InsideTrees Module 3: Nothing, Nails, and Glue

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Introduction

This activity is called “Nothing, Nails, and Glue so it’s all about the connections.

But, it’s also about using less material to get more benefits.

You will construct three beams with different connection types:

Nothing Nails & Glue

You will measure the starting and ending position of the beam before and after a weight is applied to find the impact of connection type and see which develops the most deflection for the same amount of weight applied.

Background

$$k = \frac{F}{\Delta}$$

- Wood is an ***elastic material***
  - It will keep bending until it breaks (fails)
- The *higher the stiffness (aka, spring constant (k) in the equation shown above)*, the *stiffer* a material is
  - The stiffness or spring constant is a way to tell us how stiff something is or how much deflection will take place in a beam
  - Stiffness is calculated as the amount of force (F) applied to a beam divided by the accompanying amount of deflection (Δ)
  - We will compare the stiffness of each beam we're testing

Materials

- safety glasses for all participants and activity leaders
- 9 – or more strips of balsa wood 1” across, ¼” thick, and 18” long
- wood glue, paint brush to apply glue, clamps, paper towels to catch and clean up spills
- small nails (about ¾” in length) and hammer
- tape measure
- rectangle pieces of wood or other material to support beam, approximately 5” tall
- 10 pound weight
- white or light colored cardstock to position behind beam
- marking pen to draw a line on cardstock
- ruler, pencil, and paper to record results
- calculator to determine beam stiffness

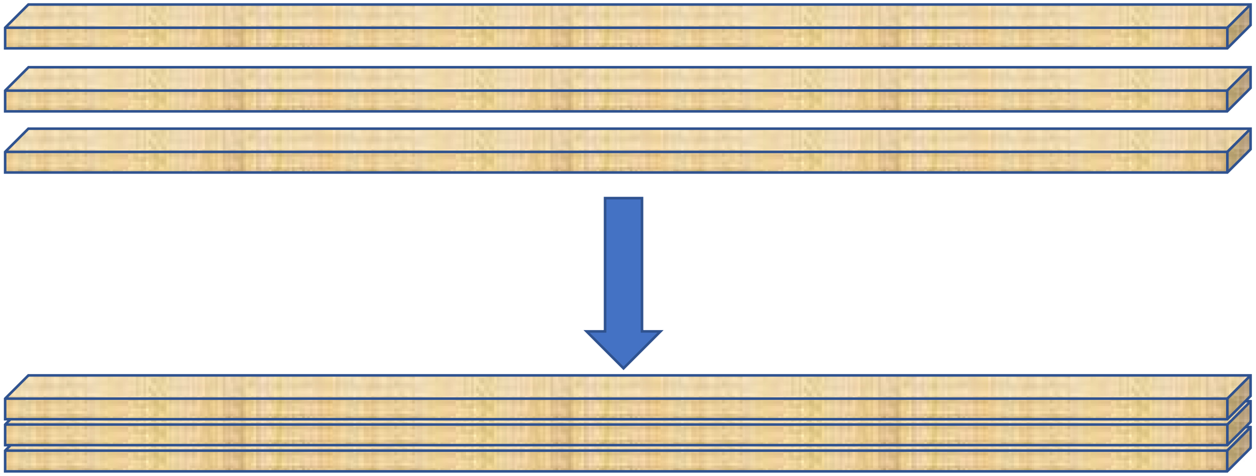
Methods overview

1. For each beam, you will position the beam over the supports so the ends do not extend past the supports.
2. After marking the starting position on the card behind the beam, you will SLOWLY lower the weight onto the center of the beam.
3. Have someone else mark the ending position on the card while the weight is still on the beam.
4. Record displacement on the data table provided at the end of this activity file.

InsideTrees summer camp participants testing beams
at Dept. of Sustainable Biomaterials, Virginia Tech, 2019

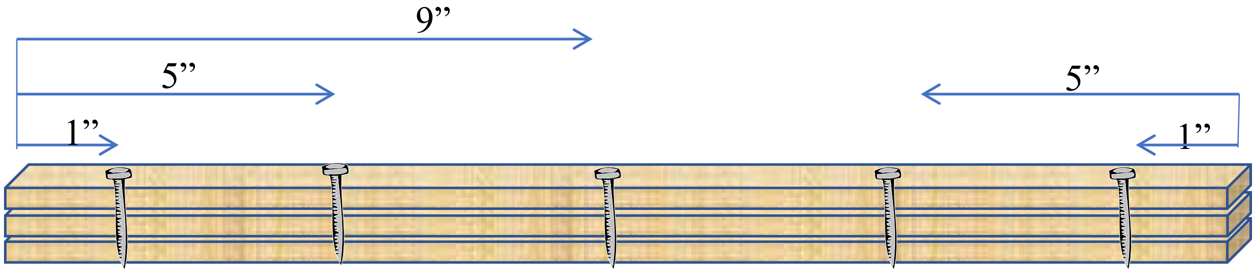
Prepare the beams - Nothing

1. connection type #1 is “nothing”
   a) simply stack 3 pieces of balsa wood one on top of the other and so that the ends are even



