OSB from Small-Diameter Southern Pine Trees – Strand Property & Effect of Fines

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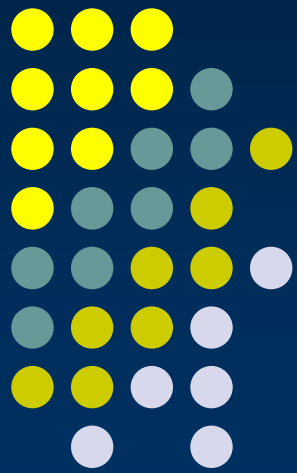
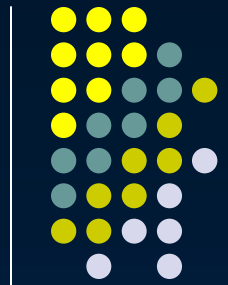


Outline



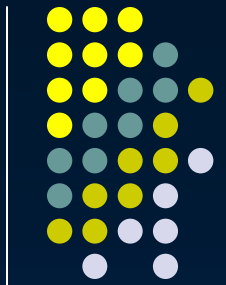
- Background, objective and scope
- Material Selection/Preparation
- Strand Properties
- Panel Properties
- Conclusions

Small-Diameter Logs for OSB

Using Small-Diameter Logs for OSB

- Adding values to plantation forests
- Juvenile wood with low strength and large swelling potential
- Flaking process leading to large percentage of fines
- This study was aimed at providing a better understanding of the properties of small-diameter southern pine materials and their use for strand-based composite manufacturing.

Scope of the Work

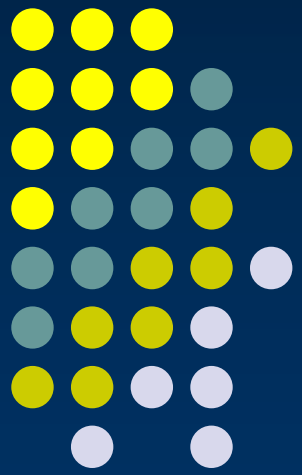


To investigate strand properties including tensile strength, dynamic modulus, and thermal stability and;

To evaluate panel performance of OSB from small-diameter southern pine logs as influenced by fines contents.

Material Selection

Small-diameter Trees



Wood Composite Sample Preparation

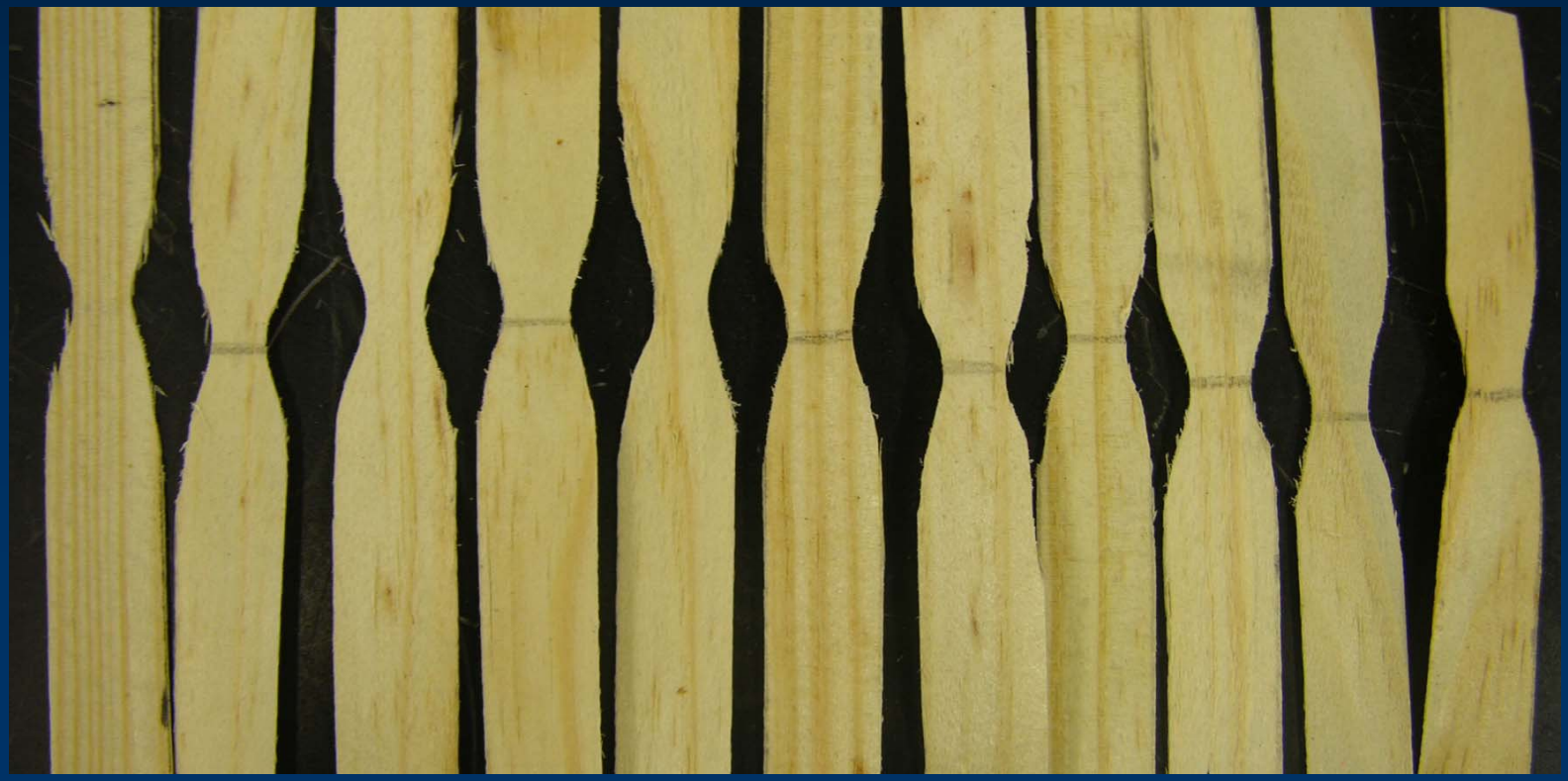
Small-diameter southern pine (*Pinus spp*.) logs (7-15 cm) were obtained from a local chip mill in southern Louisiana.

15x0.1-cm flakes with random width

Log Flaking

Strand Testing

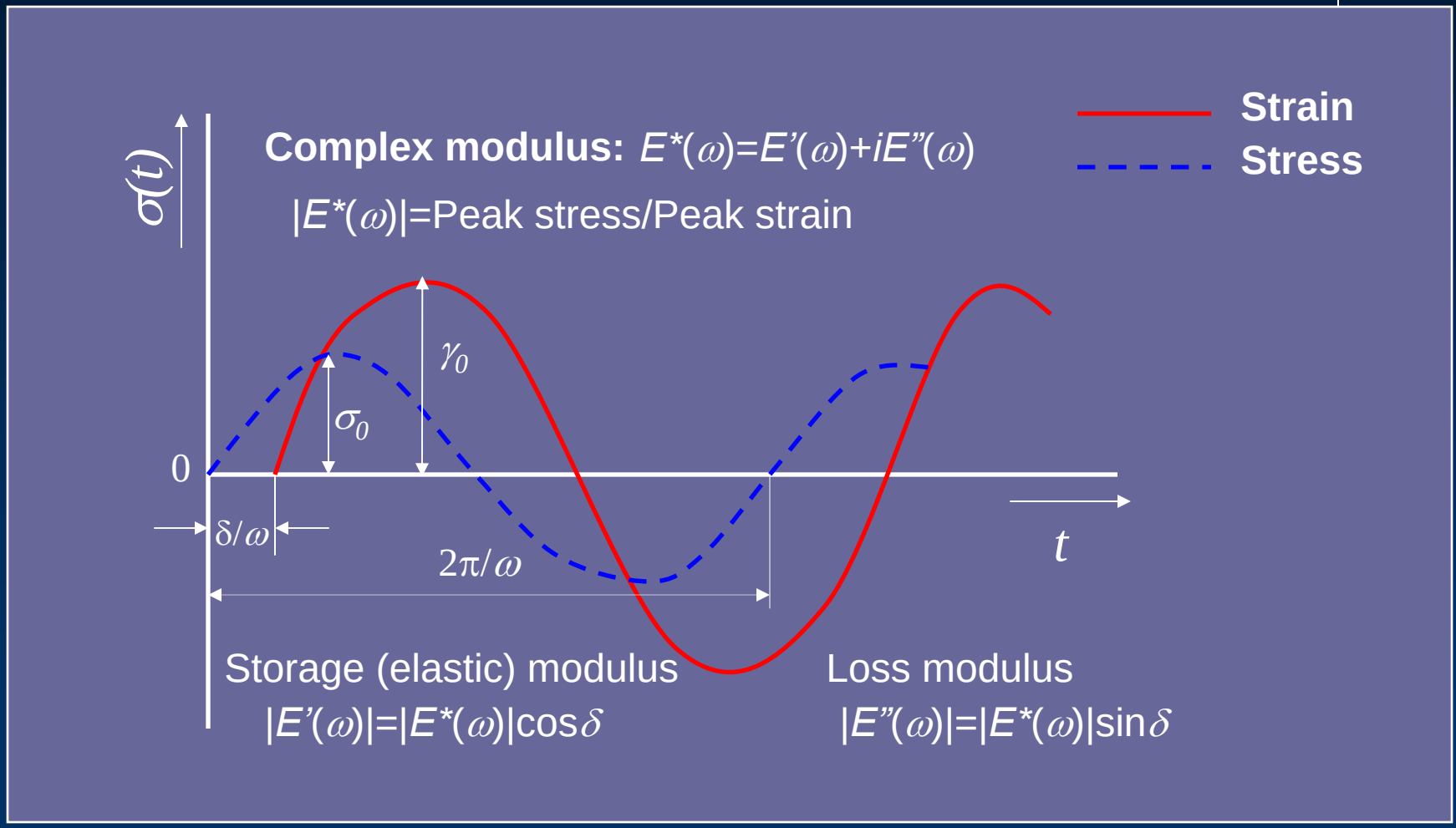
Sixty specimens of 40×10×0.5-1.0 mm for each material type were prepared. They were separated into four groups according to strand density (i.e., A: $<$ 0.41; B: 0.41-0.50; C: 0.51-0.60; D: $>$ 0.60 g/cm^3).



