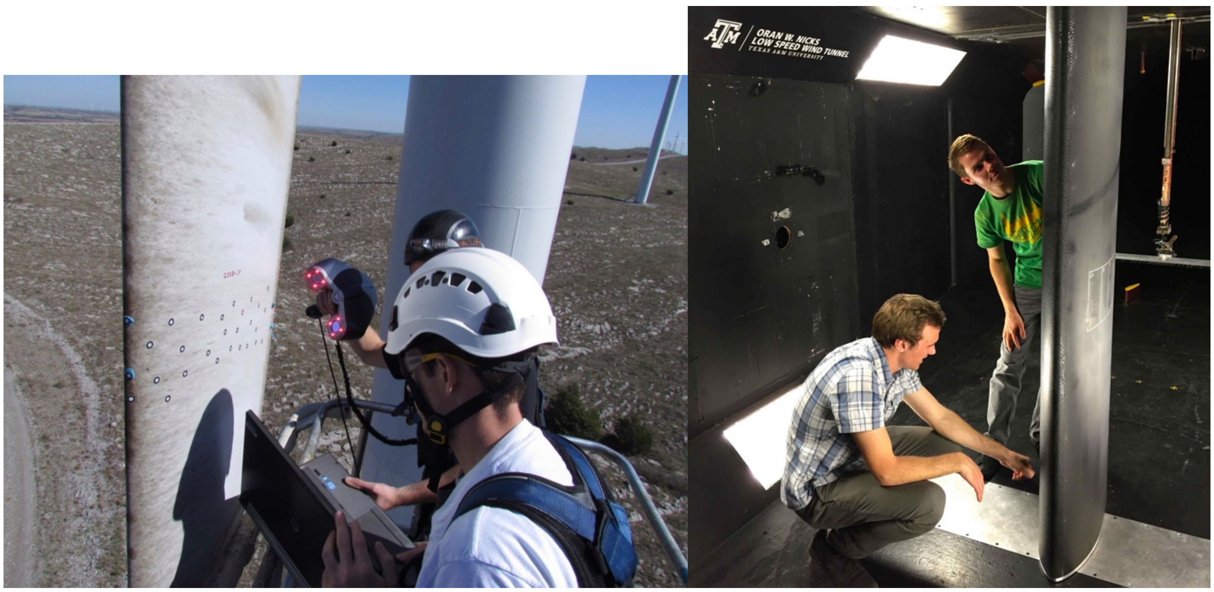
Aerospace Engineering 307: Spring 2023
NACA 63(3)-418 Airfoil Lift and Pitch Moment Test

1. Introduction

For this experiment, we will be analyzing a 32-inch-chord NACA 63(3)-418 airfoil model. This airfoil is a low-drag shape typical of what is used near the tip of utility-scale wind turbine blades. The data was generated by Ph.D. students studying how aerodynamic performance is degraded by insect strikes and blade material degradation over time. We will be generating and analyzing the sectional lift coefficient and the sectional pitch moment coefficient from surface pressure data and analyzing how the load coefficients vary with angle of attack.



For help with questions about the data or the lecture, please contact Prof. White, ebw@tamu.edu. I'm happy to help and will do so as quickly as I can.

2. Lecture Concepts

- Nondimensionalizing wind-tunnel pressure data to find C_p (without knowing p_∞).
- Calculating C_N (body fixed) and C_L (wind fixed) from C_p data.
- Moment reference center and C_m.
- Least-square $C_L(\alpha)$ fit for the "linear lift range".

3. Procedure and Data Analysis

You will receive a text file containing:

- Angle of attack, α, units of degrees.
- Dynamic pressure, q_∞, units of psf, for each α.
- Static pressures measured at specified (x, z) locations around the airfoil, units of psf, for each α.

Worksheet Instructions Data Analysis Steps

1. Briefly describe why this experiment was carried out. ***(5 points)***
2. Explain why p_∞ isn't used to compute C_p and what is done instead. ***(5 points)***
3. Explain why to compute C_L one must first compute C_N while C_m can be computed directly from pressure data. ***(5 points)***
4. Plot the nondimensional airfoil shape $(x/c, z/c)$. Be sure to close the airfoil contour and to choose an approximately correct plot scale. (It's an airfoil, not a whale.) ***(10 points)***
5. Plot $C_p(x/c)$ for $\alpha = -4°, +1°$, and $+9°$. Be sure to plot this with the C_p axis reversed so that negative values are up and positive values are down. To do this you'll need to determine the approximate p_0 for each angle of attack. That is, be sure $C_{p,\max}$ is equal to 1.0. Be sure to close the data contour so you don't lose track of the trailing edge. ***(20 points)***
6. Plot $C_L(\alpha)$ calculated using the trapezoid rule. Be sure to close the integration contour. ***(10 points)***
7. Calculate the lift-curve slope, a, and zero-lift angle $\alpha_{L=0}$ using a least-squares fit in the linear lift range. Report a in units of 1/radian and $\alpha_{L=0}$ in units of degrees. Indicate the α range over which you performed the fit and plot the resulting fit line on the plot from the previous step. ***(15 points)***
8. Explain what value of a you expect and whether the result meets you expectation. If it does not, explain why it might not. ***(5 points)***
9. Plot $C_m(\alpha)$ calculated using the trapezoid rule. Use $c/4$ as the moment reference center. Be sure your sign convention gives $C_m > 0$ for nose-up pitch and be sure to close the integration contour. ***(15 points)***
10. Is $c/4$ the aerodynamic center? Explain why it is or is not. If it is not, where else might it be besides $c/4$? How might you calculate this? ***(5 points)***
11. Briefly describe different potential sources of error. ***(5 points)***

Graphs must have axes labeled with appropriate units.