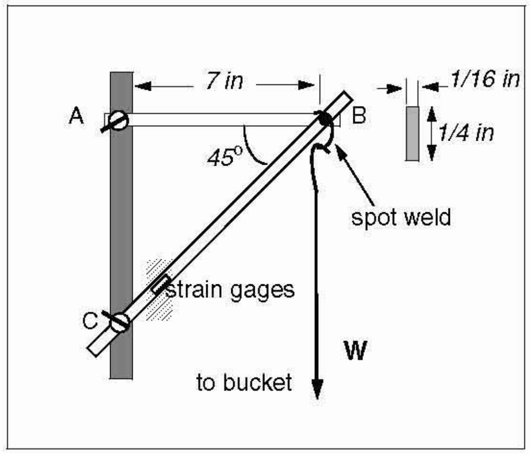
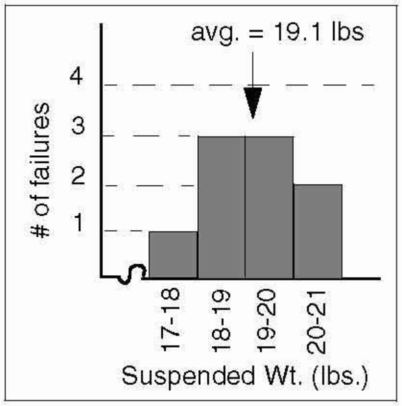
1.101 Structures Lab.
Fall 2005
Week 3 - Beam Buckling - Results

The figure at the right shows the test set-up. You suspended ever increasing weights from a chain attached to the joint - spot welded - at B. Member BC bent out-of-plane increasingly until you added a weight increment that caused the system to collapse. We attribute this failure to the buckling of member BC.



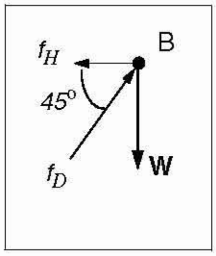
If BC were perfectly straight and the load passed through the exact center of the joint - that is, the system had no imperfections - member BC would remain perfectly straight until the buckling load was reached. This was not the case. There were imperfections and you could see the result as bending out of plane well before the critical load was reached.



The results of your nine tests are shown at the left. The results cluster around 19/20 lbs which is quite surprising considering the sensitivity of this type of failure mode to imperfections.

But note that these are values of the *suspended* weight, W. The actual compressive force in the member at failure is obtained from an isolation of the spotwelded joint, assuming the structure can be modeled as a truss. (The joint is taken to be a frictionless pin). This is not as crude an assumption as it seems. If one does a frame analysis, treating the two members as beams, joined rigidly at B as well as at the wall at points A and C, the results for the compressive force in member BC hardly change but a percent or two.

The diagram at the right shows an isolation of “pin” B and the forces, both internal and external, acting on the pin.



Force equilibrium of pin B gives (left as an exercise for the reader) that the compressive force in the diagonal

$$f_D = 1.414*W$$

and the tensile force in the horizontal member is $f_H = W$. We conclude that the buckling load is 1.414*19.1 = 27 lbs.

Note: the boundary conditions on this beam can be taken as a cantilever fixed at the root, at C, and spring supported at its other end. I have solved the eigenvalue problem for this case - with length of diagonal = 10 inches - and obtained a lowest eigenvalue of 25.6 lb which is very close to our experimental result. Note too that our result for a simply supported beam gives a lowest eigenvalue, again for a beam of length =10 inches - of $\pi^2 EI/L^2 = \pi^2(152)/100 = 15$ lbs.

Buckling is very sensitive to boundary conditions. For a compressive member somewhere in the middle of your truss, the boundary conditions are unknown but you can still test the sensitivity to length and cross-sectional dimensions changes using form $C*EI/L^2$ where C is some constant O(10).