2.89

2.89 The concrete (specific weight = 150 lb/ft³) seawall of Fig. P2.89 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*).

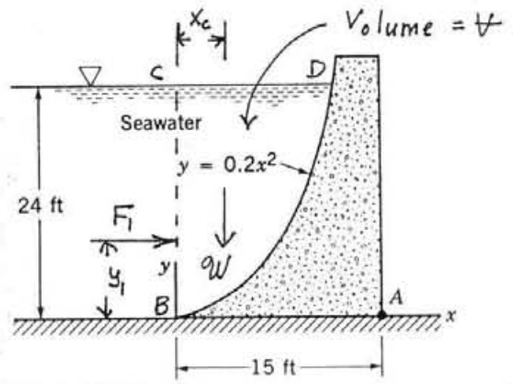


FIGURE P2.89

The components of the fluid force acting on the wall are F_1 and W as shown on the figure where

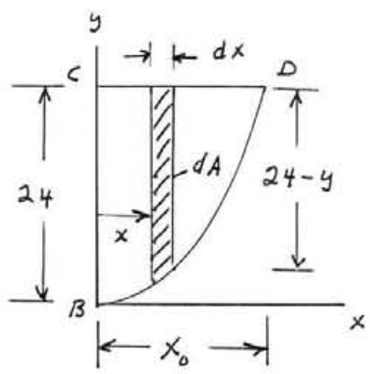
$$F_1 = \gamma h_c A = \left(64.0 \tfrac{lb}{ft^3}\right)\left(\tfrac{24\,ft}{2}\right)(24\,ft \times 1\,ft)$$

$$= 18{,}400\ lb \qquad \text{and} \qquad y_1 = \tfrac{24\,ft}{3} = 8\,ft$$

Also,

$$W = \gamma \forall$$

To determine ∀ find area BCD. Thus, (see figure to right)



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

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

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

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

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

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

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

Thus,

$$M_A = F_1 y_1 - W(15 - x_c)$$

$$= (18{,}400\ lb)(8\,ft) - (11{,}200\ lb)(15\,ft - 4.11\,ft) = \underline{25{,}200\ ft \cdot lb}$$

$x_0 = \sqrt{120}$

(Note: All lengths in ft)