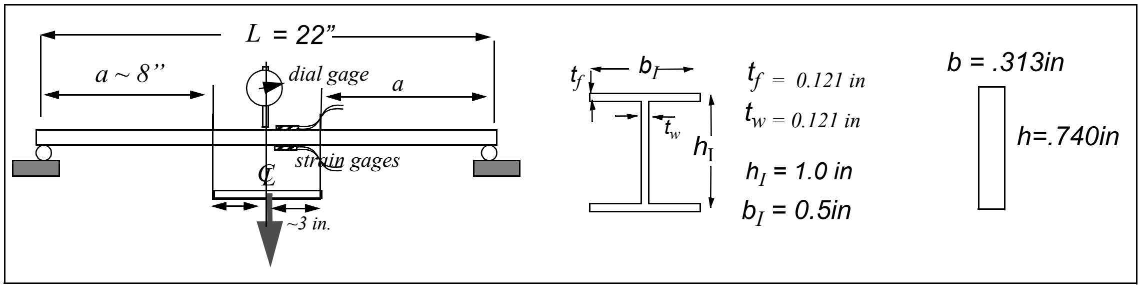
Structures - Experiment 3B
1.101 Sophomore Design - Fall 2006
Linear elastic behavior of a beam. - Summary of Results



The dimensions of the specimens, *I* beam and rectangular section, are shown above. The moments of inertia compute to:

$$I_{ibeam} = 0.0279\ in^4 \qquad I_{rectangular} = 0.0106\ in^4$$

Both show approximately the same area ~ $0.213\ in^2$.

A mistake made by near all was to take the length L as the full length of the beam (misguided, no doubt by my figure). *L*, as it figures into engineering beam theory, is the length between the two support points. These two points are at the top of the rollers; hence the distance between the axes of the rollers is *L*. This, for all four setups was *22 inches* (not 24).

The dimension a could vary from setup to setup. But since the support points of the hanging cables were 3 inches off center, approximately, *a ~ 8 inches*.

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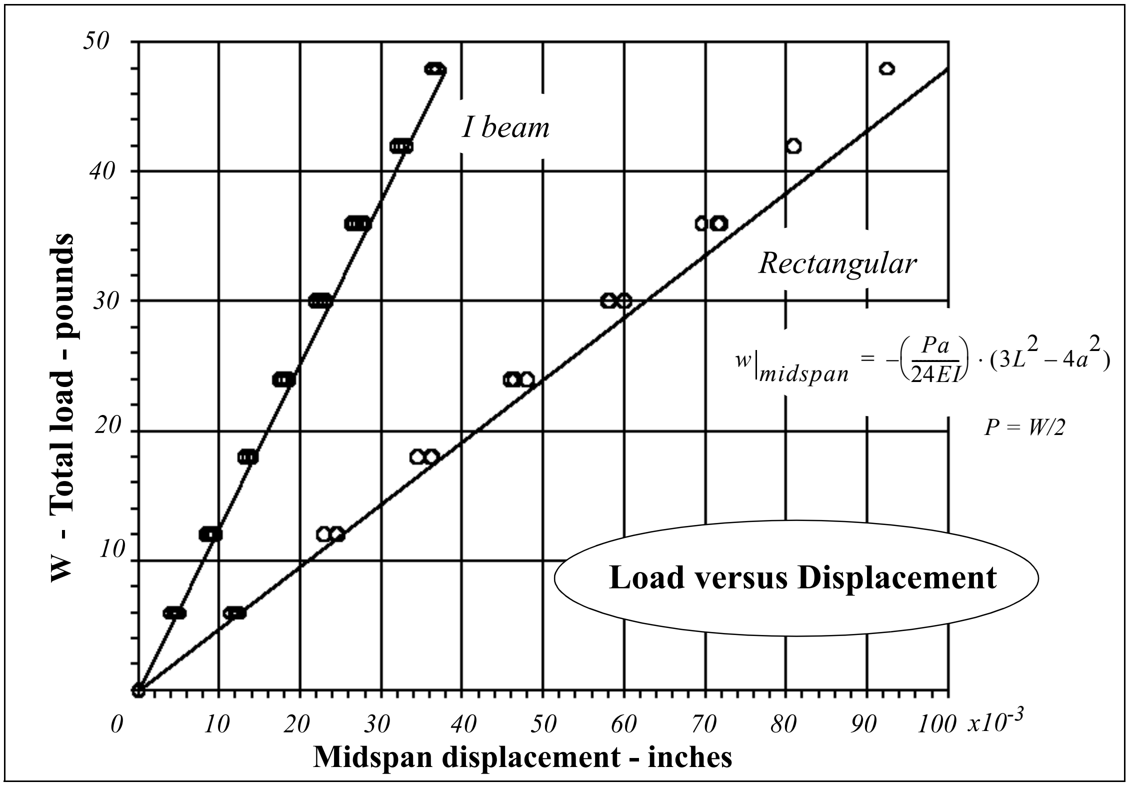
The next page shows the results - of *all* groups.

