



AEE 461 Design of Aircraft Structures

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Lecture #2 Principal of Statics

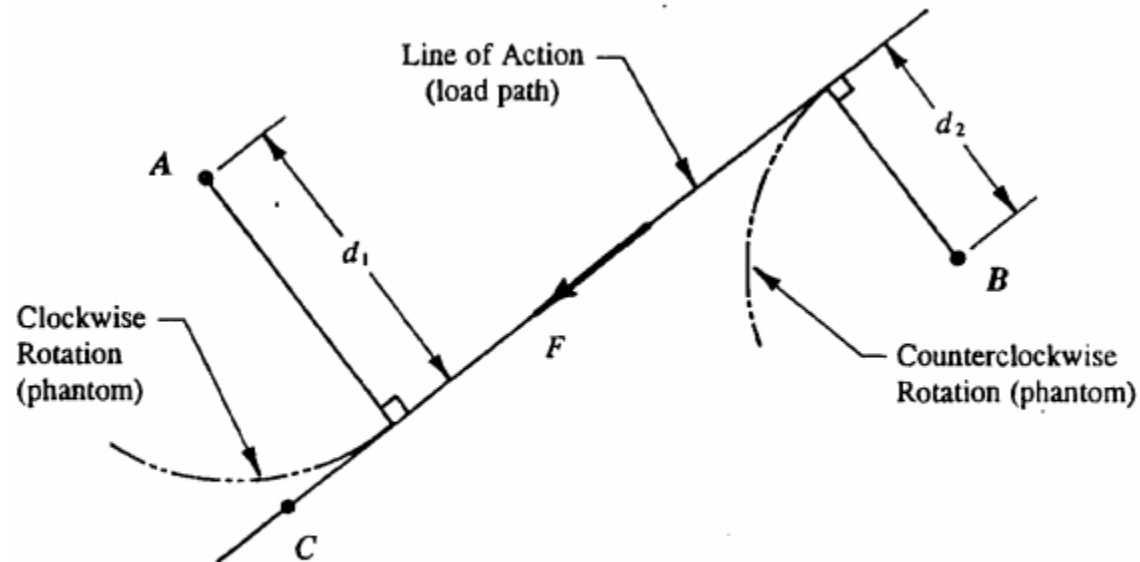


FIGURE 1-1 Illustration of a moment of a force at points A and B .

$$M = Fd. \quad (1-1)$$

Moment @ $A = M_A = Fd_1$ (clockwise rotation)

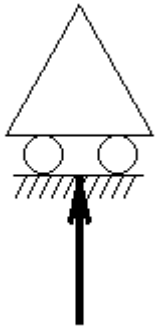
Moment @ $B = M_B = Fd_2$ (counterclockwise rotation)

$$M_A = Fd_1$$

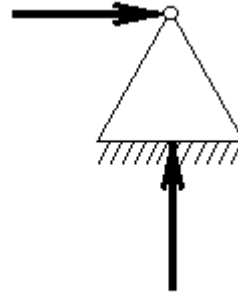
$$M_B = -Fd_2.$$

$$M_C = 0$$

Infinite number of support types are physically possible, however three of them will be discussed in here:



a) Roller Support



b) Pinned Support



c) Fixed Support

Roller Support:

