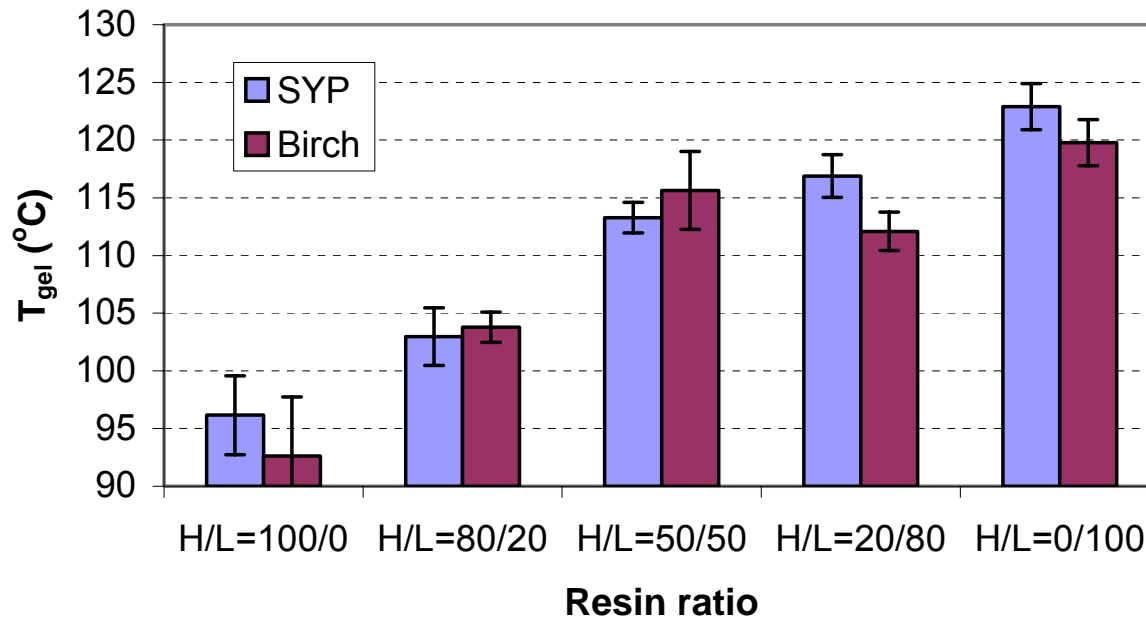
PANEL DIMENSION	10.2 MM × 320 MM × 320 MM
Panel structure	Random/one layer
Target density	706 kg/m ³
Strand MC	Approximately 5%
Closing time	35 seconds
Decompress time	40 seconds
Total pressing time	315 seconds
Temperature	215 °C
Resin content	6% (solid) based on strands weight
Wax content	1% (solid) based on strands weight

Tests for mechanical properties in accordance with ASTM D1037-99.

RESULTS AND DISCUSSION

- Dynamic mechanical analysis (DMA): Gel point and storage modulus development during curing.
- Lap-shear test: shear stress for bonded pairs of wood veneers with cured PF.
- IB strength and flexural tests for wood panels.

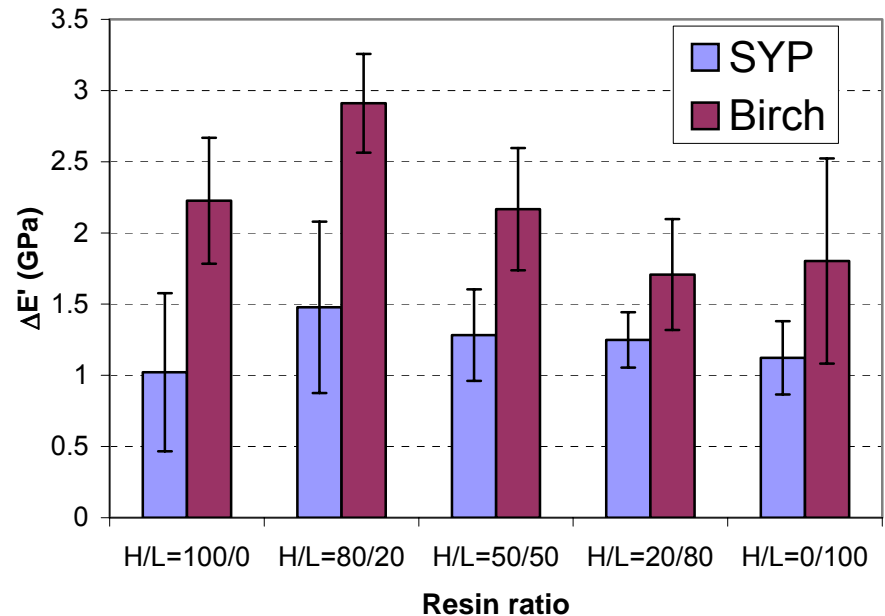
Variation of gel point with different molecular weight



