Lab 12: Tensile Testing Beams

Introduction

A Tensile Test is performed on plastic beams as shown in Figure 1. Young's Modulus for the material is measured using the dimensions of the beam and the slope of the Force vs. Elongation graph. By testing beams with different cross-sectional shapes, the student investigates the effect (if any) of shape on the outcome of the experiment.

For this lab, you will need an F4 (rectangular cross-section beam) from the ME-6987 Structures Flat Beam Set, and a T4 (**I**-Beam) from the ME-7012 Structures Thin **I**-Beam Set. Other beams that can be used in this lab include the shorter T3 (included in the ME-7012) and the ME-7011 Polycarbonate Thin **I**–Beams.

Equipment

Qty	Items	Part #
1	Materials Testing Machine	ME-8236
1	Structures Beam Adapter	ME-8242
1	Structures Flat Beam	ME-6987
1	Structures Thin **I**–Beam	ME-7012
1	Calipers	SE-8710

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Note: You will probably want to make a Compliance Calibration (using the Calibration Rod) before attaching the Structures Beam Adapter! A max force of 1000 N is adequate for this experiment. Do not use a preload over 20 N.

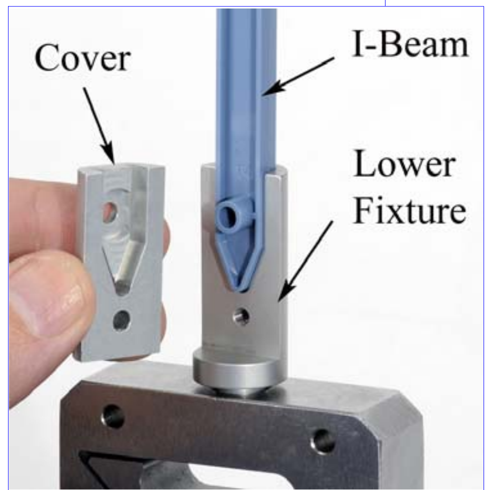


Figure 1. Tensile testing plastic beams.

Theory

A force (F) is applied to a beam of length (L) and cross-sectional area (A), causing an elongation of Δx. The stress (F/A), is related to the strain (Δx/L), by

Stress = E * Strain

where "E" is the Young's Modulus for the beam material. Combining the above and solving for the force yields

$F = (AE/L)\ \Delta x$ Eqn. (1)

Thus the slope of a graph of F vs. Δx is AE/L, and

$E = L*(slope)/A$ Eqn. (2)

Procedure

1. For both your beams (see Fig. 2), calculate the cross-sectional area. The beams were designed to have about the same area, so if the values are not close, check your calculations! Enter your values into the table.

2. Measure the effective length (L) of your beams. Note that "L" should only be the part of the beam that is actually stretching. For the rectangular (F4) beam, this would be only the thinner portion, not the thicker ends. The **I**-beam (T4) stretches mostly in the area between the two bolt holes. Enter your values into the table. What is the uncertainty in your measurement?

3. The ME-8242 Structures Beam Adapter consists of two major parts: The upper fixture with the longer thread sticks up through the cross-head and is held in place by the knurled cap nut. The lower fixture screws directly into the Load Cell as shown in the inset to Figure 1.

4. Install the T4 **I**-beam, and secure the covers on both fixtures using the cap screws.

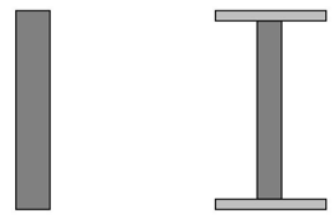


Figure 2. Cross-section of beams

Dimensions:
Rectangular Cross-section = 2.61 mm x 10.18 mm
A = 2.66×10^{-5} m²

I Flange: thickness = 0.97 mm width = 6.42 mm
I Web: thickness = 1.61mm width = 8.02mm
A = 2 (6.227 mm²) + 12.91 mm²
= 2.54×10^{-5} m²
L= ±5 mm