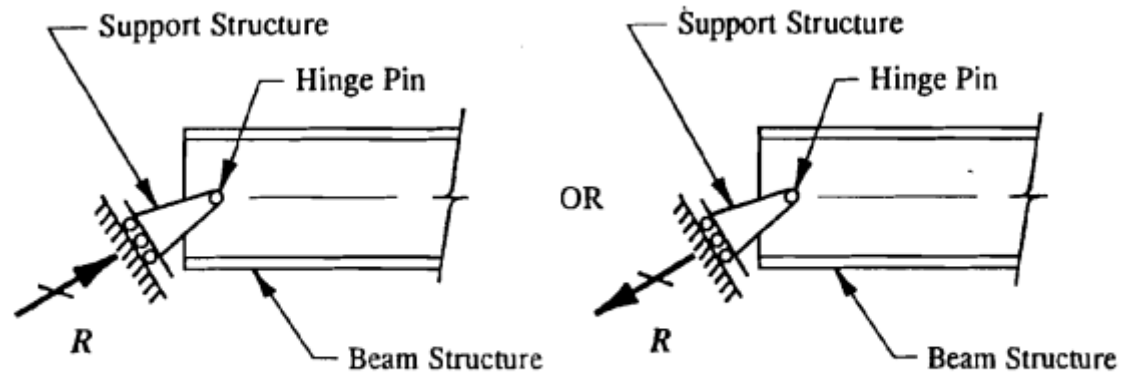
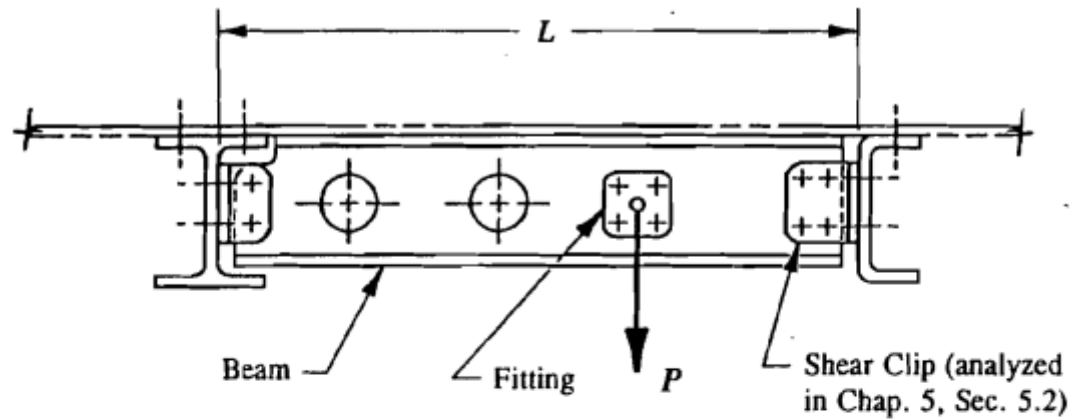
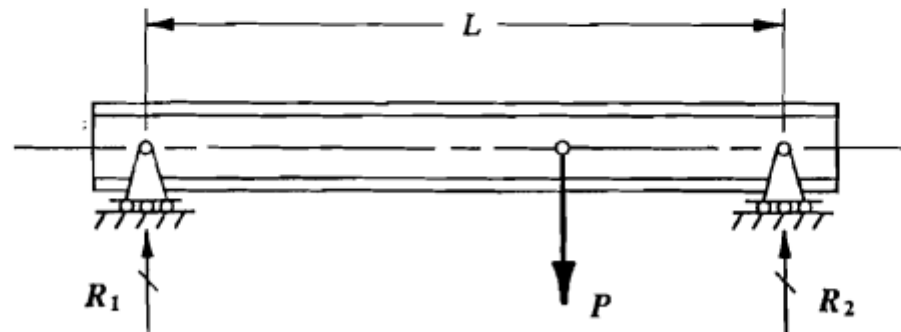


FIGURE 1-2 Roller support. The line of action indicated by the reaction R .

Roller Support:



(a) Actual Beam Structure



(b) Idealized Beam Structure

FIGURE 1-3 Beam simply-supported at its ends by shear clips.

Pinned Support:

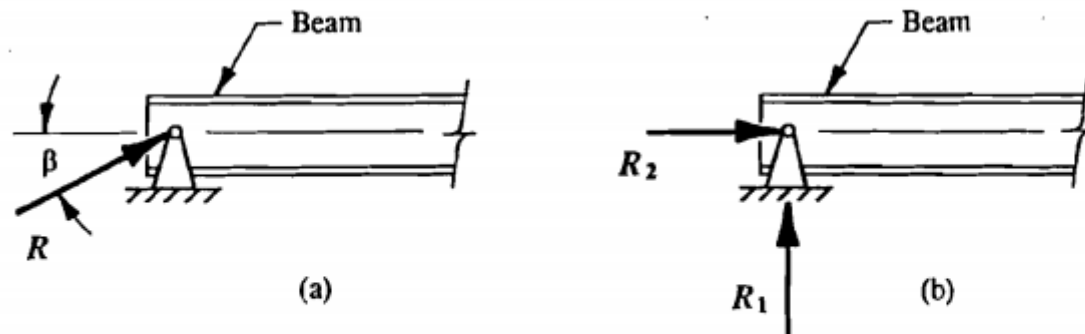


FIGURE 1-4 Pinned support, (a) line of action of the reaction force R , (b) the reaction force R represented by equivalent component forces.