Strand Testing

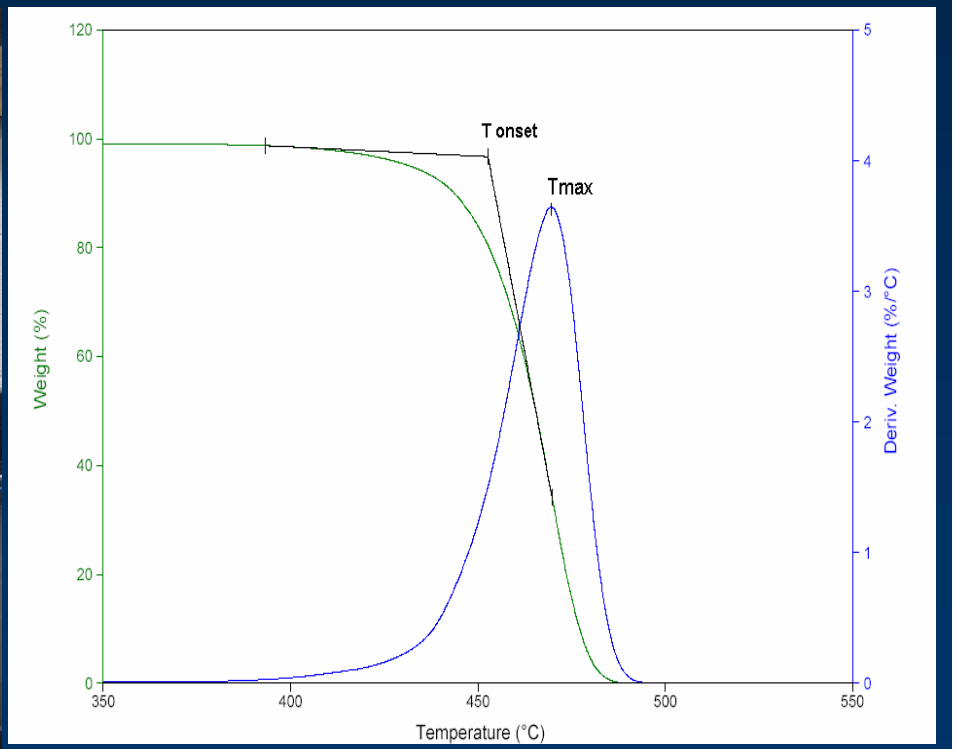
Dynamic mechanical analysis (TA Q-800) - Test runs were made in bending at a constant temperature of 25^{o}C and a varying temperature from 25^{o}C to 200^{o}C with a heating rate of 2^{o}C/min using 1 Hz frequency.

Strand Testing

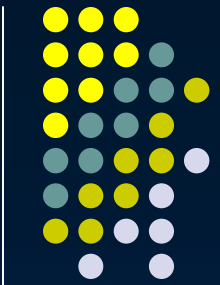


Strand Testing

Thermogravimetric analysis (TA Q-50 TGA) - Each test was run under a nitrogen atmosphere at a heating rate of 20°C /min over a temperature range of 50 to 500°C. Extrapolated onset temperature, maximum weight loss temperature, and residual weight for each sample were recorded.



Panel Fabrication/Testing



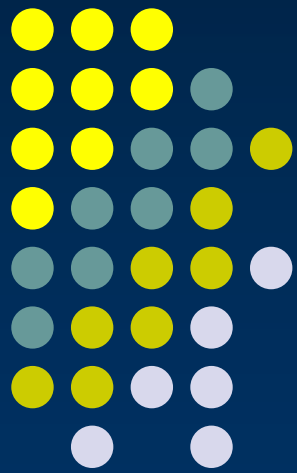
- Three-layer boards were made with large flakes in the face layer and varied amount of fines uniformly distributed in the core layer. The fines contents in the core layer were 0, 10, 20, 30, and 45% based on the total flake weight in the panel.
- All three-layer panels (570 × 500 × 12 mm) were constructed with a face and core flake weight ratio (i.e., shelling ratio) of 55 to 45.
- The PF resin and wax were applied to the strands at 4% and 1% loading levels, respectively, based on the oven-dry weight of the strands.
- The formed mats were loaded into the press and hot-pressed to the target thickness at a temperature of 190^{o}C for 4 min.