	Beam	Area (m^2)	Length (m)
1	F4	2.66E-5	0.120
2	T4	2.55E-5	0.129
3			
4			
5			

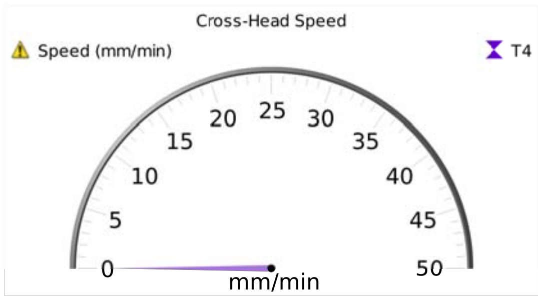
Taking Data

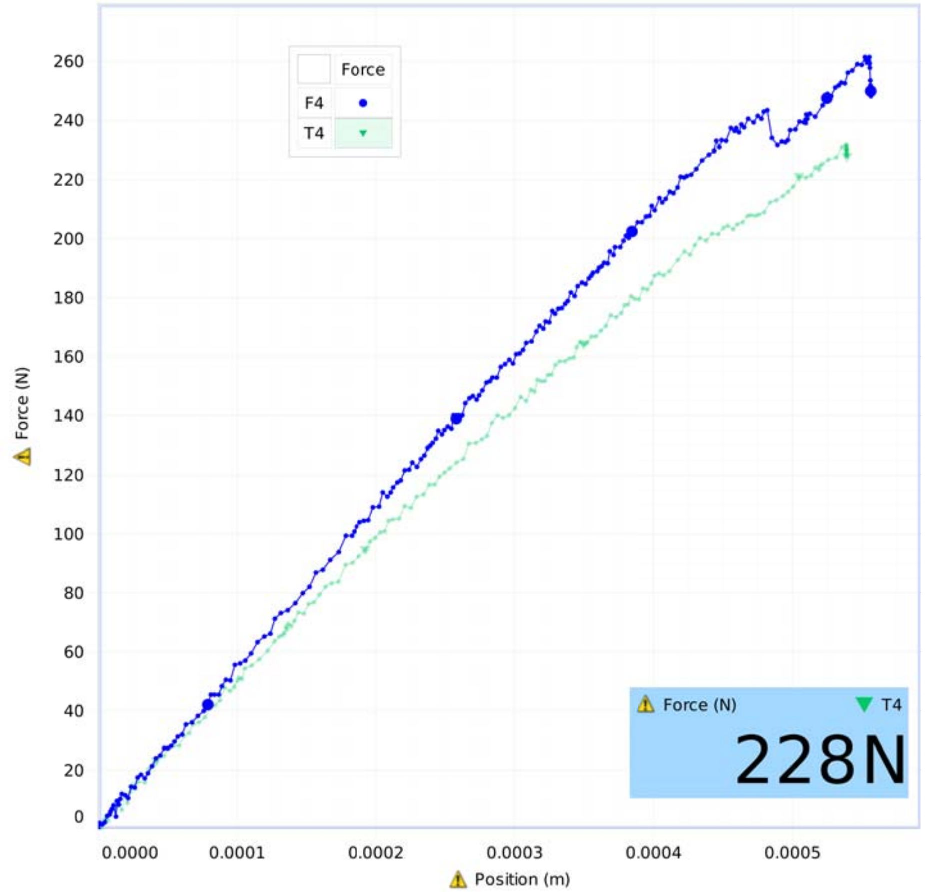
Note. Your data will look better if you use the normal procedure to "seat" the test sample. If you use a pre-load, do not go over 20 N, as the forces required in this lab are quite low. Remember that you should use the same method for testing your sample, as you used when performing a Compliance Calibration with the Calibration Rod. Note the cross-head speed display below. Try and use about the same speed for both your samples.

