Muddy Card Responses Lecture M7 2/13/2004

Synopsis. Reviewed derivation of equations of simple beam theory. Re-examined derivation of shear stress-shear force equation from point of view of equilibrium of a partial section of the beam. Applied moment-curvature, moment-stress and shear force-shear stress equations to a beam with a continuous, uniform applied load. Integrated M(x) twice to obtain w(x) (deflection). Applied boundary conditions, w=0 at x=0, L to obtain constants of integration. Observed that the bending stresses are greater than the shear stresses by a factor of L/h (thereby justifying our assumptions of simple beam theory). Began to consider case of discontinuous or point loading which results in discontinuous bending moment equations in x. Need to integrate M(x) for each segment of the beam and ensure equal slopes and displacements at the connections between the segments. We will cover this more next time.

It was helpful to learn how to use the moment equation to find w(x) and how to correctly apply the boundary conditions. In the beginning of lecture you drew a diagram, and said that the shear force was equal to the axial force. Is there only a shear σ_{zx} at height z0 or does it exist elsewhere in the z-axis? I think there should be some shear σ_{zx} elsewhere, but I am not sure how to find it. For a rectangular section the shear stress distribution varies parabolically with z. It has a maximum at z=0.

This is from: $\sigma_{xz}(z) = -\dfrac{SQ}{I_{yy}b}$, where $Q = \int\limits_{z}^{h/2} z b\, dz$. For a rectangular cross-section:

$$Q = \int\limits_{z}^{h/2} zb\,dz = \left[\frac{z^2}{2}b\right]_{z}^{h/2} = \frac{b}{2}\left[\frac{h^2}{4} - z^2\right]_{z}^{h/2} : \text{ Hence } \sigma_{xz} = -S\frac{b}{2}\left[\frac{h^2}{4} - z^2\right] \times \frac{12}{bh^3} \times \frac{1}{b}, \text{ which}$$

simplifies to: $\sigma_{xz} = -\dfrac{6S}{bh^3}\left[\dfrac{h^2}{4} - z^2\right]$

What is not simple beam theory? Simple beam theory, as we define it, is confined to slender (L>b,h), symmetric cross-sections, loaded by transverse loads along the axis of symmetry of the cross-section.

More general structural idealizations lead to:

General beam theory allows for arbitrary transverse loads and arbitrary cross-sections (non-symmetric). A general beam-column (or beam rod) has axial loading superimposed on the transverse (bending loading). Plate theory allows for b to be of the same order as L (and both are greater than h). Shell theory allows for curved surfaces rather than flat plates.   General beam theory and beam-columns are taught in 16.20. Plate and shell theory is largely a graduate subject.

To what extent is theoretical analysis in determining the stresses acting on a wing? Not exactly sure what this question is. I think that it is most likely that you are asking to what extent is it useful.   If the wing were long, slender and had a symmetric cross-section it would

do very well – simple beam theory works very well, and you will see this in a lab in a few weeks time. For a wing that is not particularly slender, and , such as those you are using on the Dragonfly sequence of systems problems it will get you a reasonable estimate of the deflections and stresses on the wing – perhaps 20%. For actual design of full scale flight structures we will need to better than that.

 I need to go over the notes and try the p-set. Fair enough.

There were 11 muddy cards with no mud, or positive responses. Thank you.

Also many thanks for the St. Valentine's day serenade and card. It is very much appreciated.