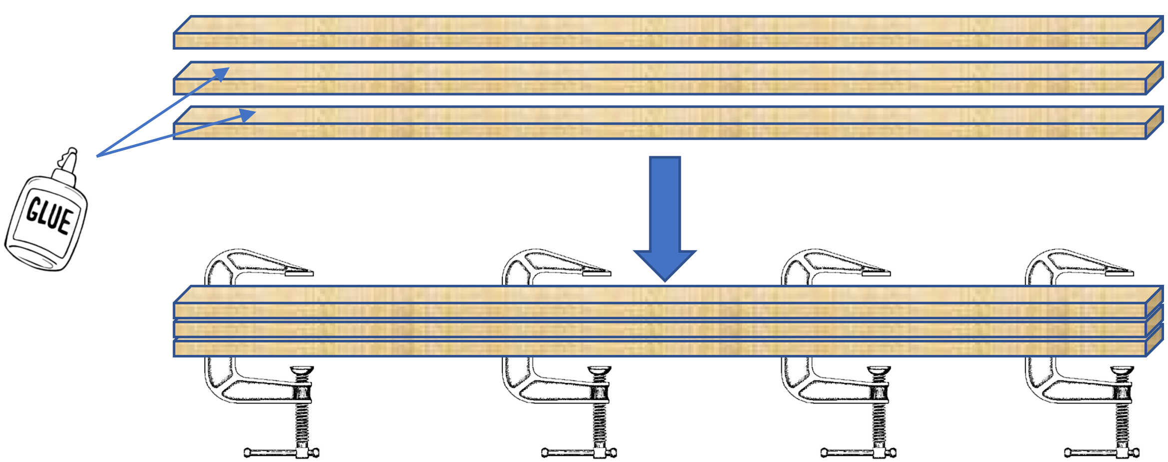
Prepare the beams - Nails

2. connection type #2 is "nails"
   a) all participants and leaders put on safety glasses
   b) stack 3 pieces of balsa one on top of the other with ends even
   c) use hammer to nail 5 nails centered across the piece width and spaced along the length as shown in the image below



Prepare the beams - Glue

3. connection type #3 is “glue”
   a) spread out paper towels or plastic sheet to catch spills
   b) use brush or glue spreader to apply a uniform, liberal coating of glue along 2 faces of the balsa strips
   c) clamp the pieces together at several places along the length; make sure there is sufficient glue and pressure to get squeeze out of the glue
   d) allow glue to cure for at least 30 minutes to 1 hour



Test the beams

1. position beam across supports making sure beam does not extend beyond supports
2. position card behind beam and mark initial, unloaded position on card at the center of the beam; may have to hold the card in place
3. **gently and slowly** lower the 10 lb. weight at the beam center point; VERY gently keep holding on to the weight so it does not fall off
4. mark the deflected position on the card at the center of the beam length
5. remove load and card
6. measure the difference between the initial, unloaded position and loaded position; this is the deflection of the beam
7. record the deflection on the data record at the end of this file

Calculate beam stiffness

$$k = \frac{F}{\Delta}$$

1. Stiffness is calculated as the force applied which in our activity is 10 lbs divided by the deflection (Δ in equation above) we measured for each connection type
2. Recall Δ was the difference between the 2 lines we drew on the card, 1 before load and 1 after
3. Record beam stiffness on the next slide

Data Chart

Connection type	Force applied (F) (10 lbs)	Deflection (Δ) (inches)	Stiffness (F / Δ) (lbs/inch)
Nothing	10		
Nails	10		
Glue	10		

Discussion Questions

- Which beam deflected the most and therefore had the lowest stiffness?

- Which one had the least deflection and the highest stiffness?

- What do you think caused these results?

Synthesis Reflections

- Knowing how much wood will deflect is a crucial thing to know for engineering and construction.
  - Stiffness of a beam is calculated prior to installation to make sure the beam will not deflect too much.
- The way the glued beam was connected affected the beam’s bending stiffness, or, the ability to withstand a load without deforming too much.
- Engineered wood composite products like plywood, parallel laminated beams, or cross-laminated timbers are all stiffer than wood alone because of the connections’ ability to transfer load throughout the specimen.
- Load sharing through the connections results in better products, less waste, and better overall natural resource utilization.