Notes on CQ #1

$$D_1' = q_{\infty_1} c C_d \left(\mathrm{Re}_1\right)$$
$$D_2' = q_{\infty_2} c C_d \left(\mathrm{Re}_2\right)$$

$$\Rightarrow Drag\ scales\ with\ V_\infty^2 \times C_d(V_\infty)$$

$$\begin{cases} q\infty_1 = \frac{1}{2} p\infty V_1^2 \\ q\infty_2 = \frac{1}{2} p\infty V_2^2 = 4q\infty_1 \\ \mathrm{Re}_1 = \frac{V_1 C}{V\infty} \\ \mathrm{Re}_2 = \frac{V_2 C}{V\infty} \end{cases}$$

$$D' = q_\infty c\, C_d(\mathrm{Re})$$

From data, $C_d \propto \mathrm{Re}^{-\frac{1}{2}} \Rightarrow$ Laminar flow behavior

$$D' \propto \underbrace{q_\infty}_{\propto V_\infty^2} c \underbrace{\mathrm{Re}^{-\frac{1}{2}}}_{\propto V_\infty^{-\frac{1}{2}}}$$

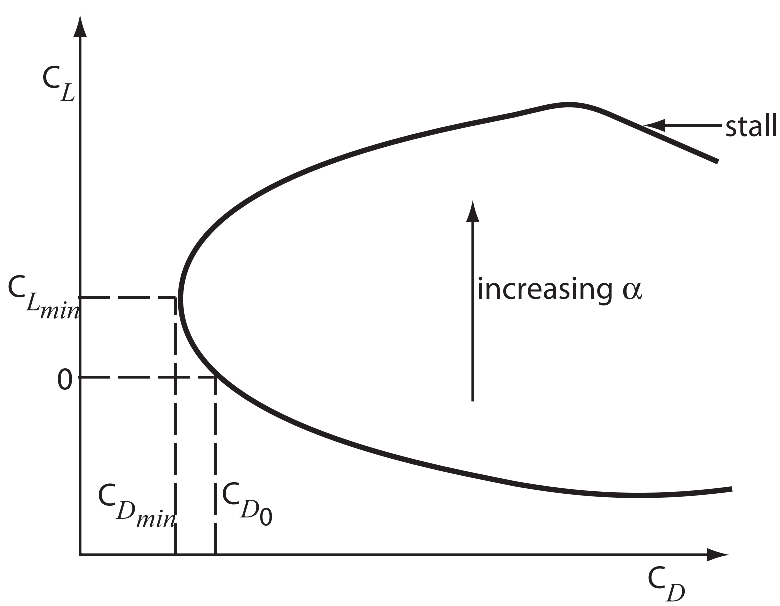
$\boxed{D' \propto V_\infty^{\frac{3}{2}}}$, $c.f.$ Turbulent $C_d \propto \mathrm{Re}^{-\frac{1}{7}}$, $D' \propto V_\infty^{\frac{13}{7}}$

$\Rightarrow \boxed{D' \uparrow with\, V_\infty \uparrow}$

Note dependence on chord $D' \propto c^{\frac{1}{2}}$, c.f. Turbulent $D' \propto c^{\frac{6}{7}}$

Drag Polar

$$C_L \equiv \frac{L}{q_\infty \underbrace{S_{ref}}_{\substack{usually \\ wing \\ planform}}} \text{ or } C_l \equiv \frac{L'}{q_\infty \underbrace{\ell_{ref}}_{\substack{usually \\ chord}}}$$



For many aircraft,

$$C_D \cong C_{D_{\min}} + k_{\min}\left(C_L - C_{L_{\min}}\right)^2$$

Also, since $C_{D_{\min}} \approx C_{D_o}$ & $C_{L_{\min}} \approx 0$

$$C_D \cong C_{D_O} + kC_L^2$$

The first option will be slightly more accurate, but both are reasonable approximations.

Notes on CQ #2

(1) First, we note that C_{D_O} & k will almost certainly depend on the Reynolds number. But, this dependence is probably weak since the b.l. flow will be turbulent. So, we <u>assume</u> C_{D_O} & k remain constant to good approximation. Also important is that for a general aviation aircraft, we expect no wave drag since the flight is subsonic.

(2)

$$D = \frac{1}{2}\rho V^2 S\left(C_{D_O} + kC_L^2\right)$$

$$= \frac{1}{2}\rho V^2 S C_{D_O} + k\left(\frac{1}{2}\rho V^2 S\right)\left(\frac{W}{\frac{1}{2}\rho V^2 S}\right)^2$$

$$D = \underbrace{\left(\frac{1}{2}\rho S C_{D_O}\right)V^2}_{D_0} + \underbrace{\left(\frac{k}{\frac{1}{2}\rho S}W^2\right)\frac{1}{V^2}}_{D_L}$$

So we see that $D_0 \propto V^2$ & $D_L \propto \frac{1}{V^2}$

(3) Often at cruise, $D_{0_C} \approx D_{L_C}$ for prop-aircraft.

$$\boxed{D_C = D_{0_C} + D_{L_C} = 2D_{0_C}}$$

At approach:

$$\boxed{D_A = 4D_{0_C} + \frac{1}{4}D_{0_C} = 4\frac{1}{4}D_{0_C}}$$

Note: $D_A > D_C$