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# Mechanical Characterization of Loblolly Pine

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Changing the World's Energy Future

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Idaho National Laboratory

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# Mechanical Characterization of Loblolly Pine

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[1]INL – Biomass Characterization

## Background and Motivation

Biorefineries are faced with various material flow challenges during feeding and handling, due to inherent variability and inhomogeneity of biomass feedstocks. This impacts the efficiency of refinery processes and unit operations. Proper characterization of bulk properties allows for optimal process design and reduction of overall costs. This work is aimed at evaluating the physical and mechanical properties that impact bulk flow of loblolly pine.

## Material Preparation

| Unit Operation | Method |
|---|---|
| Size Reduction | Hammer mill: ½" discharge screen |
| Particle size distribution | Analytical sieves: RoTap |
| Sample Wetting | Water sprayed to moisture contents: 5%, 20% and 40% |
| Tissue Separation | Air classified into concentrated samples of bark, stem, needle and whole pine |

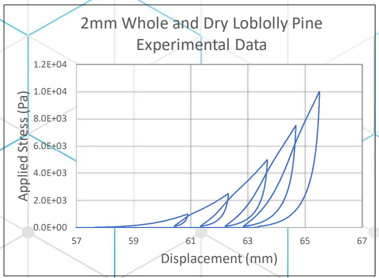
## Experimental Design

Axial compression tests were performed using and Instron load frame

Loaded cell

Incremental force applied

## Elastic Modulus




Bulk Modulus

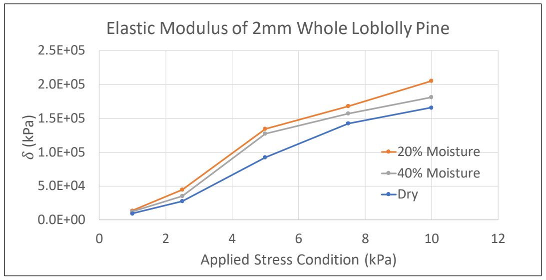
$$K = \rho \frac{dP}{d\rho}$$

Elastic Modulus

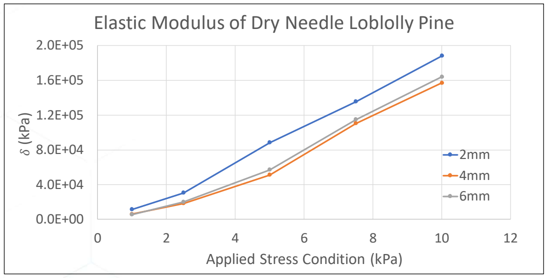
$$\delta = \frac{stress}{strain}$$

## Results

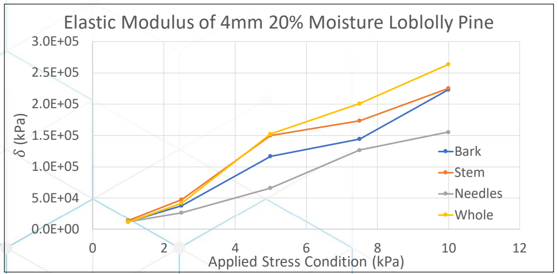
Applied stress vs Elastic Modulus plots for various Loblolly Pine samples at different moisture contents, sizes, and tissue fractions:




- Elastic modulus is lowest for dry samples indicating they are stiffer than wet samples

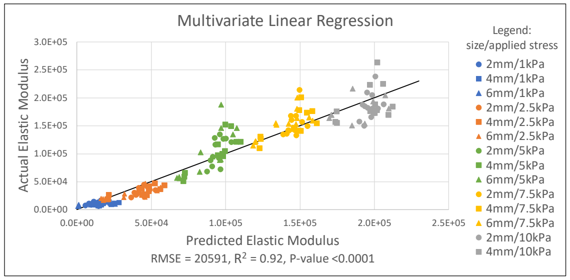



- Elastic modulus is highest for the 2mm size sample in the dry needle tests suggesting how size can impact mechanical properties




- Elastic modulus is lowest for the 4mm 20% moisture pine needle sample

## Statistical Analysis




Preliminary estimate:

$$\delta = 20500 * A + 418 * \rho_0 - 21900 * S - 224 * w - 32700$$

$\delta$ = *Elastic Modulus*, $\rho_0$ = *Initial Density*, $A$ = *Applied Stress*, $S$ = *Size Distribution Span*, $w$ = *Moisture Content*

## Future Work

- Bulk shear testing and hopper flow testing will be performed for complete flow characterization
- Tissue fractions will be isolated and variations in mechanical properties evaluated in greater detail

Needles

Stem

Bark

- The current statistical analysis has a $R^2$ = 0.92 which explains 92% of the variance but only 72% of the standard deviation. A more robust analysis including tissue concentration data will be performed to describe more of the observed behavior

## Conclusion

- Dry particles are 26.9% stiffer than 20% wet particles at and 18.2% stiffer than 40% wet particles
- Dry needle 2mm is 32.9% more elastic than the 4mm and 30.0% more elastic than the 6mm
- Needles have the lowest elastic modulus compared to other 4mm 20% wet tissue fractions
- While the estimate needs to be evaluated further, the preliminary results suggest moisture content, applied stress, initial density, and relative span of particle size distribution are the most significant predictors for E

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