2.75

2.75 The concrete (specific weight = 150 lb/ft³) seawall of Fig. P2.75 has a curved surface and restrains seawater at a depth of 24 ft. The trace of the surface is a parabola as illustrated. Determine the moment of the fluid force (per unit length) with respect to an axis through the toe (point *A*).

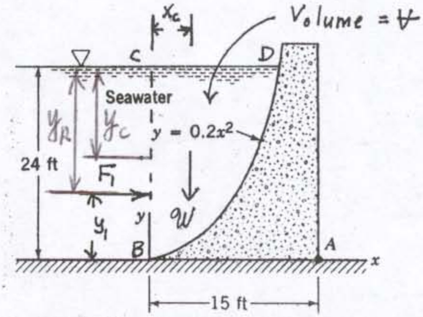


FIGURE P2.75

The components of the fluid force acting on the wall are F_1 and $\mathcal{W}$ as shown on the figure where

$$y_R = \frac{I_{xc}}{y_c A} + y_c = \frac{\frac{1}{12}\times 1\times 24^3}{12\times 1\times 24} + 12 = 16\,ft$$

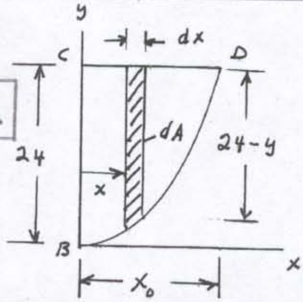
$$F_1 = \gamma h_c A = \left(64.0\,\frac{lb}{ft^3}\right)\left(\frac{24\,ft}{2}\right)(24\,ft \times 1\,ft) = 18{,}400\,lb \quad \text{and} \quad y_1 = \frac{24\,ft}{3} = 8\,ft$$

$$\boxed{y_1 = 24 - y_R = 24 - 16 = 8\,ft.}$$

Also,

$$\mathcal{W} = \gamma \forall$$

To determine $\forall$ find area BCD. Thus, (see figure to right)



$$A = \int_0^{x_0} (24 - y)\,dx = \int_0^{x_0} (24 - 0.2x^2)\,dx$$

$$\boxed{24 = 0.2x_0^2 \Rightarrow x_0 = \sqrt{120}}$$

$$= \left[24x - \frac{0.2x^3}{3}\right]_0^{x_0}$$

(Note: All lengths in ft)

and with $x_0 = \sqrt{120}$, $A = 175\,ft^2$ so that

$$\forall = A \times 1\,ft = 175\,ft^3$$

Thus,

$$\mathcal{W} = \left(64.0\,\frac{lb}{ft^3}\right)(175\,ft^3) = 11{,}200\,lb$$

To locate centroid of A:

$$x_c A = \int_0^{x_0} x\,dA = \int_0^{x_0} (24 - y)\,x\,dx = \int_0^{x_0} (24x - 0.2x^3)\,dx = 12x_0^2 - \frac{0.2x_0^4}{4}$$

and

$$x_c = \frac{12(\sqrt{120})^2 - \frac{0.2(\sqrt{120})^4}{4}}{175} = 4.11\,ft$$

Thus,

$$M_A = F_1 y_1 - \mathcal{W}(15 - x_c)$$
$$= (18{,}400\,lb)(8\,ft) - (11{,}200\,lb)(15\,ft - 4.11\,ft) = \underline{\underline{25{,}200\,ft\cdot lb}}$$