Fines used to simulate industrial OSB process

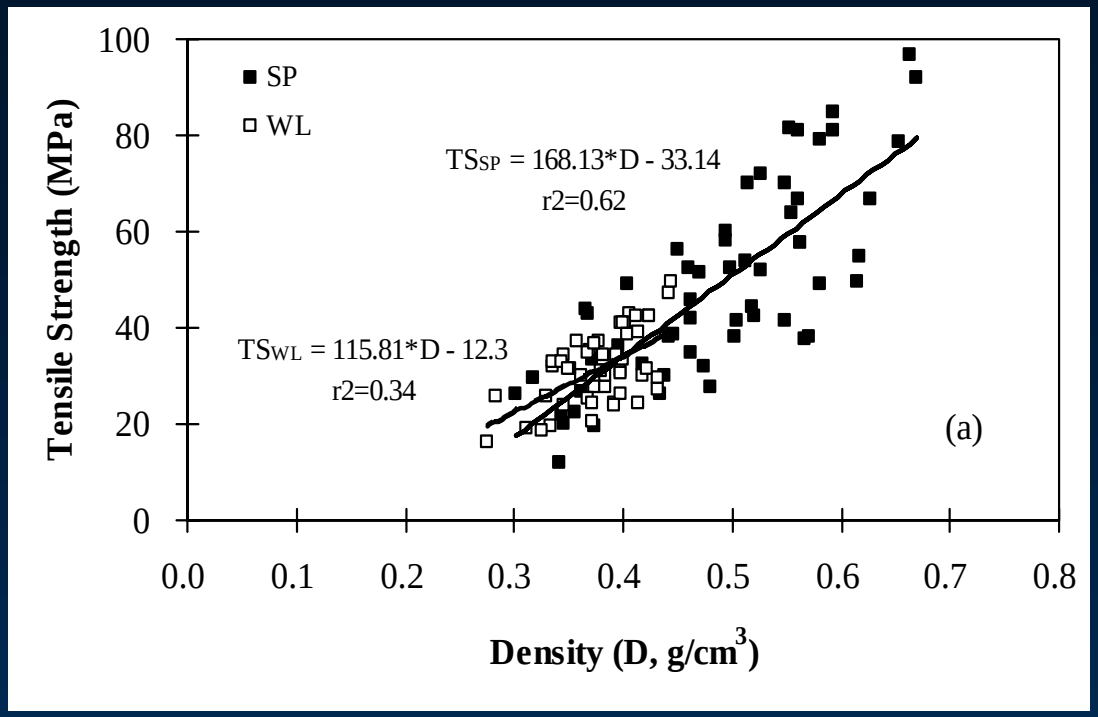
Board Forming

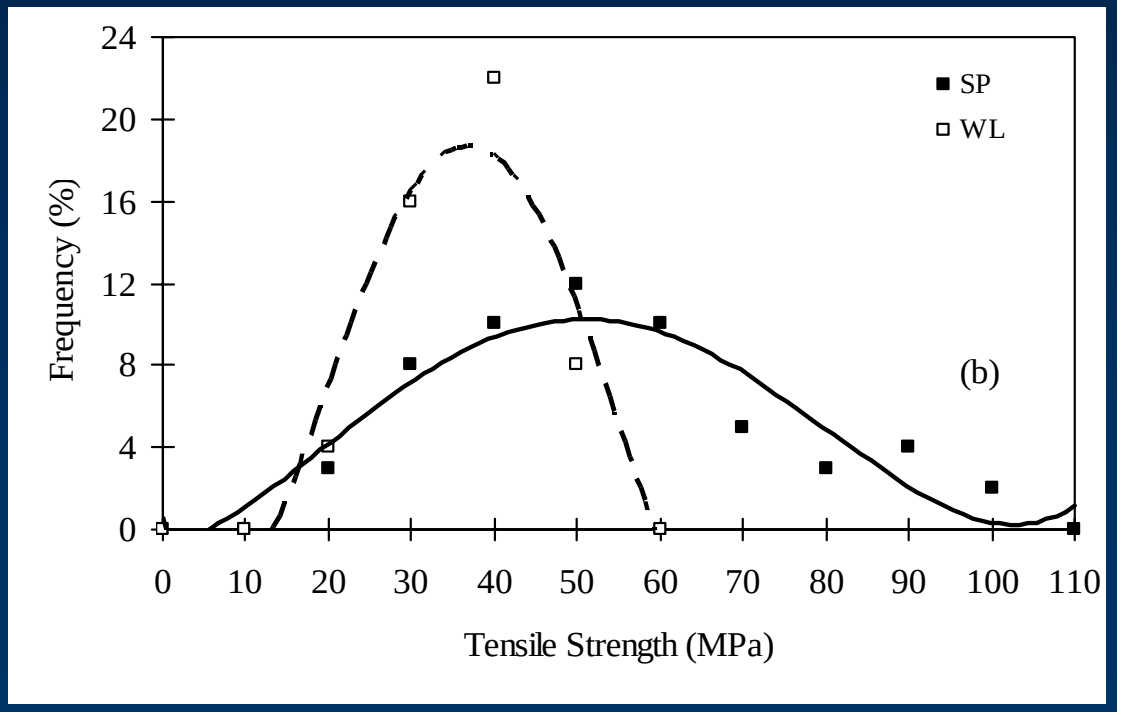
Strand Properties

Small-diameter trees

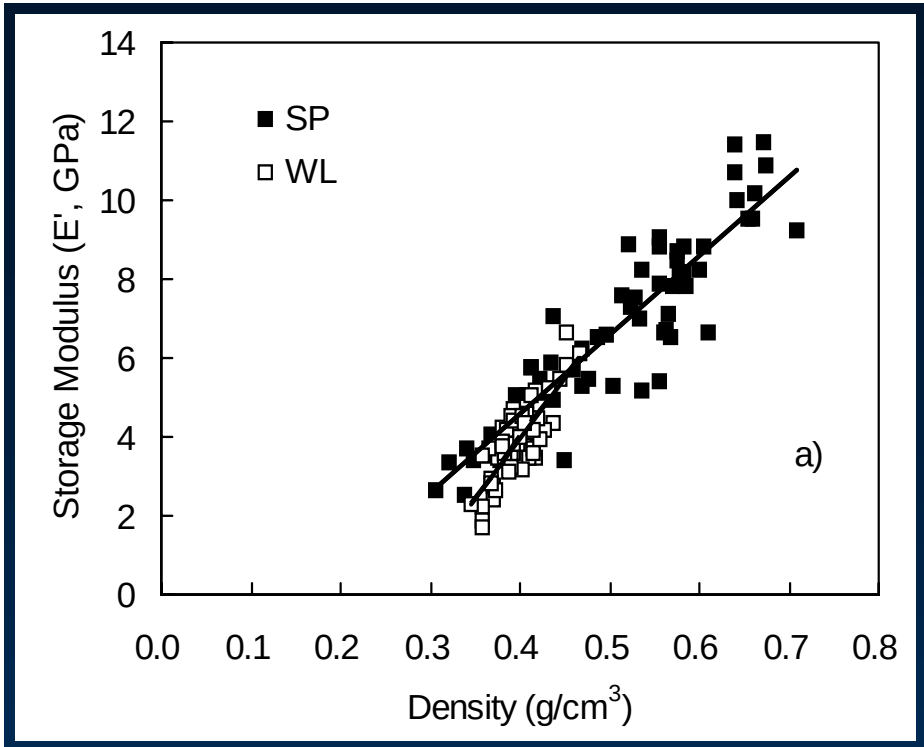


Tensile Strength





Dynamic Modulus



$E'_{SP} = 20.182*\rho - 3.506 \quad r^2 = 0.82$

$E'_{WL} = 30.176*\rho - 8.078 \quad r^2 = 0.66$

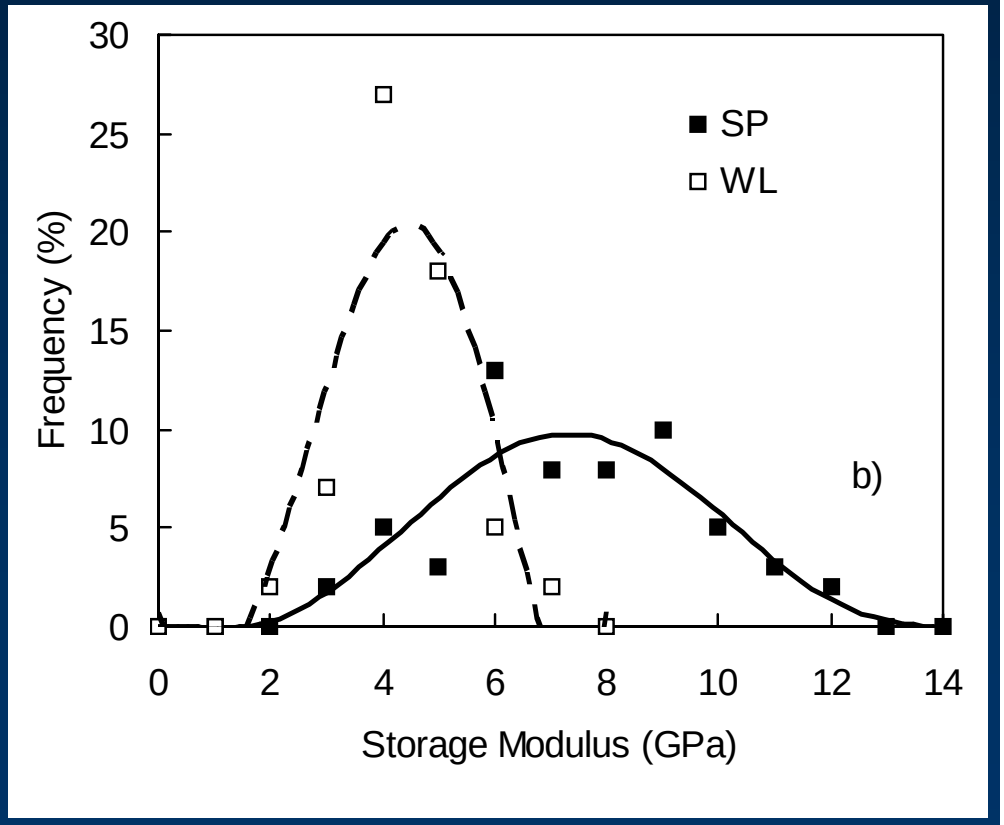
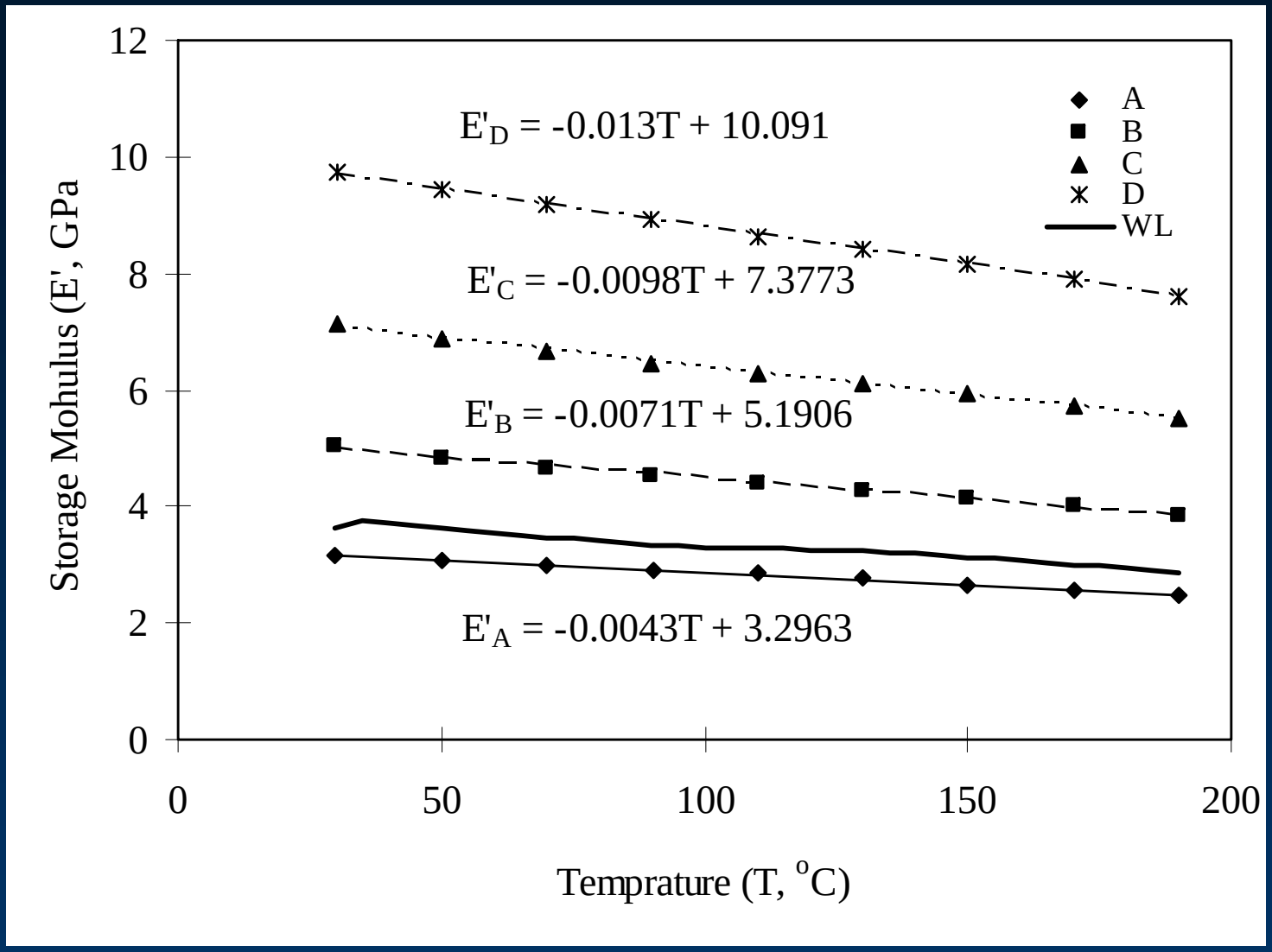


Table 1. Summary of DMA results [a].

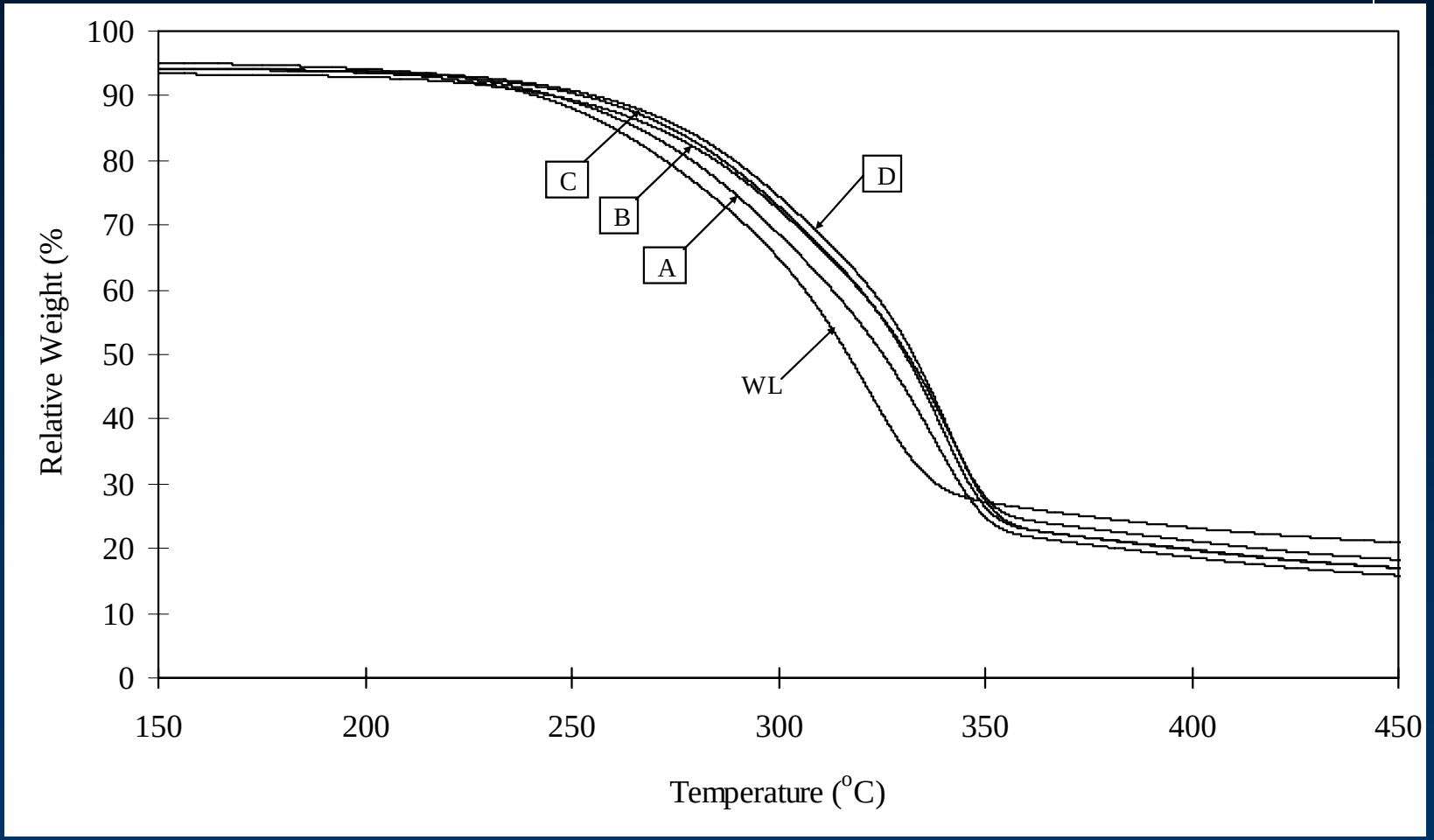
Material type	Density Group [b] (g/cm^3)	Specimen		Storage modulus (GPa)	Loss modulus (GPa)	tanδ
		Width (mm)	Thickness (mm)			
Southern Pine	A	8.26(0.26)	0.69(0.16)	3.53(0.74)	0.089(0.01)	0.026(0.01)
	B	8.66(0.53)	0.67(0.09)	5.69(0.81)	0.161(0.05)	0.028(0.01)
	C	9.34(0.57)	0.63(0.07)	7.23(1.26)	0.192(0.06)	0.027(0.01)
	D	9.00(0.55)	0.59(0.12)	10.00(1.48)	0.242(0.05)	0.025(0.01)
Willow	0.40 (0.03)c	9.41(0.18)	0.80(0.04)	3.91(0.94)	0.115(0.06)	0.030(0.01)

[a] The results given as averages and standard deviations (in parentheses).
[b] Density group (g/cm^3): A: < 0.41; B: 0.41-0.50; C: 0.51-0.60; D: > 0.60.
[c] The density of willow is treated as a group.



For every 10 degree of temperature increase,
E'_A, E'_B, E'_C, and E'_D decreased by about 40, 70, 100, and 130 MPa, respectively.

TGA Data



Density group (g/cm³): A: < 0.41; B: 0.41-0.50; C: 0.51-0.60; D: > 0.60.

