Quantifying the Percent Wood Failure in Adhesive Bonded Joints via UV-VIS Spectroscopy

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Abstract

The aim of this project is to automate the determination of percent wood failure in shear-tested structural composite bondlines through the utilization of a UV-VIS spectrometer. Manufacturers are particularly interested in this topic for continuous improvement efforts in quality assurance and compliance to safety standards. A robust and repeatable statistical model to rapidly measure the ratio of wood to adhesive failure will replace traditional methods which are either slower, more expensive, or vary in accuracy.

This method will be calibrated according to ASTM D5266 – *Standard Practice for Estimating the Percentage of Wood Failure in Adhesive Bonded Joints*. Current techniques are laborious and sometimes inefficient at measuring intermediate wood failure. The utilization of Multivariate Data Analytics methods such as Principal Component Analysis (PCA) and Soft Independent Modelling of Class Analogies (SIMCA) will provide for viable differentiations between certain wood species and adhesive spectra.

Implementing this nondestructive and relatively affordable technology in the mill environment will provide manufacturers of CLT, Glulam, LVL, Mass Plywood, and Softwood Plywood with cost savings through increased efficiency and an ultimate competitive advantage. Additionally, the resulting ergonomic improvements will drive employee satisfaction in the workplace. A spectrometer will be used to quantify the percentage wood failure in these shear-tested laminated composite products. This approach is expected to maintain an accuracy within five percent wood failure (ASTM D5266), repeatability between operators, and to occur faster than traditional methods.

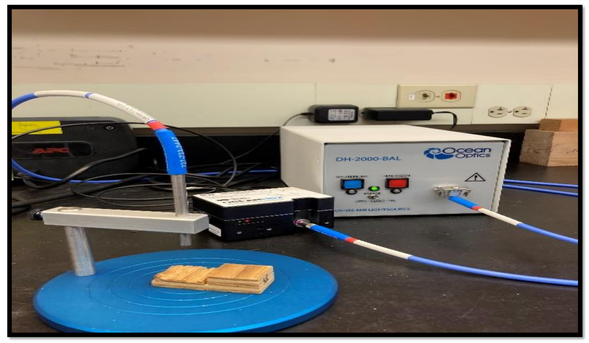
Goal: 1 - Differentiate wood species and adhesives to develop models for implementation.

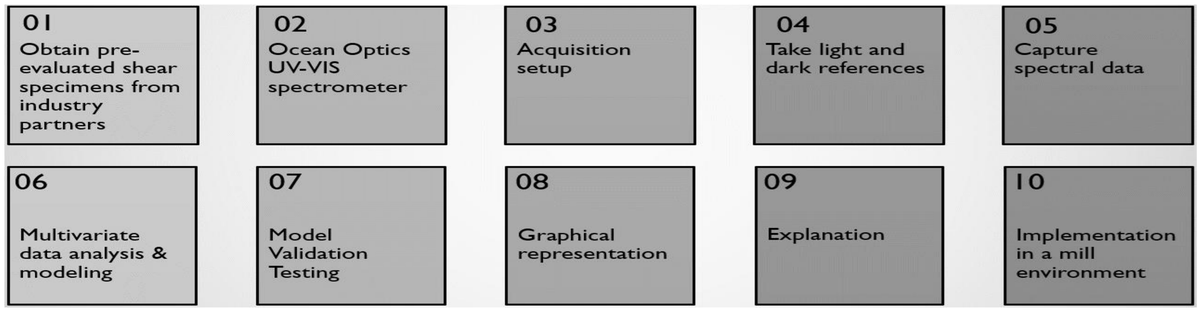
Goal: 2 – Provide a more robust, efficient, and repeatable test method for evaluating PWF in shear tested specimens.

Methodology

UV-VIS Spectroscopy System

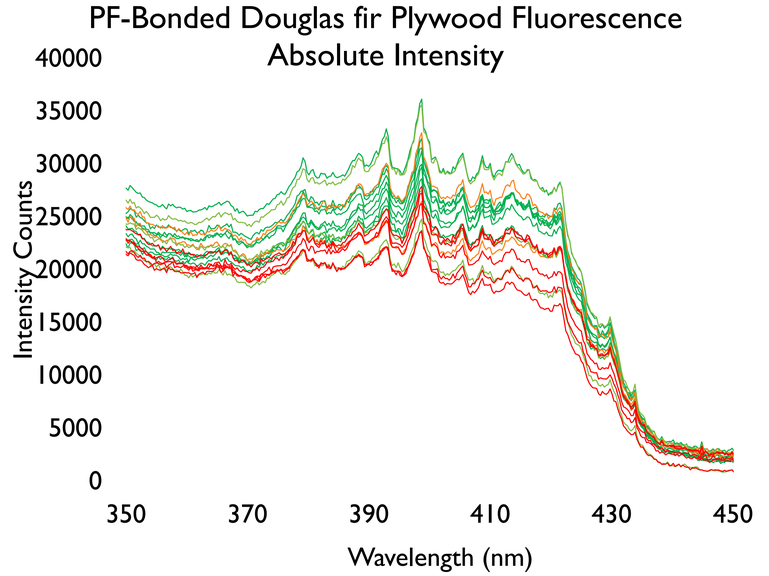
- Ocean Optics OCEANHDX-UV-VIS Spectrometer
  - Approximately $12,000 for all required equipment
- Dual light source
  - Deuterium & halogen (215 – 2000nm)
- UV-VIS range 100-800 nm
- Integrated fiberoptic probe
- Modular system
- Proven application in wood products industry





Materials and Preliminary Findings

- Focusing on a limited number of light and dark wood species and adhesives to develop an initial model.
  - Phenol-formaldehyde, soy protein, and melamine-formaldehyde
  - Douglas-fir heartwood & sapwood; earlywood & latewood
  - Yellow-poplar, Aspen
- After methodology is demonstrated on the initial test matrix, conduct trials on other adhesive/wood systems as time permits.
- Stains to be avoided, except for developing reference data sets if needed



Estimated Percent Wood Failure →

98%	98%	98%	95%	95%	95%	90%	90%	85%
80%	65%	60%	60%	55%	50%	50%	40%	20%

Industrial Relevance and Early Implications

Relevance

- Routine adhesive bond testing for R&D and quality assurance in the laminated wood products industry.
- Current method is through ASTM D5266, a visual assessment of PWF by a trained technician. This method is subjective and has poor repeatability (15-40% variation between readers).
- A rapid and repeatable method is desired that meets or exceeds the accuracy of ASTM D5266, requires less training, and has reasonable cost.
  - Efficiency and accuracy through automation will result in cost savings and a competitive advantage for manufacturers.
- Research Roadmap: A3 – Performance Evaluation, Improved Testing Methods

Implications

- Preliminary work with lab-manufactured specimens indicate UV-VIS spectroscopy will be sensitive to PF and MUF on Douglas-fir and Southern Yellow Pine.
- Principal Component Analysis (PCA) will effectively model our spectra.
- Simple and inexpensive UV-VIS equipment set-up appears to be feasible.

Considerations

- Probe distance from specimen surface affects acquisition region size and intensity
- One surface from two halves of a shear

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