

Lab 10 – Wing Structural Analysis and Bending Test

Unified Engineering

20 Apr 06

Learning Objectives

- Structural analysis of a foam wing.
- Benchtop bending test of wing, and comparison with analysis.

Procedure

- Correct any calculation errors which occurred in the wing design in previous Labs.
- Cut your wing on the AA CNC foam cutter. Save the “scrap” foam beds which remain.
- Measure the *actual* root and tip chords and thicknesses c_r , c_t , t_r , t_t of the airfoil. Their ratios will not correspond exactly to your τ and λ , because the foam cutting isn’t perfect. For multi-panel wings, measure the thicknesses at the two ends of each panel.
- Perform the spreadsheet structural analysis of your wing, per the Lab 10 notes. Use a spanwise bending inertia distribution $I(y) = 0.037 c t^3$ corresponding to your measured chords and thicknesses. For a simple taper, the local c , t would be

$$c(y) = c_r + (c_t - c_r) 2y/b$$
$$t(y) = t_r + (t_t - t_r) 2y/b$$

- Determine a set of weights (washers, pennies) and weight locations which will approximate the net loading $q(y)$ in 1g flight. The number and placement of weights is up to you. As a check, you can verify with your spreadsheet program that the weights give nearly the same predicted deflection as the continuous loading.
- Glue the center joint of your wing with 5-minute epoxy.
- Mount the wing upside down on the bench, with one wing half between its foam beds. Firmly clamp the foam beds next to the center joint, so the joint cannot squirm under load. Prop up the clamped wing at an angle, so that the cantilevered wing is nearly horizontal.
- Place the weights at the chosen y locations. The chordwise location is at the airfoil’s center of pressure, which for UExx is roughly at $(x/c)_{cp} \simeq 0.35$ at an intermediate c_ℓ .
- Measure the tip deflections δ_{LE} and δ_{TE} at the leading and trailing edge. Compute average deflection $\delta = (\delta_{LE} + \delta_{TE})/2$. Also compute the tip twist angle $\Delta\alpha = (\delta_{LE} - \delta_{TE})/c$.

Reporting – one report for each team

- Title, team number, team member names, date
- Geometry Documentation
 - Briefly explain any design changes which were made since Lab 9. If no changes were made, then you can simply re-submit the Lab 9 documentation.
 - 3-view drawing of the airplane.
 - Table of key aircraft parameters
- Structural analysis of the wing, via spreadsheet or Matlab.
 - Plots of the spreadsheet inputs: Loading $q(y) \simeq K_q c(y)$, and the bending stiffness $EI(y)$. Explain how these were calculated.
 - Plots of the spreadsheet outputs: $\mathcal{S}(y)$, $M(y)$, $\kappa(y)$, $\theta(y)$, and $w(y)$.
- Comparison of the calculated and measured tip deflections $\delta \equiv w(b/2)$. Discussion of uncertainties in the calculations and the measurements.