Table 2. Summary of TGA results.

Material type	Density Group [b] (g/cm^3)	Initial weight loss temp (^oC)	Extrapolated onset temp[a] (^oC)	Maximum weight loss temp (^oC)	Residual weight (%)
Southern Pine	A	188	286	350	14.44
	B	191	298	353	15.52
	C	196	299	356	15.57
	D	206	303	361	16.69
Willow	0.40[c]	182	273	340	19.40

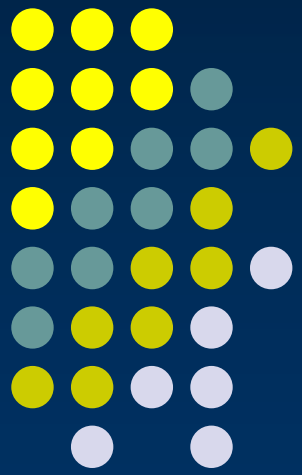
[a] Extrapolated onset

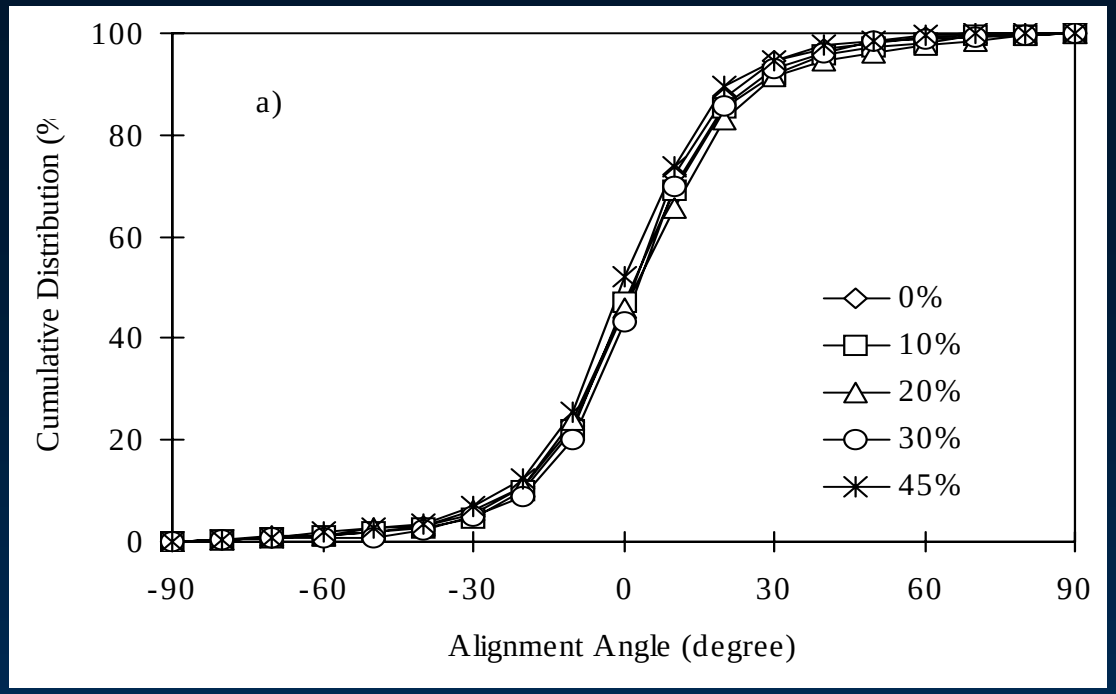
[b] Density group (g/cm^3): A: $<$ 0.41; B: 0.41-0.50; C: 0.51-0.60; D: $>$ 0.60.

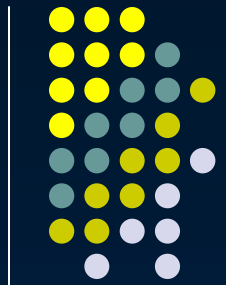
[c] The density of willow is treated as a group.