- **Effect of MW was significant**
- **Small variation observed for different wood species**

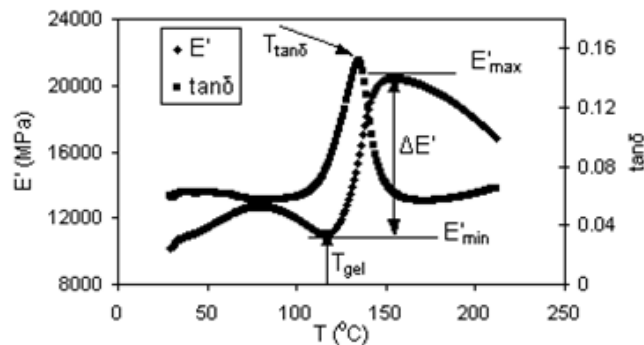
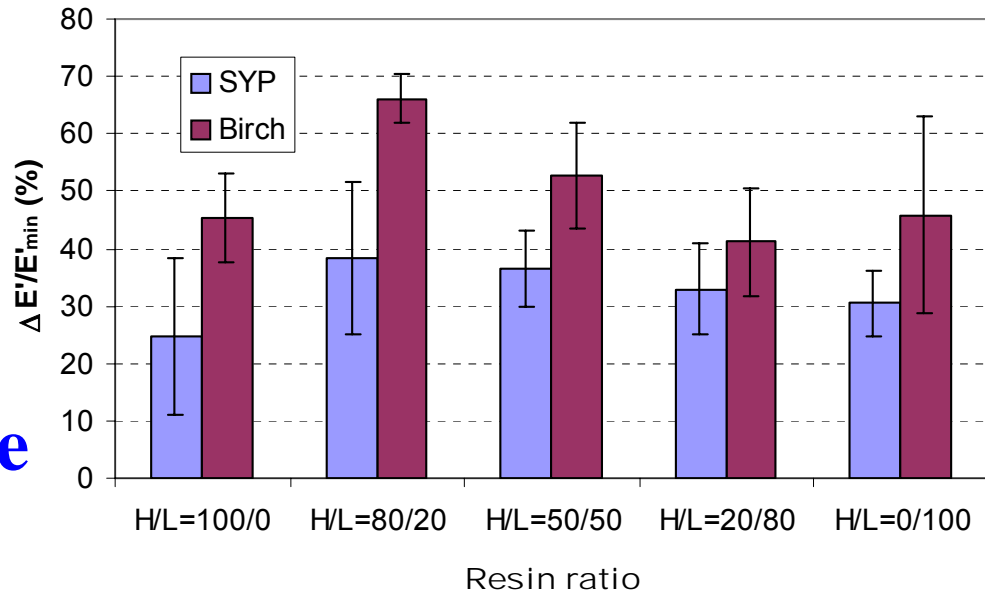
Storage modulus difference ($\Delta E'$)

- $\Delta E'$ increased first and then decreased with resin ratio (MW) for birch.
- $\Delta E'$ was different for different wood species.

