Beam Bending Lab Report

Submitted to

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**Executive Summary**

For the beam bending study, four different materials and shapes of beams were tested in order to find their deflection in response to different forces. The mechanism used to record the data and conduct the test was one in which the beam was locked into place vertically, while a string connected to the top of the beam would have an increasing amount of weight added to the base. Recording deflection was a bar pressed against the beam, which would move as the beam does, and records its position on a dial measured in inches.

As for the results of the several tests, the two rectangular beams showed to measure consistently high for deflection, in relation to the theoretical results. The square aluminum beam though, measured much lower than theoretical, and was the only one of the three to be both biased and imprecise. As for the unknown beam, it is impossible to say how biased it was without definitely knowing what the material was, however we can say that it is quite precise in its consistency. After measuring the deflection and calculating Young’s Modulus, the team has concluded that it was a steel rectangular beam. The numbers pointed to it being Carbon Fiber reinforced Plastic, but logically it was not that at all, because it had all visual and physical characteristics of Steel.

What the team understood from the experiment was that the method of conducting this test was relatively precise, however it had very clear bias. The reasoning for this conclusion could very well be many things such as improper setup or wear on the contraption, however it should simply be known that the equipment used was outdated and misaligned.

1. **Introduction and Purpose**

In this lab, the team collected data from four different beams of different material and shape in order to find the deflection of each beam in response to various different forces applied to them. The purpose of this is to find out what material the final beam is composed of, and determine the validity of the measurements made by the contraption.

1. **Data**

Figure 1: Deflection versus Force for Aluminum Rectangular Beam

Figure 2: Deflection versus Force for Copper Rectangular Beam

Figure 3: Deflection versus Force for Aluminum Square Beam

Figure 4: Deflection versus Force for Steel Flanged Beam

1. **Results**
   1. **Aluminum Rectangular Beam**

The results for the Aluminum Rectangular Beam were shown to be quite far off from the theoretical deflection results (see Figure 1). With some exceptions, deflection was measured to be between 27-32% higher than our expected results.

* 1. **Copper Rectangular Beam**

The results for the Copper Rectangular Beam were slightly closer to theoretical than the Aluminum was, however it was still more biased than we had desired (see Figure 2). The results on this test were not as precise, and seemed to derive from the theoretical path a bit. With the mean percent error being 21%, it was closer to what we were looking for, but not by much.

* 1. **Aluminum Square Beam**

The Aluminum Square Beam produced the worst measurements we got in this entire test (see Figure 3). With the average error being -44%, we figured we were definitely doing something wrong, however upon further testing we concluded that these were the best results producible.

* 1. **The Unknown Beam – Steel**

The final beam was one which had no theoretical measurements, so error was fortunately not of as much concern during this test. While the final measurements seemed to be quite precise (see Figure 4), the final calculation of Young’s Modulus had further proven the bias in our measurements. The value we had calculated for this material was ~146 GPa, which closest represented Carbon Fiber reinforced Plastic. The beam we had worked with definitely didn’t look, feel, or weigh the same as Carbon Fiber reinforced Plastic, rather it appeared to be Steel. From this, further testing on the unknown material would be required in order to form a legitimate conclusion.

1. **Discussion Questions**
2. **Identify the impact of the various materials and shape configurations (How is a box beam different from a rectangular beam? How does aluminum vs. copper affect deflection? Etc.)**

From the test results, a box beam is much sturdier than a rectangular beam, and copper is a bit stronger than aluminum.

1. **Discuss the difference between measured and theoretical deflection values (% error)**

The percent error for each of the tests was much higher than it should have been. While mostly precise, further testing would be required to form valid results.

1. **The mathematical definition for Area Moment of Inertia is I = ∫ y2 \* dA.**

**Based on your experimental work in beam bending, give a qualitative definition or explanation for the Area Moment of Inertia.**

The Area Moment of Inertia is a beam’s ability to resist deflection from a given force. Beams with more area will bend less from the same force.

1. **If you needed to reduce deflection in a loaded aluminum rectangular box beam in your structural design, which of the following variable(s) would you INCREASE? Which would be the MOST effective in reducing deflection? Assume W and T are outside dimensions and w and t are inside dimensions of a hollow box beam. L is the unsupported length.**

You would increase W and T, keeping w and t the same so that the beam becomes thicker. The lesser variable between W and T would be the best to increase, so that the beam would gain more thickness.

1. **What is the E value of the unknown material? What material do you suspect it to be?**

The E value is 2.12e7, which would align closest with Carbon Fiber reinforced Plastic. It is most likely Steel, so further testing would be required.

1. **For question 2 above, what material could you substitute for aluminum in your design to decrease the deflection? Why?**

Steel, since it has a much higher resistance to bending than Aluminum

1. **The mathematical definition for the Modulus of Elasticity or Young’s Modulus is E = Stress / strain. Based on your experimental work in beam bending, give a qualitative definition or description for the Young's Modulus or the Modulus of Elasticity.**

Young’s Modulus is the measurement of how much a material can bend.

1. **Which has the larger Area Moment of Inertia, a 2” x 2” square beam of high strength stainless steel or a 2” x 2” square beam of balsa wood? Support your answer qualitatively or quantitatively.**

Both square beams would have the same Area Moment of Inertia since their dimensions are the same.

1. **Should the Elastic modulus of a beam change if the unsupported length of the beam is changed? Why?**

Yes, because there is more strain being put on the beam from more unsupported length.

1. **What would be the percent change in deflection if a solid rectangular beam has its unsupported length changed from 30 inches to 36 inches? SHOW YOUR CALCULATION. What does this tell you about the importance of unsupported beam length in structural design?**

(50\*30^3)/(3\*1e7\*1.119e-4) = 402.14

(50\*36^3)/(3\*1e7\*1.119e-4) = 694.91

402.14 / 694.91 \* 100 = 57.87%

The deflection increases by 57.87%. This shows that unsupported length is incredibly important when designing structures, as 6 inches (in this case) makes a huge difference.

1. **Is the Modulus of Elasticity indicative of what the failure load of a beam would be? Why?**

No, because the modulus of elasticity is only a measure of a material’s stiffness, not a measure of the load it can take.

1. **Which has a higher resistance to deflection (that is, a smaller ratio of deflection/F which is the slope on your graph), a solid square, 1”x1” beam, or a square box beam with outer dimensions of 1”x1” and inner dimensions of 0.95”x0.95”? (Assume that L and E are the same for both.) What advantages are there to using the box beam instead of the solid beam?**

A solid square would have a greater resistance to deflection. The advantages to using the box beam though, would be that it is lighter and cheaper.

1. **In how many significant figures do you think the final value of the modulus of elasticity for each of the beams should be reported? Why?**

3, because every other value used was presented in 3 significant figures or more.

1. **Conclusion**

From this lab, our team found that square beams are much sturdier than rectangle beams. We also found that aluminum is sturdier than copper, and that steel is sturdier than both. As far as what the lab could improve upon, we believe that the contraption used could either be tested and calibrated before the real measurements, or done away with entirely and replaced. The setup and measurement of young’s modulus based on the percent error was poor, and if going by numbers alone, the identification of the unknown material would have no confidence behind it. Since further testing is required, such tests should include a re-test of the deflection with more advanced equipment, and perhaps finding the weight per cubic inch as a measure of assurance.