4–135. If the resultant force is required to act at the center of the slab, determine the magnitude of the column loadings \( F_A \) and \( F_B \) and the magnitude of the resultant force.

**Equivalent Resultant Force:** By equating the sum of the forces along the \( z \) axis to the resultant force \( F_R \),
\[
\uparrow F_R = \Sigma F_z: \quad -F_R = -30 - 20 - 90 - F_A - F_B
\]
\[
F_R = 140 + F_A + F_B \quad (1)
\]

**Point of Application:** By equating the moment of the forces and \( F_R \) about the \( x \) and \( y \) axes,
\[
(M_R)_x = \Sigma M_x: \quad F_B(3.75) = -F_B(0.75) - 30(0.75) - 90(3.75) - 20(6.75) - F_A(6.75)
\]
\[
F_R = 0.2F_B + 1.8F_A + 132 \quad (2)
\]
\[
(M_R)_y = \Sigma M_y: \quad F_R(3.25) = 30(0.75) + 20(0.75) + 90(3.25) + F_A(5.75) + F_B(3.75)
\]
\[
F_R = 1.769F_A + 1.769F_B + 101.54 \quad (3)
\]

Solving Eqs. (1) through (3) yields
\[
F_A = 30 \text{kN} \quad F_B = 20 \text{kN} \quad F_R = 190 \text{kN} \quad \text{Ans.}
\]

4–138. Determine the magnitudes of \( F_A \) and \( F_B \) so that the resultant force passes through point \( O \) of the column.

**Equivalent Resultant Force:** By equating the sum of the forces in Fig. \( a \) along the \( z \) axis to the resultant force \( F_R \), Fig. \( b \),
\[
\uparrow F_R = \Sigma F_z: \quad -F_R = -F_A - F_B - 8 - 6
\]
\[
F_R = F_A + F_B + 14 \quad (1)
\]

**Point of Application:** Since \( F_R \) is required to pass through point \( O \), the moment of \( F_R \) about the \( x \) and \( y \) axes are equal to zero. Thus,
\[
(M_R)_x = \Sigma M_x: \quad 0 = F_B(750) + 6(650) - F_A(600) - 8(700)
\]
\[
750F_B - 600F_A - 1700 = 0 \quad (2)
\]
\[
(M_R)_y = \Sigma M_y: \quad 0 = F_A(150) + 6(100) - F_B(150) - 8(100)
\]
\[
150F_A - 150F_B + 200 = 0 \quad (3)
\]

Solving Eqs. (1) through (3) yields
\[
F_A = 18.0 \text{kN} \quad F_B = 16.7 \text{kN} \quad F_R = 48.7 \text{kN} \quad \text{Ans.}
\]
4-145. Replace the distributed loading with an equivalent resultant force, and specify its location on the beam measured from point A.

**Loading:** The distributed loading can be divided into two parts as shown in Fig. a. The magnitude and location of the resultant force of each part acting on the beam are also shown in Fig. a.

**Resultants:** Equating the sum of the forces along the y axis of Figs. a and b,

\[ + \downarrow F_R = \Sigma F; \quad F_R = \frac{1}{2} w_0 \left( \frac{L}{2} \right) + \frac{1}{2} w_0 \left( \frac{L}{2} \right) = \frac{1}{2} w_0 L \]

Ans.

If we equate the moments of \( F_R \), Fig. b, to the sum of the moment of the forces in Fig. a about point A,

\[ M_R = \Sigma M_A; \quad -\frac{1}{2} w_0 L (\frac{L}{6}) = -\frac{1}{2} w_0 \left( \frac{L}{2} \right) \left( \frac{L}{6} \right) - \frac{1}{2} w_0 \left( \frac{L}{2} \right) \left( \frac{2L}{3} \right) \]

\[ \xi = \frac{5L}{12} \]

Ans.

---

4-153. Wet concrete exerts a pressure distribution along the wall of the form. Determine the resultant force of this distribution and specify the height \( h \) where the bracing strut should be placed so that it lies through the line of action of the resultant force. The wall has a width of 5 m.

**Equivalent Resultant Force:**

\[ \rightarrow F_R = \Sigma F; \quad -F_R = -\int_A \delta A = -\int_0^m w dz \]

\[ F_R = \int_0^m (200 \lambda^2) (10^3) dz \]

\[ = 106,670 (10^3) N = 107 \text{ kN} \quad \text{Ans} \]

**Location of Equivalent Resultant Force:**

\[ \bar{\xi} = \frac{\int_A zdA}{\int_A dA} = \frac{\int_0^m (200 \lambda^2) (10^3) \lambda d\lambda}{\int_0^m (200 \lambda^2) (10^3) \lambda d\lambda} = \frac{\int_0^m (200 \lambda^2) (10^3) d\lambda}{\int_0^m (200 \lambda^2) (10^3) \lambda d\lambda} = 2.40 \text{ m} \]

Thus, \( h = 4 - \bar{\xi} = 4 - 2.40 = 1.60 \text{ m} \)  \quad \text{Ans}
4-158. The distributed load acts on the beam as shown. Determine the magnitude of the equivalent resultant force and specify where it acts, measured from point A.

\[ F_x = \int w(x) \, dx = \int_a^b (-2x^2 + 4x + 16) \, dx = 53.333 = 33.3 \text{ lb} \quad \text{Ans} \]

\[ x = \frac{\int x \cdot w(x) \, dx}{\int w(x) \, dx} = \frac{\int x \cdot (-2x^2 + 4x + 16) \, dx}{53.333} = 1.60 \text{ ft} \quad \text{Ans} \]

5-3. Draw the free-body diagram of the dumpster D of the truck, which has a weight of 5000 lb and a center of gravity at G. It is supported by a pin at A and a pin-connected hydraulic cylinder BC (short link). Explain the significance of each force on the diagram. (See Fig. 5-7b.)

**The Significance of Each Force:**
- \( W \) is the effect of gravity (weight) on the dumpster.
- \( A_x \) and \( A_y \) are the pin A reactions on the dumpster.
- \( F_{BC} \) is the hydraulic cylinder BC reaction on the dumpster.

5-6. Draw the free-body diagram of the crane boom \( AB \) which has a weight of 650 lb and center of gravity at G. The boom is supported by a pin at A and cable BC. The load of 1250 lb is suspended from a cable attached at B. Explain the significance of each force acting on the diagram. (See Fig. 5-7b.)
The Significance of Each Force:

$W$ is the effect of gravity (weight) on the boom.

$A_x$ and $A_y$ are the pin $A$ reactions on the boom.

$T_{BC}$ is the cable $BC$ force reactions on the boom.

1250 lb force is the suspended load reaction on the boom.