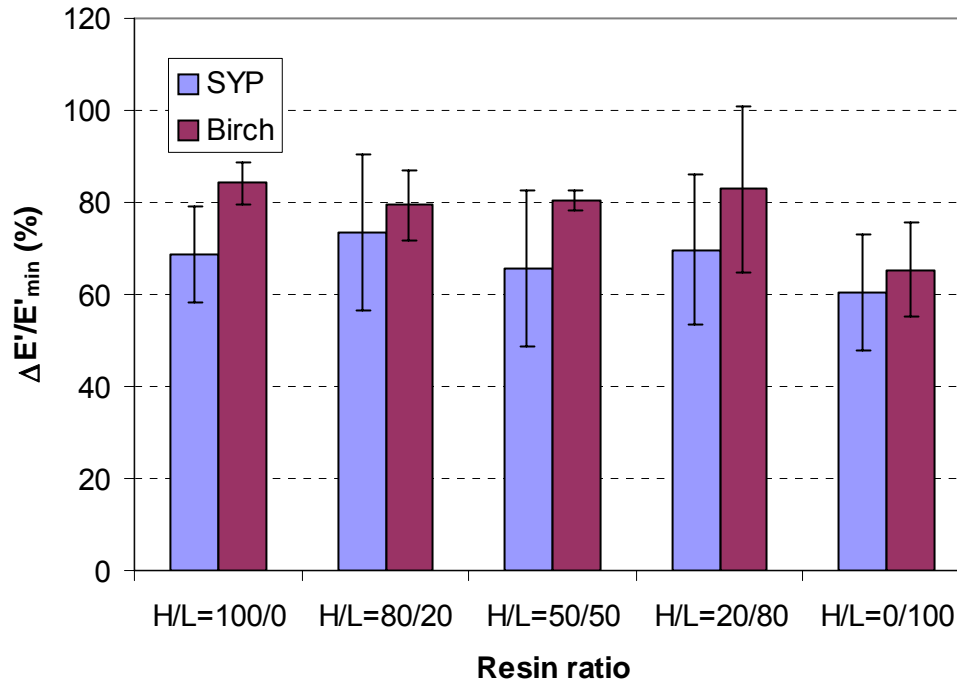


Relative modulus difference $\Delta E' / E'_{\min}$

- When the effect of minimum storage modulus was considered, the same trend as $\Delta E'$ was obtained.

