Prototype III

Group 10

Jason Jang
Joudi Fayad
Pablo Florencia Villarreal
Jacob Hodgins
Feyisayo Owolabi

March 26st, 2023

Table of Contents

1 Introduction

This deliverable focuses on the final prototype which will be based on testing the stability and strength of the structure using software. The tests we completed as part of this deliverable are strength tests of the wooden 2x4's on our 3D model in solidworks.

2 Prototype III and Tests

What: For the final prototype we are going to do a strength test of the materials in the greenhouse; that is, the strength of the wood beams under compression and flex. The test will consist of calculations in the Solidworks 3D modelling program and therefore does not have a specific test duration. We will use this test to quantify the strength of the wood that we are using, and determine if we should adjust dimensions to account for lapses in compression strength or undesired bending.

Why: The purpose of the strength test is to make sure the dimensions of materials used in construction have enough stability. We want to ensure that we won't encounter any more issues going forward with construction as we inch closer and closer to design day. We were also questioning the importance of implementing ratchet straps (guy lines) for our greenhouse as the hexagonal structure of the greenhouse is quite stable, additionally the roof has enough weight to properly ground the structure.

How: This was done by calculating the maximum load that can be put on the wooden beams and then compared strength test results from solidworks to see if any adjustments would be required. From the previous prototype, the wooden beams were mated together rather than developing and installing nails in the program due to time constraints. We needed to make this fix so that we could get more accurate results for our tests (if we tested the mated connections, the strength would be drastically larger than the actual number since two mated parts cannot be physically separated).

The preliminary calculations were done as follows: we used the relation for the flexural strength of an object under a 3 point bend as shown in figure 1. We made the assumption that an axial force (applied by the beams forming the roof of the greenhouse onto the vertical frames forming the walls) is equal to the force applied to the midpoint of the pins.

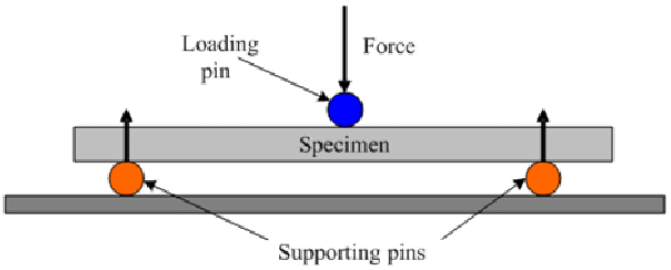

Figure 1: 3 Point Bend

In this case, ignore the loading pin indicated in the diagram as we are relating the perpendicular force to the axial force not applying a force to the side of the beam. The

equation for the flexural strength of a beam due to a 3 point bend is, $\sigma = \frac{3FL}{2bd^2}$, where σ is the flexural strength, F is the force applied, L is the length of the support span between pins, b is the width of the object, and d is the depth/thickness of the material. We arranged this equation for the force of the object as follows, $F = \frac{2\sigma bd^2}{3L}$. The value for σ was obtained online; we were unsure of the type of wood that was used for the 2 by 4's so we have assumed that it to be Douglas Fir since it is a cheaper wood. The compressive/flexural strength of Douglas Fir is 43.1-51.2 MPa; we will choose a mid range value of 47.15 MPa for the calculation. The calculation was done as follows in figure 2 (keep in mind that the values for b and d are not 2 and 4 inches since 2x4's shrink in size from initial cut from tree to actual use in construction):

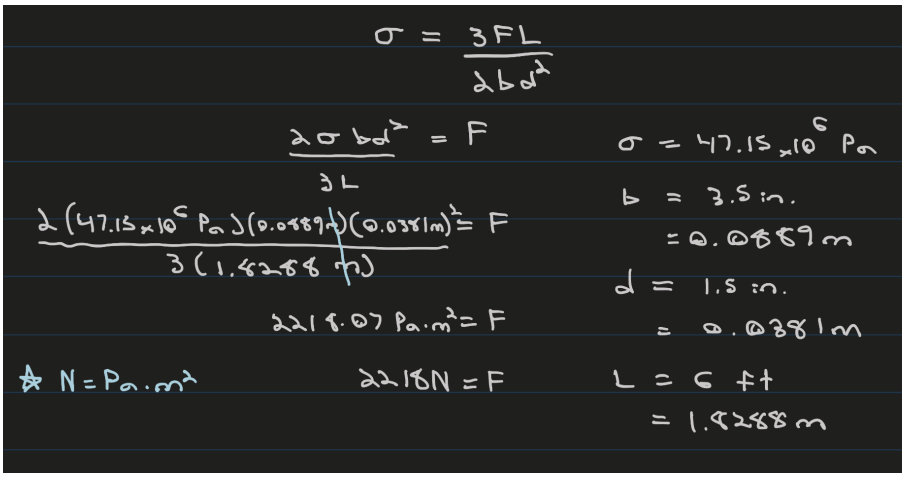

Figure 2: Applied Force Calculation

This calculated value represents the max load that can be put on a singular wooden 2x4 beam with length 6 feet. Any force exceeding this value will cause deformation or failure in that particular part. This specific criteria relates exclusively to the vertical wooden beams that make up the frames of the walls in our greenhouse.

4 Update to Target Specifications, Design, or BOM

There were some updates made to the design of the structure which included adding a smaller hexagon on the top of the roof, similar to the picture shown below. Additionally, we will create a door frame with plexiglass (or polyethylene sheeting based on if we can be supplied by the professor) instead of a dutch door and we install just two windows instead of one in each frame besides the door.

5 References

1. Flexural strength equations: https://en.wikipedia.org/wiki/Flexural_strength
2. 3 point bend photo: https://www.researchgate.net/figure/Three-point-bending-test-8_fig1_264713313