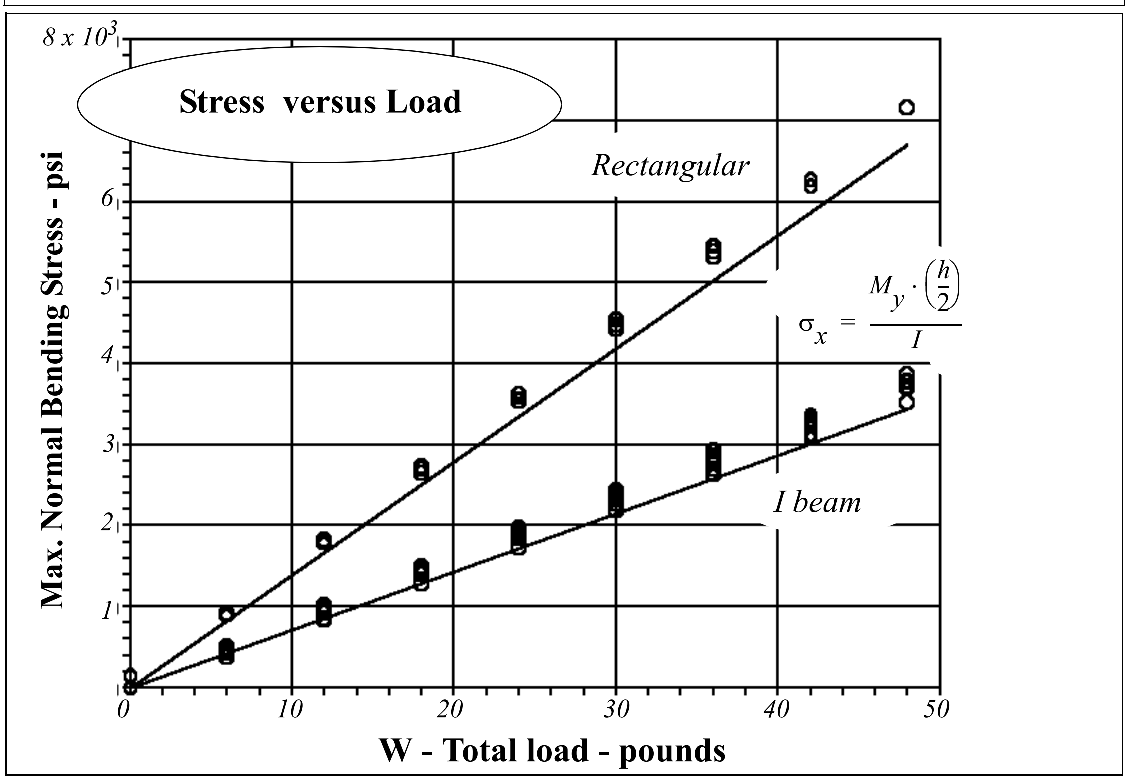
The first thing to note is the *consistency* of the data obtained by *all* groups. I have corrected for errors made by some groups in carrying out the reduction of the op-amp data to stress values.

The second thing to note is the *linearity* of the experimental results. I leave it to you to sketch in (with a straight edge) a linear fit to the load displacement data and compare the slope - the stiffness - with that of the lines shown, which were obtained from engineering beam theory.

The third thing to note is the relatively good fit (within ?? %) of theory with experiment. (You should compare percentage difference of slopes).

Finally you should note the advantage of using a beam with an I section relative to using a rectangular section of the same cross-sectional area, and hence the same amount of material. The maximum bending stress is lower for the same applied load (by a factor of ??) and the displacement less (by a factor of ???.)


I beam
Rectangular
$w|_{midspan} = -\left(\frac{Pa}{24EI}\right) \cdot (3L^2 - 4a^2)$
P = W/2
Load versus Displacement
W - Total load - pounds
Midspan displacement - inches
x10^-3


Stress versus Load
Rectangular
$\sigma_x = \frac{M_y \cdot \left(\frac{h}{2}\right)}{I}$
I beam
Max. Normal Bending Stress - psi
8 x 10^3
W - Total load - pounds