Pinned Support:

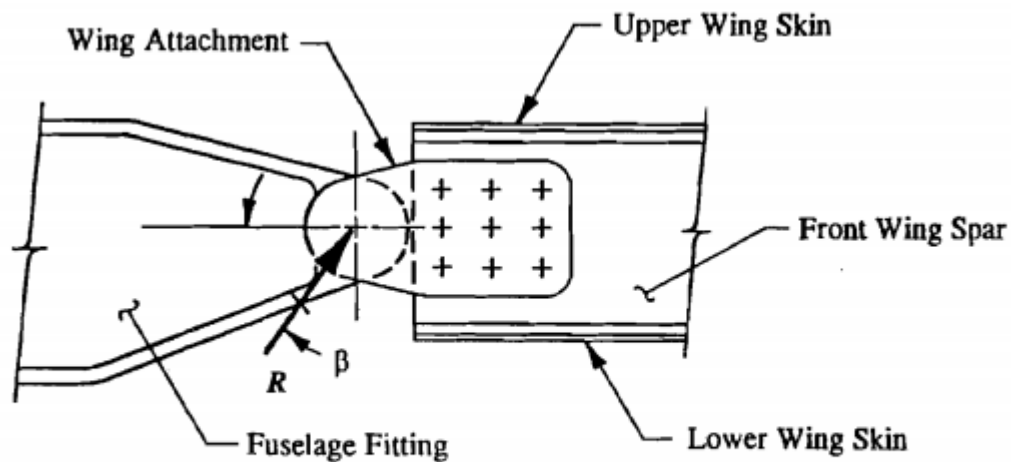


FIGURE 1-5 An actual lug and pin arrangement which transmits a reactive force R in any direction.

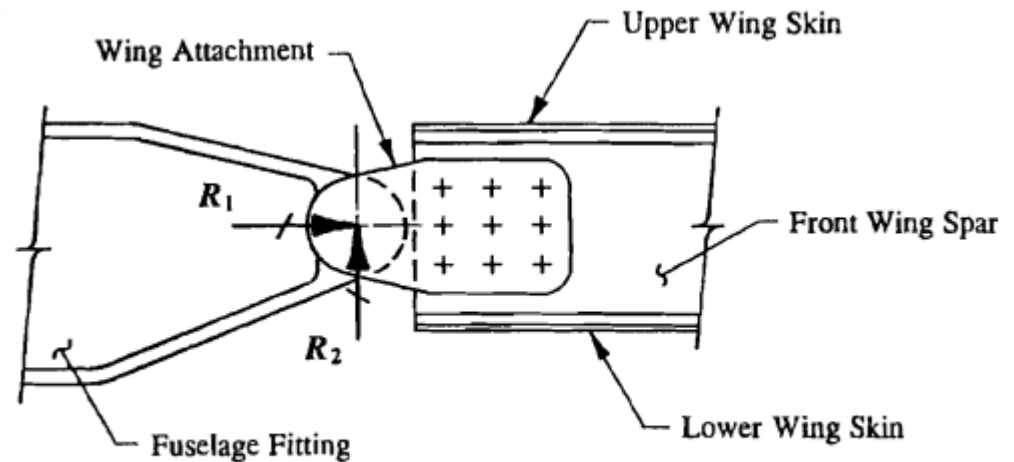


FIGURE 1-6 Resultant force replaced by component forces R_1 and R_2 .

Fixed Support:

