The Mechanics of Glue Laminated Wood

Sometimes large wood members are made by gluing together many layers of thinner beams. The members made this way are called "glue-laminated" wood or "glulam" wood.

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Glulam wood offer a number of advantages:

•larger sections can be built up than can be obtained from trees (for instance, glulam members have been made up to 140 feet long)

•defects which reduce the strength of the wood can be cut out of the layers before they are glued together

•curved shapes, like the wood arches in the photographs, can be made by bending each layer around a mold before gluing all the layers together

At the Boston Nature Center, the wood members supporting the roof of the new building near the community gardens are all glue-laminated wood. The large arches supporting the roof of the Back Bay station are also glue-laminated wood.

In the demonstration, you can load several wood beams and measure how much they deflect under load. There are three beams:

•a solid wood beam which is 0.4" thick
•a glue-laminated wood beam that is also 0.4" thick
•a set of 5 unbonded wood layers each 0.08" thick with a total thickness of 0.4"

First, load the solid wood beam and the glue-laminated beam with the same weight in the center of each beam. Notice that they deflect about the same amount.

Next, load the set of 5 unbonded wood layers, again in the center of the beam. Notice that the deflection of the layers is much higher than that of the bonded beam or the solid beam, even though they all have the same total thickness. Bonding the layers makes them act together as a single thicker beam.

We can write an equation for the deflection of a beam under a load at the center of the beam:

$$deflection = \frac{load \times (length)^3}{4 \times Young's\ modulus \times width \times (thickness)^3}$$

All the beams are loaded with the same load.

All the beams have the same length, Young's modulus (the stiffness of the wood) and width.

For this set of beams, the deflections depend on the thickness.

For the solid wood beam and the glue-laminated wood beam, the thickness is 0.4 inches.

For the unbonded layers, the deflection of each layer is controlled by the thickness of a single layer (which is 0.08"). The deflection of a single layer 0.08" thick is $\left(\frac{0.4}{0.08}\right)^3 = 125$ times that of the solid beam which is 0.4" thick..

The deflection of 5 unbonded layers is about $\frac{125}{5}$ =25 times the deflection of the 5 layers which are bonded in the glue-laminated beam.

Gluing the layers together gives a beam with the same deflection as the solid beam. The bonded layers act like one thick beam rather than 5 separate layers.