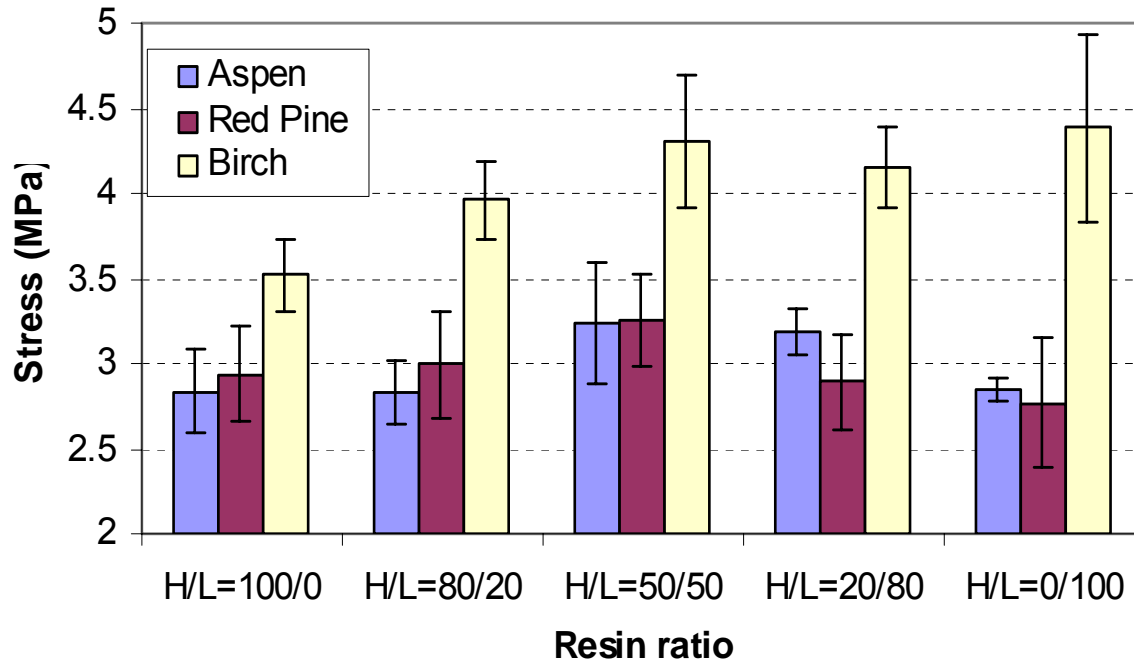


Relative storage modulus difference for high resin loading



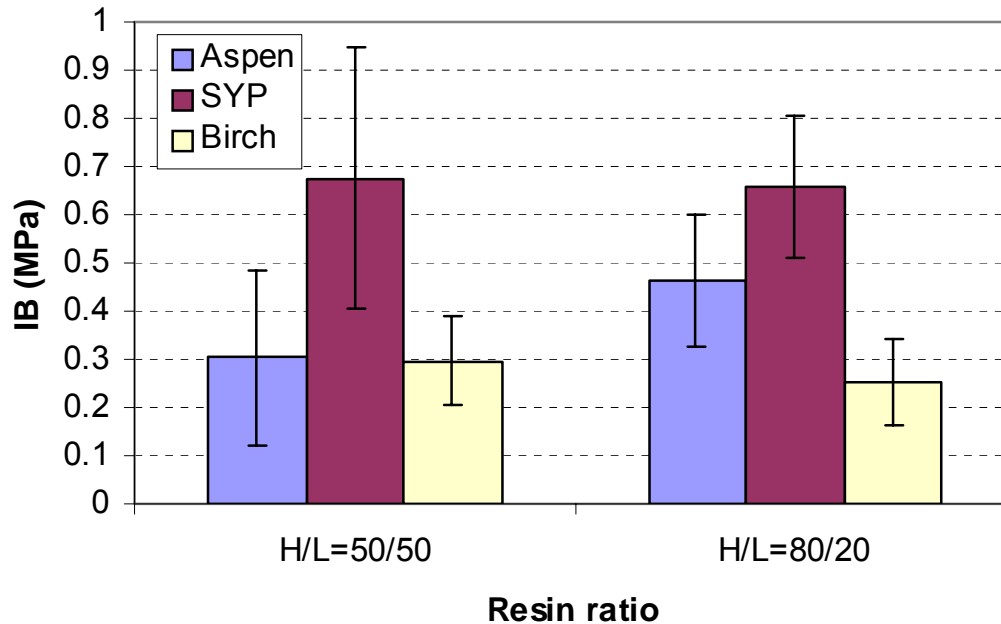
- The MW had no effect when the amount of resin loading was doubled.

Lap-shear test results



- The stress for birch was much higher than for aspen and red pine due to higher bulk density.

IB strength for OSB panels

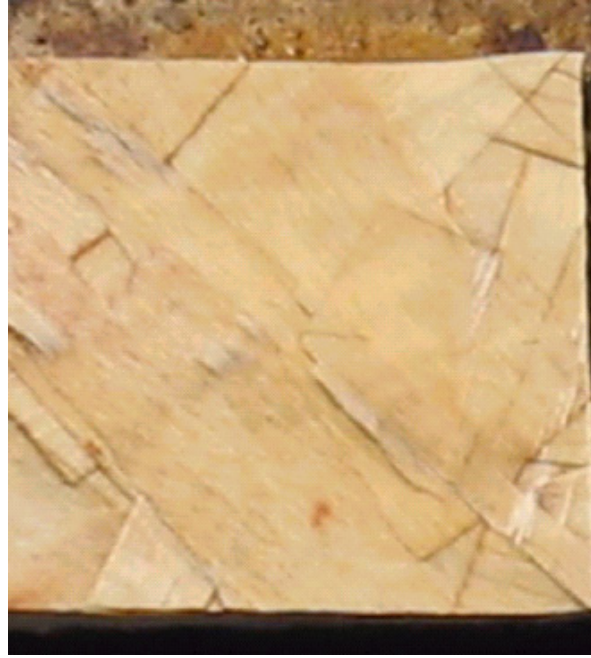


- MW had no effect except for aspen
- IB varies with species due to different compression ratios (same target density)

