OWL: Oscillation of Wheat to determine Lodging Parameters

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Introduction & Background

- Lodging occurs when too much force is exerted upon the stem of a crop, usually in the form of strong storm winds.[1-2]
- To understand the factors contributing to lodging of a crop, we must first understand the biomechanics of the wheat stem
- A system is needed to measure these biomechanics
- By exploring the mechanics of a simulated stem and using a mechanical system to capture data, the biomechanics can be properly determined.

Example of Lodging in Corn

But Why Care About Lodging?

Lodged wheat is difficult to harvest and can drastically reduce the total yield.

Overview

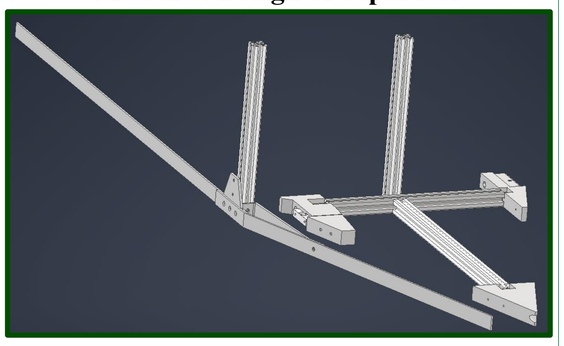
- To properly determine the biomechanics of wheat, two components are used: A simulation of a wheat stem with variable physical properties based on material testing, and a mechanical design used together with the Agriculture and Agri-food Canada cart in the field.
- Materials testing (four-point bend test and cross-sectional analysis) were conducted on several live and dead wheat stems to simulate varying moisture content in the crop.
- A simulation of a stem was created using the parameters found in the material testing, which could then be used to simulate oscillation of a crop.
- The mechanical design focused on perturbing the wheat a large enough distance to induce oscillation while measuring the force required to push it to that point and then capturing the oscillation that followed. The design is made to enforce a manageable sample size.

AAFC Cart Attachment

Mechanical Design

Modelled Design of Separator

A triangle base component and a detached 'arm' were modelled to contain and separate a select few stems of wheat to simplify the collection of data .



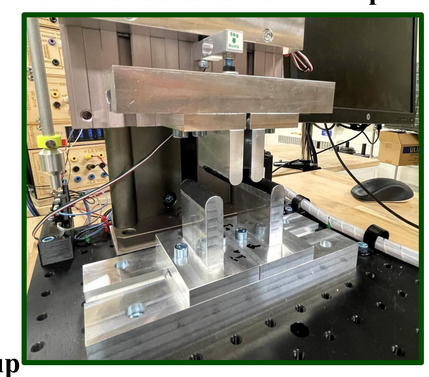
Full Design of Separator

- A load cell was placed before the oscillation to measure the force applied to perturb.
- The perturbation is captured by a camera placed at a 15° angle above the design.

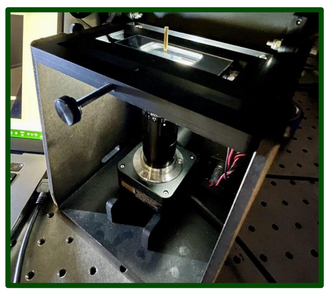
Materials Testing

- A 4-point bend test was conducted to calculate the maximum stress.
- Friction tape was placed on each point to prevent any sliding of the samples.
- Stems were tested in long sections, separated at the nodes

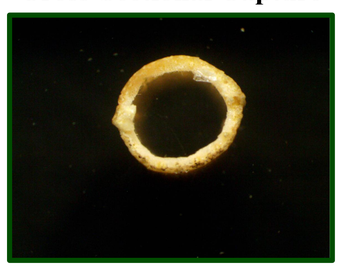
Four-Point Bend Test Setup



Cross-Section Imaging Setup



Cross-Sectional Capture

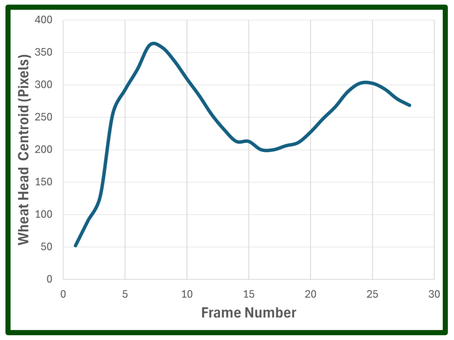


A cross-section of every stem that was load tested was then cut and captured with a microscope camera. This allowed us to accurately calculate the inner and outer radii of each stem.

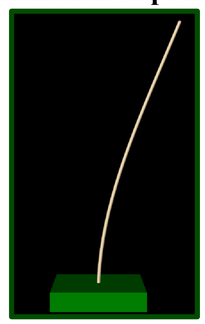
Analysis

The data found in the material testing was used to calculate stiffness and force parameters that would then be inputted into biomechanical stem model as shown below. The oscillation patterns of the design and simulation could then be compared.

Measured Test Oscillation Pattern



Simulation Capture



Using the following equations, values were found for stiffness, stress and oscillation frequency.[3]

$$k = \frac{F}{\delta} = \frac{3EI}{L^3} \quad \sigma_{\max} = \frac{4PL}{\pi r^3} \quad \omega_i = \sqrt{\frac{\beta_i^4 EI}{\rho A}}$$

Values for modulus of elasticity and density were researched.[4]

Next Steps

For future development of this research, the implementation of the mechanical design, the 'wheat separator', in conjunction with the AAFC cart is required for field data collection. Using the data found in the field and the previously discussed equations, a set of parameters that describe the biomechanics of wheat in the field can be developed. Comparing the field data with the simulated and test data allows for the verification of the validity of the captured data. Using the found parameters from the field in the simulation allows for the exploration of these characterizations further where variability in the physical properties of the wheat is straightforward.

References

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