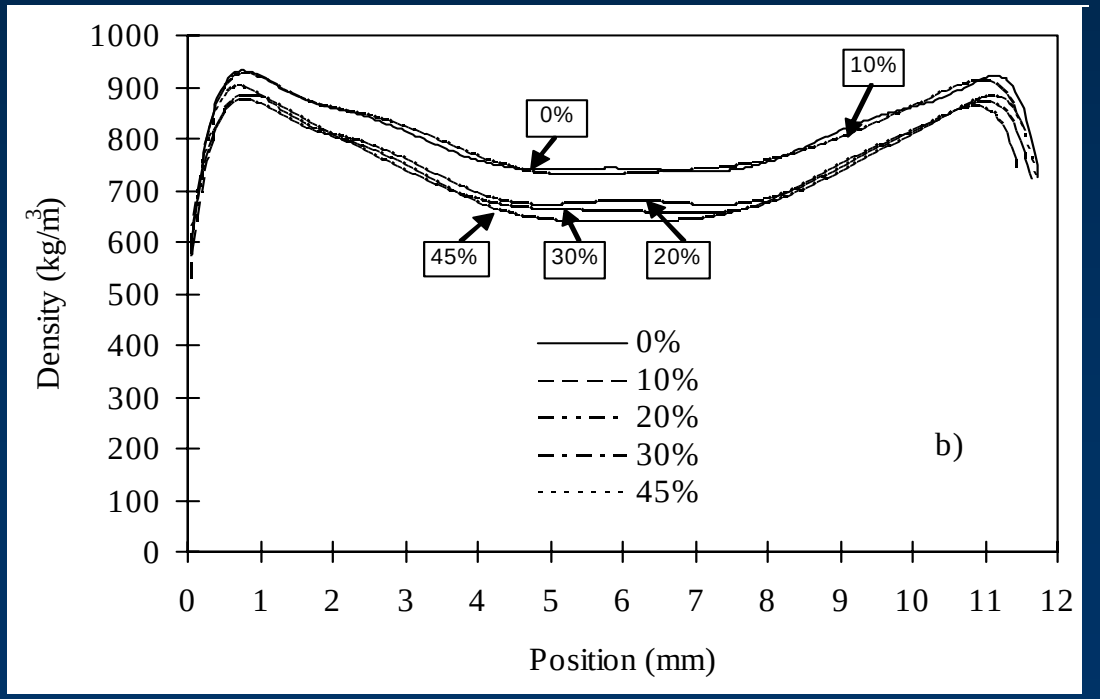
Panel Properties

Small-diameter trees

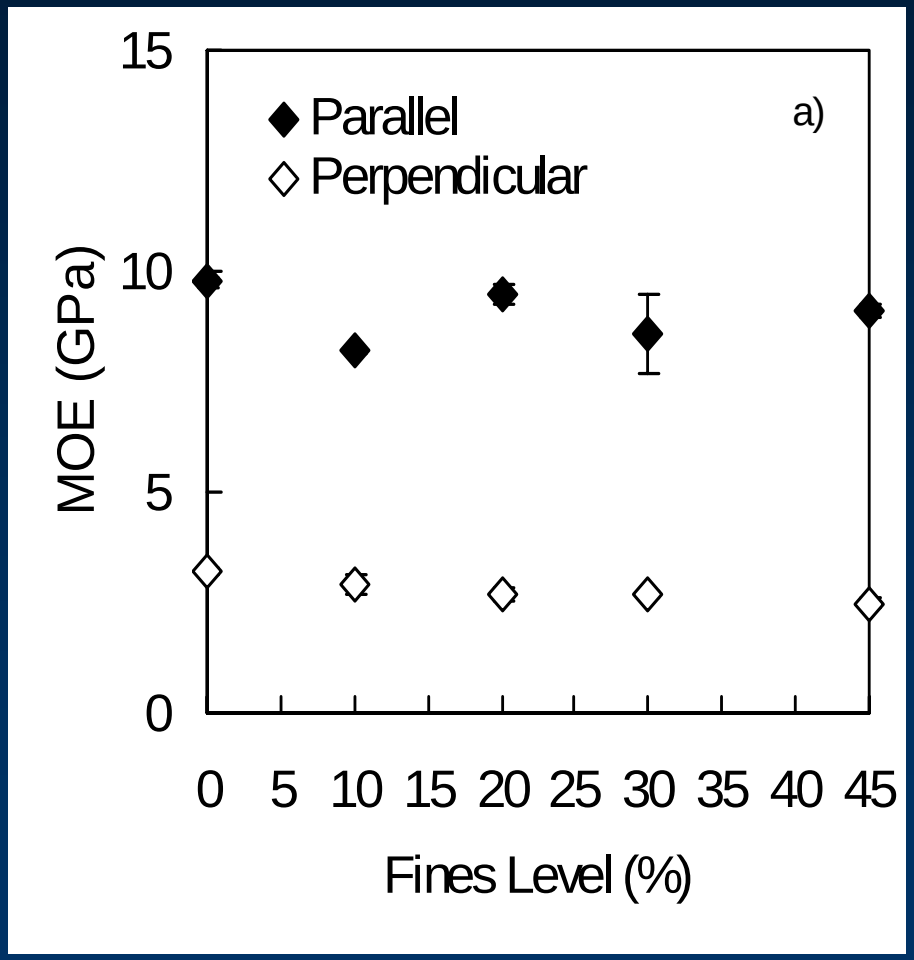


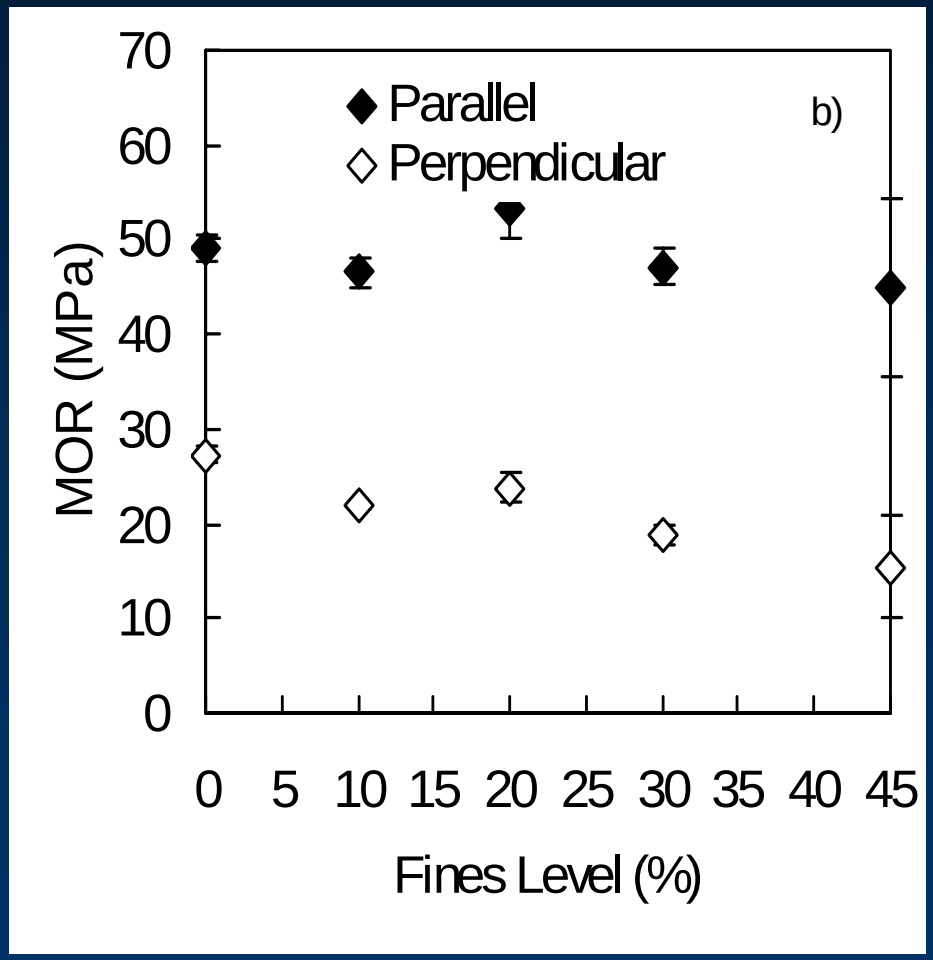

a)
Cumulative Distribution (%
100
80
60
40
20
0
-90
-60
-30
0
30
60
90
Alignment Angle (degree)
0%
10%
20%
30%
45%



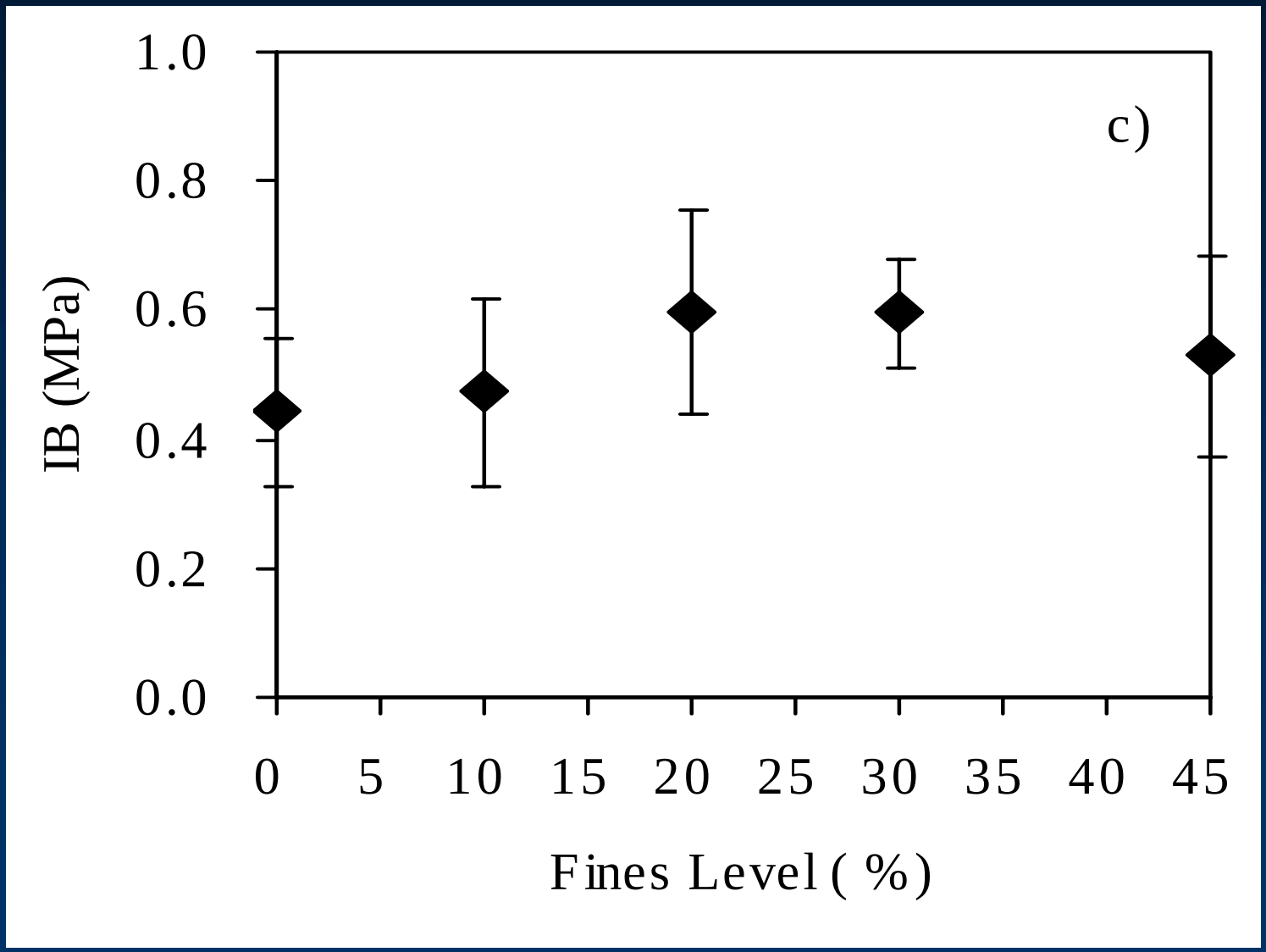

Density (kg/m3)
1000
900
800
700
600
500
400
300
200
100
0
0
1
2
3
4
5
6
7
8
9
10
11
12
Position (mm)
0%
10%
20%
30%
45%
b)