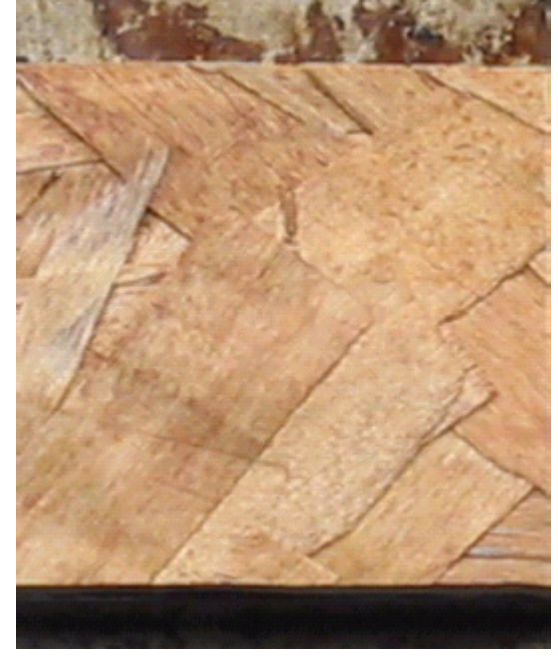
Broken interface of IB test



SYP



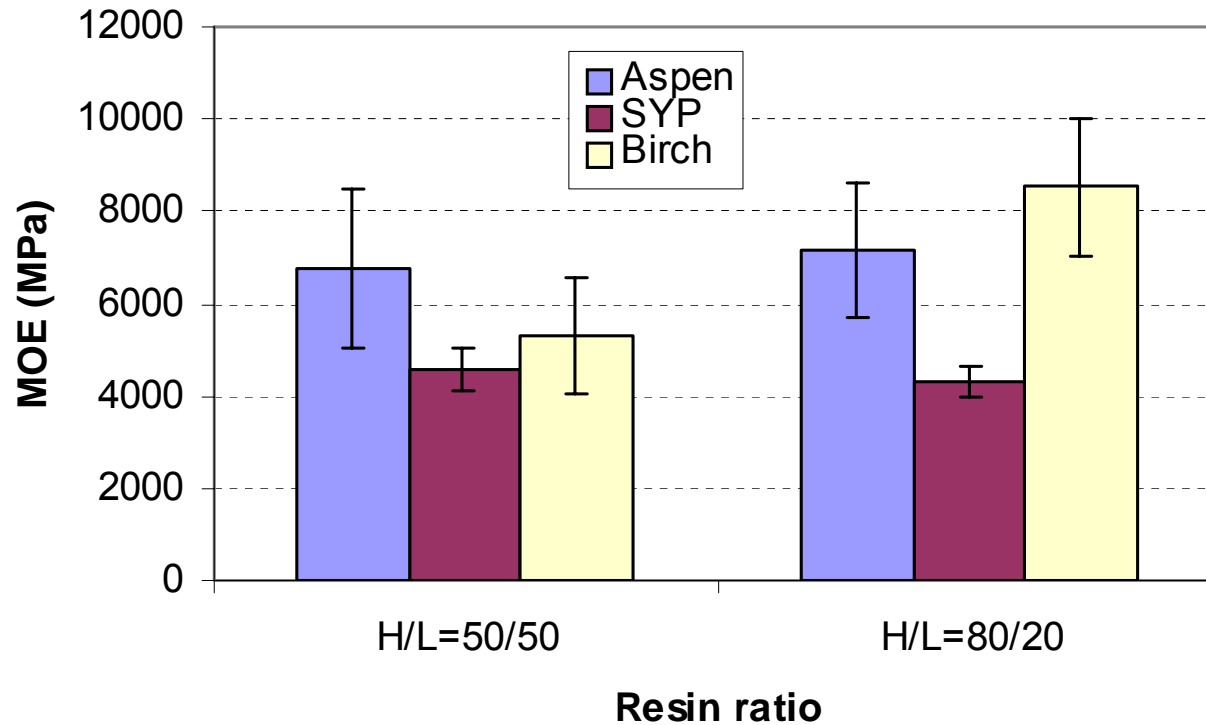
Aspen



Birch

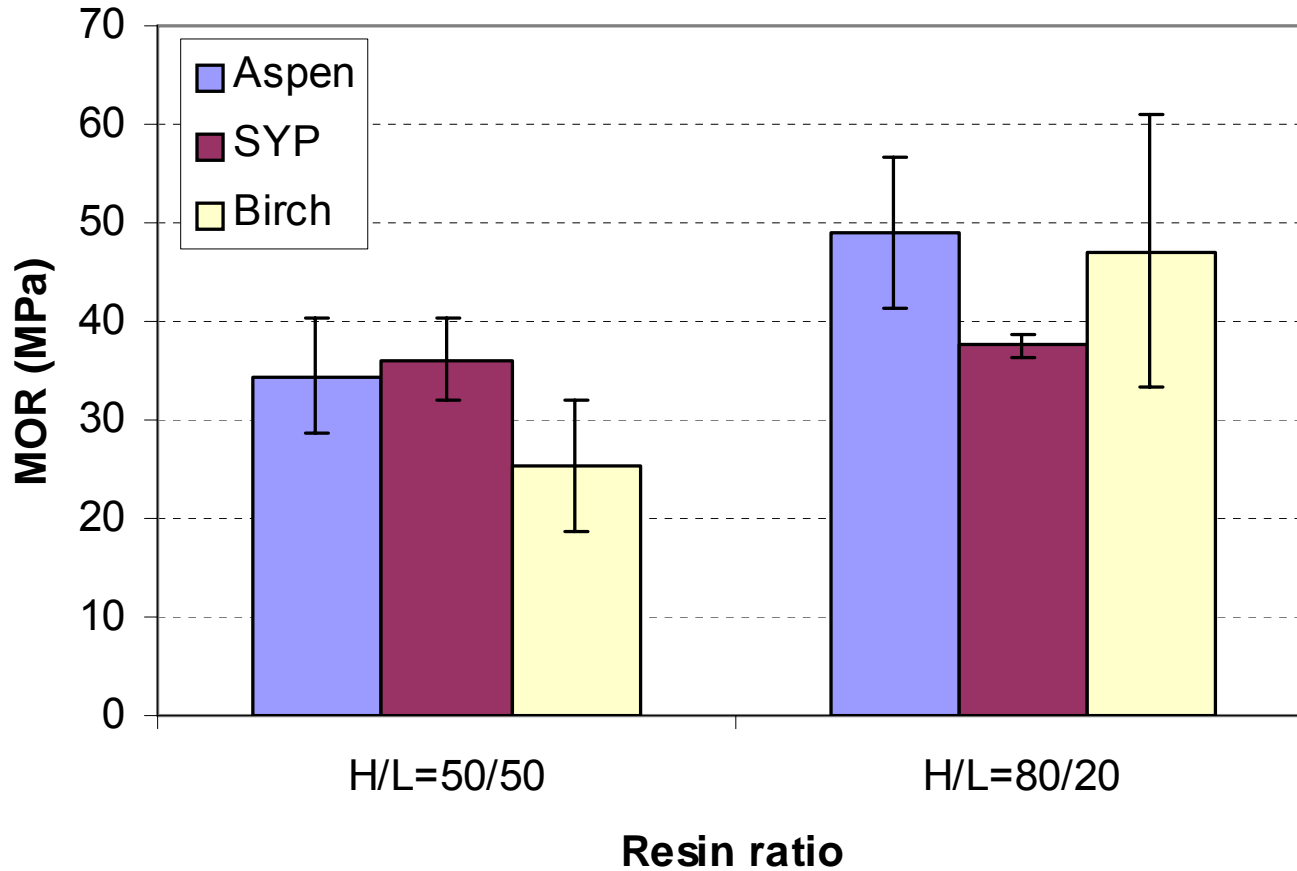
- **Wood breakage for SYP was evident. This might result in the higher IB for SYP than for aspen and birch.**

MOE for OSB panels



•MOE has a different trend from IB

MOR for OSB panels



CONCLUSIONS

- **Molecular weight of liquid phenolic resins has significant influence on the curing rate.**
- **A resin that contained both high molecular weight and low molecular weight fractions showed the best bonding performance. This requirement may vary with different wood species.**
- **Wood species had significant influence on the mechanical properties of OSB panel. More research is needed for verifying the effect of molecular weight on the bonding performance in the manufacturing of OSB panel.**

ACKNOWLEDGEMENT

- **Value to Wood Program, CFS, NRCan for financial support.**
- **Esther Huh, a summer student and Jeffrey Chan, a undergraduate student for part of the experiments.**