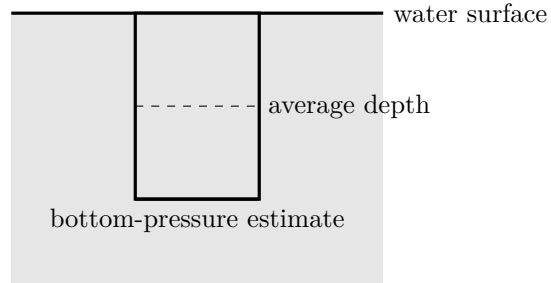
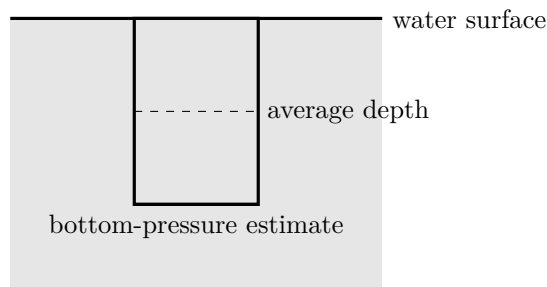


Question 9

A student uses constant pressure at the bottom of a 3-m-tall vertical rectangular gate. Explain the resulting bias and find the ratio of this estimate to the true force when the top is at the surface.



Question 9 – Solution



Step 1: Write the student's estimate. The student applies the bottom pressure $p = \gamma(3)$ uniformly over the entire gate of area A . Thus

$$F_{\text{est}} = 3\gamma A.$$

Step 2: Find the true force. For a rectangular gate extending from the surface to depth 3 m, the centroid is at the average depth

$$\bar{y} = \frac{0 + 3}{2} = \frac{3}{2} \text{ m.}$$

Therefore,

$$F_{\text{true}} = \gamma A \bar{y} = \frac{3}{2} \gamma A.$$

Step 3: Compare the estimate with the true force.

$$\frac{F_{\text{est}}}{F_{\text{true}}} = \frac{3\gamma A}{\frac{3}{2}\gamma A} = 2.$$

Thus the estimate is twice the true value:

$$F_{\text{est}} = 2F_{\text{true}}.$$

Step 4: Express the bias as a percent error.

$$\frac{F_{\text{est}} - F_{\text{true}}}{F_{\text{true}}} \times 100\% = (2 - 1)100\% = 100\%.$$

The bottom-pressure estimate is 100% too high.