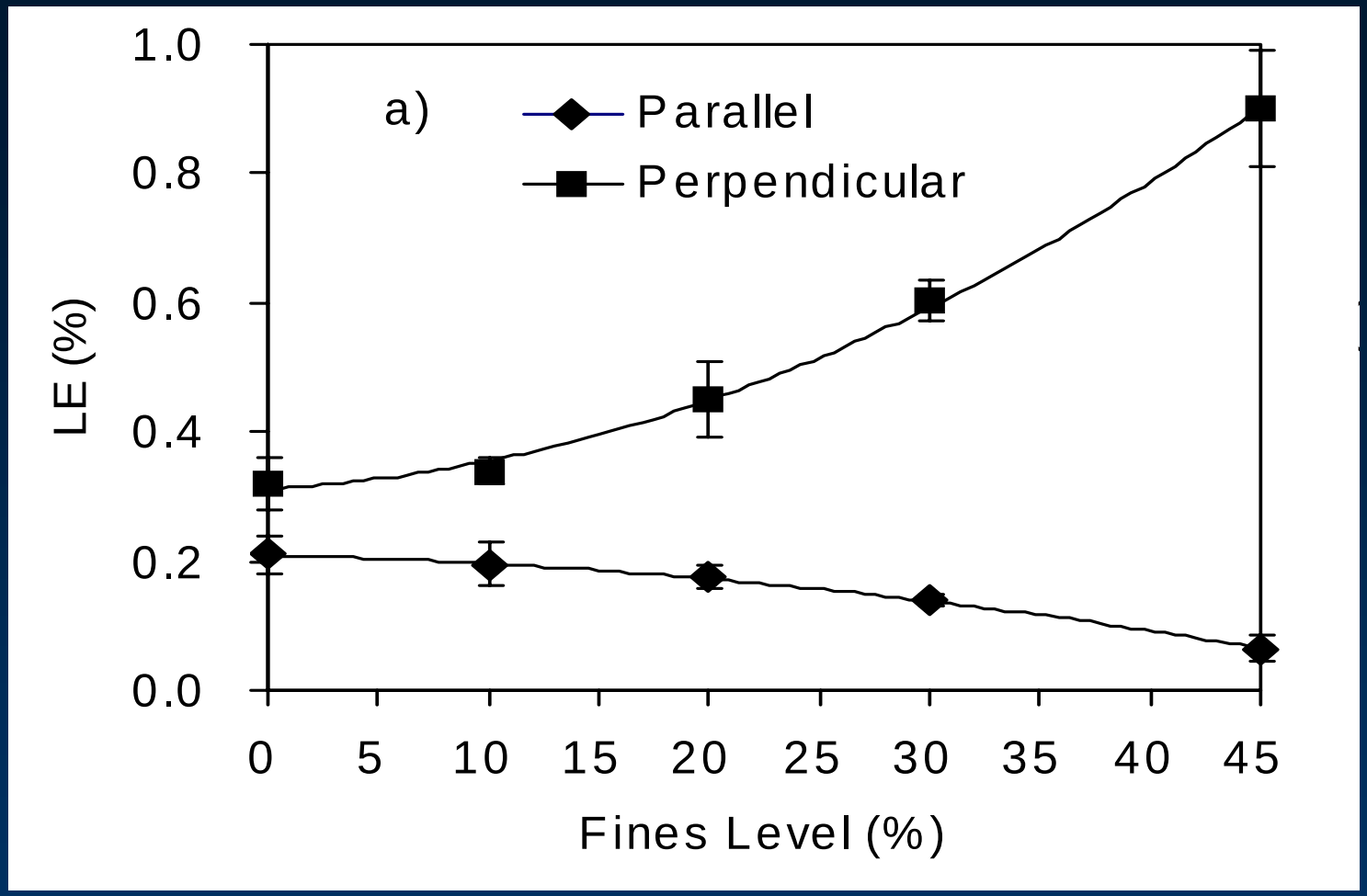
Bending Properties





IB Strength

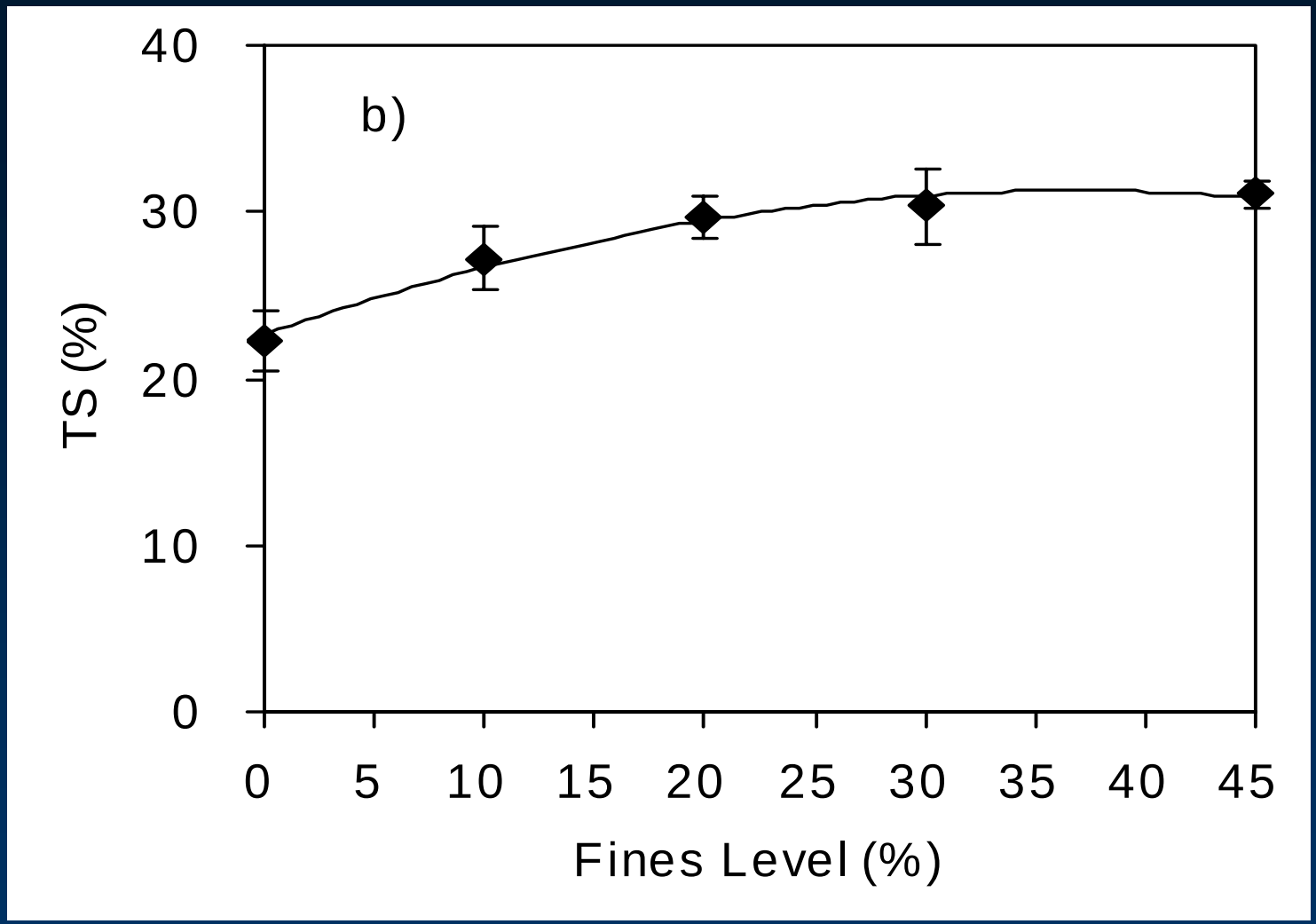




LE

$LE_{\perp} = 0.0003\ FL^2 + 0.0018\ FL + 0.312$ $r^2 = 0.99$

$LE_{//} = -0.00005\ FL^2 + 0.0007\ FL + 0.209$ $r^2 = 0.99$



TS

$TS = -0.0064\ FL^2 + 0.4722\ FL + 22.615$ $r^2 = 0.98$

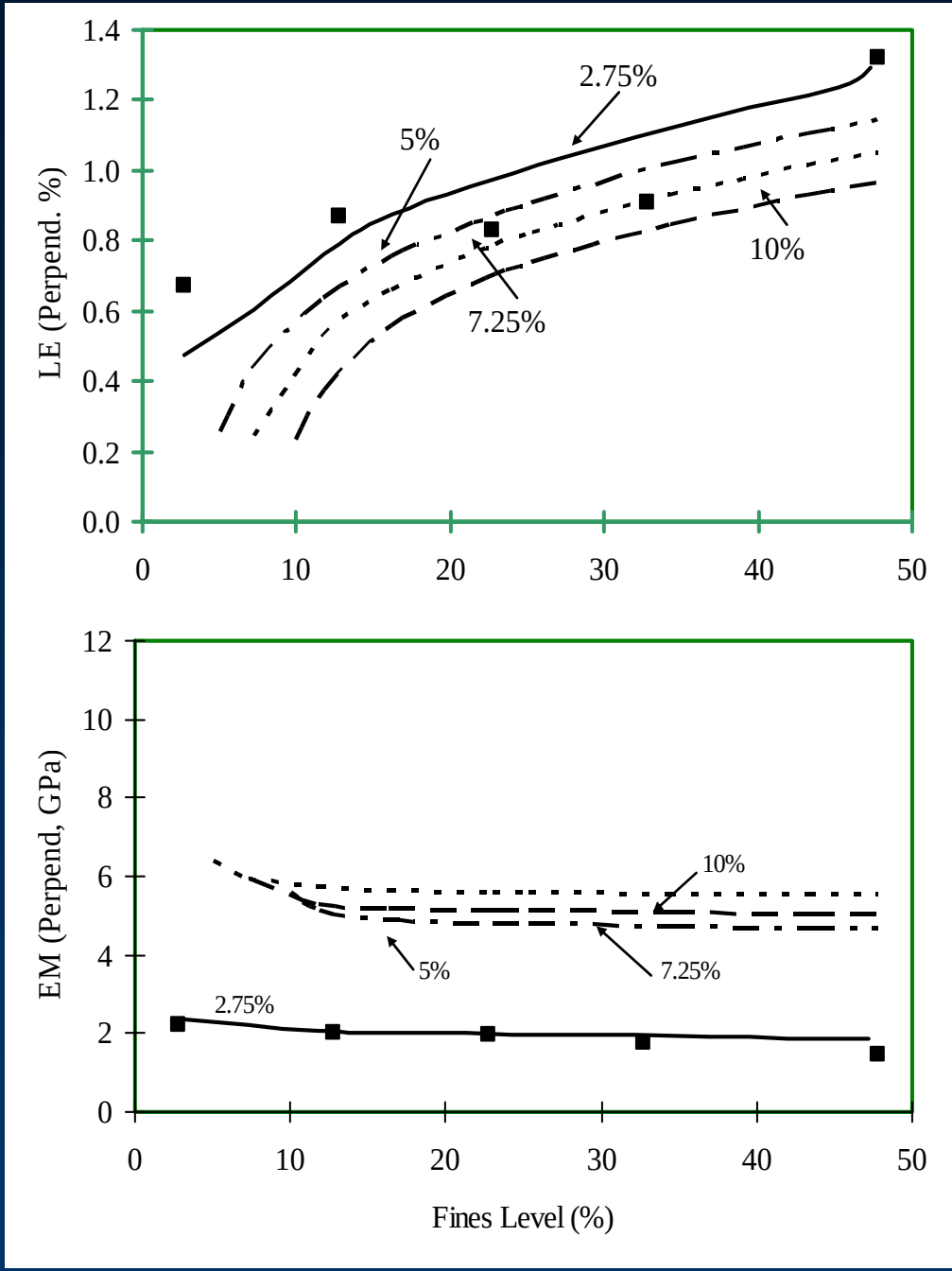
Summary of Strand Property

- Both tensile strength and dynamic moduli were positively correlated with strand density.
- Strands with higher density had higher tensile properties and storage modulus (E′).
- Compared to willow, a large variation in tensile strength and E′ values was observed for southern pine strands.
- E′ showed a decreasing trend with the increase of temperature in the selected temperature range, indicating reduced stiffness at higher temperature.
- Southern pine strands with higher densities had higher thermal stability than low-density strands.

Summary of Panel Property

- Three-layer OSB showed panels made of small-diameter trees had satisfactory strength and dimensional stability performances.
