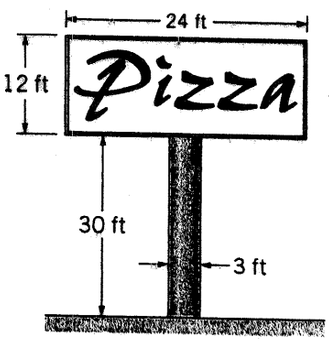
9.57

9.57 The structure shown in Fig. P9.57 consists of a cylindrical support post to which a rectangular flat-plate sign is attached. Estimate the drag on the structure when a 50-mph wind blows against it.



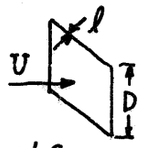
■ FIGURE P9.57

$\mathcal{D} = \mathcal{D}_{sign} + \mathcal{D}_{post}$, where $\mathcal{D}_{sign} = \frac{1}{2}\rho V^2 A_{sign} C_{D_{sign}}$ and (1)

$\mathcal{D}_{post} = \frac{1}{2}\rho V^2 A_{post} C_{D_{post}}$

Also, $A_{sign} = 12\,ft\,(24\,ft) = 288\,ft^2$ and

$A_{post} = 3\,ft\,(30\,ft) = 90\,ft^2$



From Fig. 9.28, for a thin flat plate with $l/D \approx 0.1$, $C_D = 1.9$

Thus, $C_{D_{sign}} = 1.9$

Also, for the cylinder (post), $Re = \frac{VD}{\nu}$, where

$$V = 50\frac{mi}{hr}\left(\frac{1\,hr}{(60)^2 s}\right)\frac{5280\,ft}{1\,mi} = 73.3\,\frac{ft}{s}$$

so that

$$Re = \frac{(73.3\,\frac{ft}{s})(3\,ft)}{1.57\times10^{-4}\,\frac{ft^2}{s}} = 1.40\times10^6$$

Hence, from Fig. 9.21, $C_{D_{post}} = 0.8$

By using the above data, Eq. (1) gives

$$\mathcal{D} = \frac{1}{2}\rho V^2\left[A_{sign} C_{D_{sign}} + A_{post} C_{D_{post}}\right]$$

$$= \frac{1}{2}\left(0.00238\,\frac{slugs}{ft^3}\right)\left(73.3\,\frac{ft}{s}\right)^2\left[288\,ft^2(1.9) + 90\,ft^2(0.8)\right]$$

or

$$\mathcal{D} = \underline{\underline{3{,}960\,lb}}$$