1. Click on Record. Turn the crank clockwise, stretching the sample. Increase the force to between 200 N to 300 N. You are interested in the linear portion of the graph: You do not need to destroy the sample!

2. Click on Stop. The data should be fairly linear. It is OK if there is a slight curvature at the beginning or end, but if there is not a straight section in the middle, you probably have something wrong.

3. Once you have a good run of data, replace the beam with the rectangular cross-section (F4) beam, and repeat.





Tensile Test of Sample

Analysis

1. Use a linear curve fit to find the slope (F/Δx) for both your beams and record in the table below.

2. The calculation for "E" is being done automatically. Use Eqn. (2) to verify that this is calculated correctly. What are the units?

3. Use your uncertainty in the measurement of "L" to estimate the uncertainty in your final answer. Do you get about the same value of "E" for both beams? Why might one beam be better than the other?

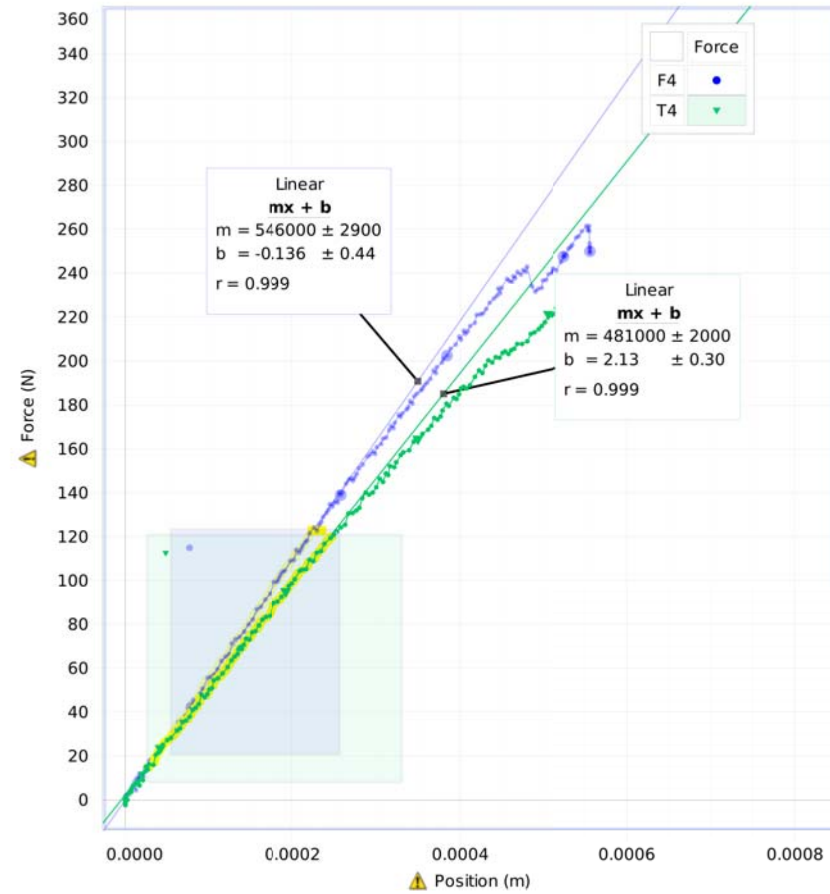
4. For further study, there are other beams that can be used in this lab, including the shorter T3 (included in the ME-7012) and the ME-7011 Polycarbonate Thin I-Beams. You can also test the beams to destruction, but you will probably need to make a new Compliance Calibration.

Same value for E within the uncertainty of ±0.1 GPa

The beams are the same in tension but not the same in bending or compression.

E=(10⁻⁹)*[Slope (F/Δx) (N/m)]*[Length (m)]/[Area (m²)]

	Beam	Area (m²)	Length (m)	Slope (F/Δx) (N/m)	E (GPa)
1	F4	2.66E-5	0.120	544000	2.45
2	T4	2.55E-5	0.129	481000	2.43
3					
4					



Tensile Test of Sample