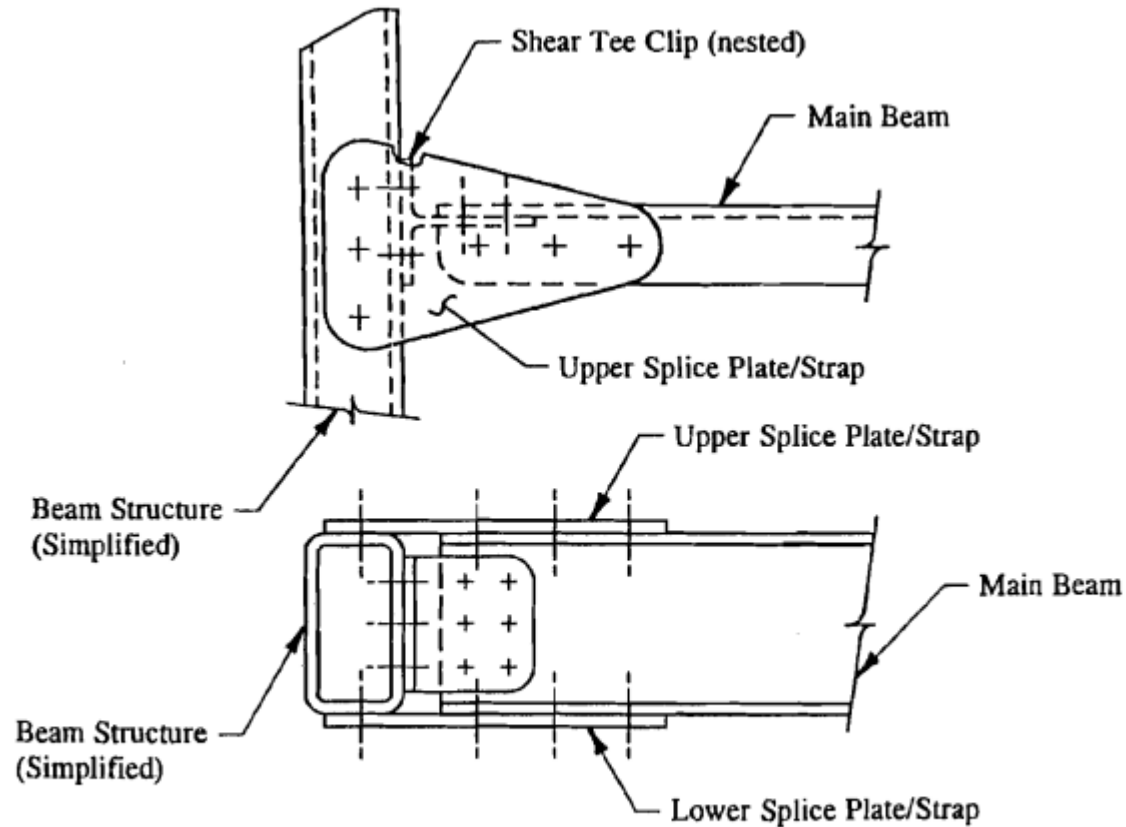


FIGURE 1-7 Fixed support structure represented by actual structure.

Fixed Support:

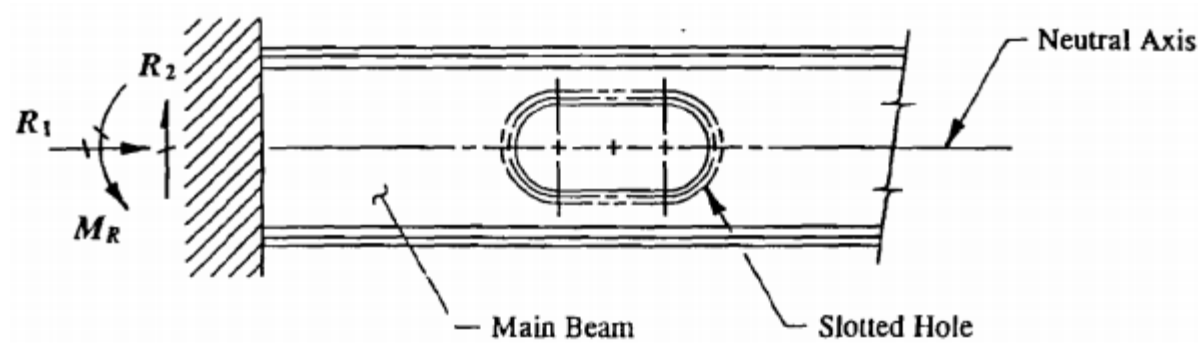


FIGURE 1-8 Idealization of a fixed support structure.

Concentrated Load:

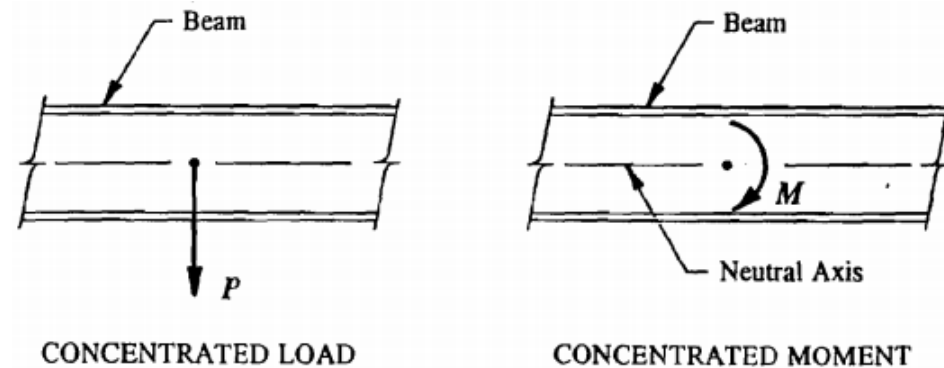


FIGURE 1-9 Idealization of concentrated loading types.