- Fines levels had variable effects on the panel properties. With increased fines contents, the internal bond strength showed an increasing trend; bending strength and stiffness varied little in the parallel direction and slightly decreased in the perpendicular direction.
- Increased fines in the core layer led to increased thickness swelling and a poor balance of linear expansions between parallel and perpendicular directions.

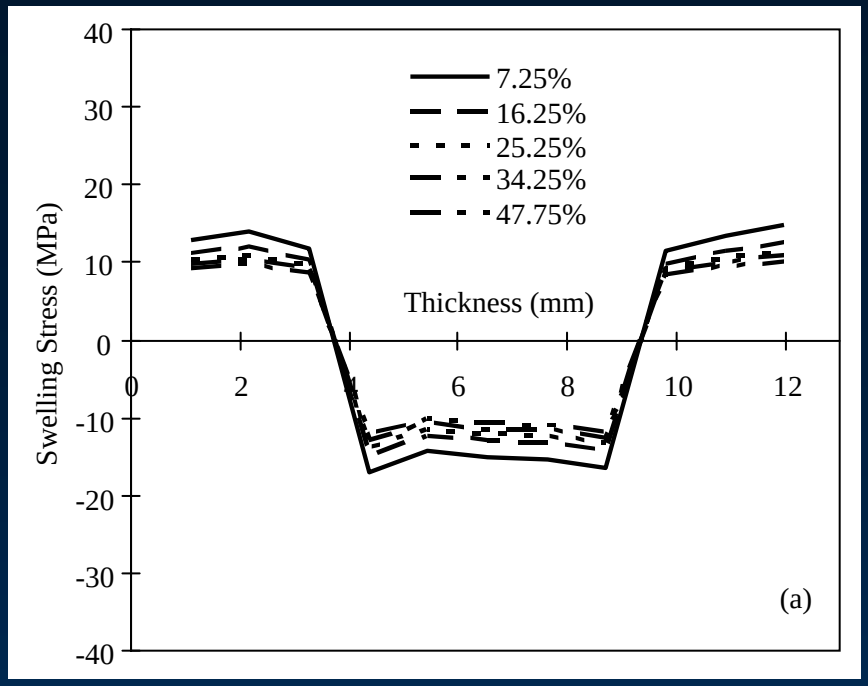
Simulation Study

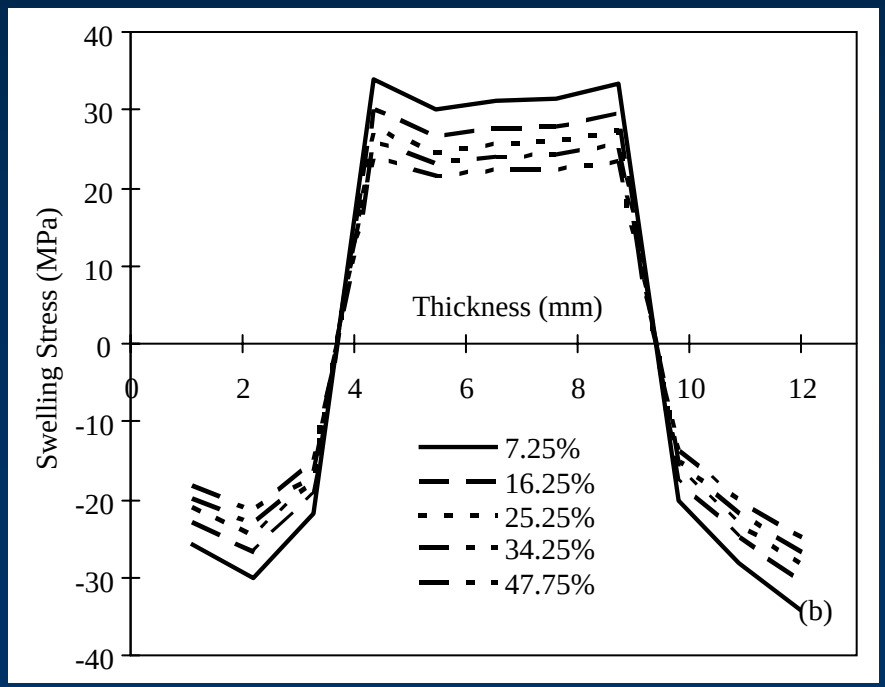


$$\delta\varepsilon_{LE} = \frac{\int_0^{TK} [d\ \varepsilon_{FE}\ (i)\ E(i) dx]}{\int_0^{TK} [E\ (i)\ dx]}$$

$$EM = \frac{1}{I}\sum_{i=1}^{n} E^i [I_0^i + A^i (d^i)^2]$$

Han, G., **Q. Wu,** and J.Z. Lu. 2007. The Influence of Fines Content and Panel Density On Properties Of Mixed Hardwood Oriented Strandboard. Wood Fiber Sci. 39(1):2-15.





Simulation Study

$$\delta\sigma(i) = [d\,\varepsilon_{LE}(i) - d\,\varepsilon_{FE}(i)]E(i)$$

Han, G., **Q. Wu,** and J.Z. Lu. 2007. The Influence of Fines Content and Panel Density On Properties Of Mixed Hardwood Oriented Strandboard. Wood Fiber Sci. 39(1):2-15.