Distributed Load:

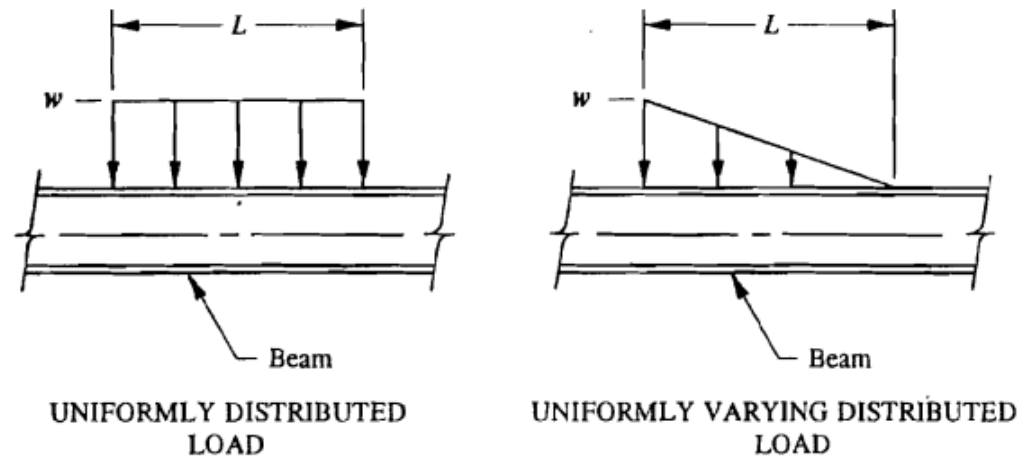
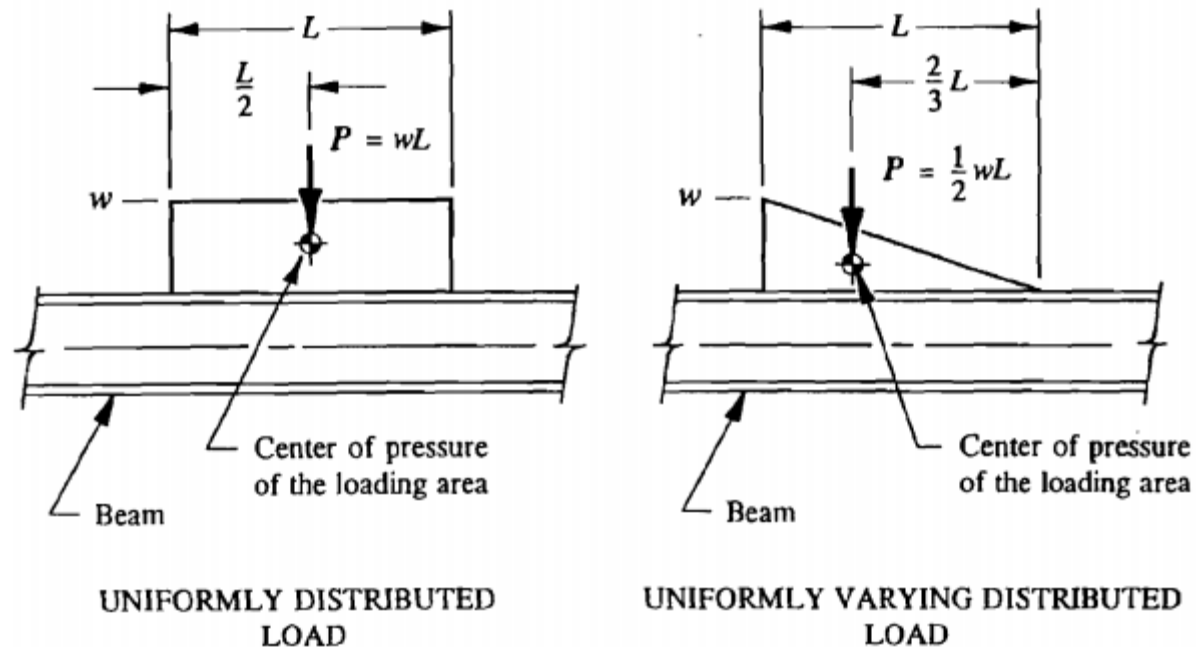
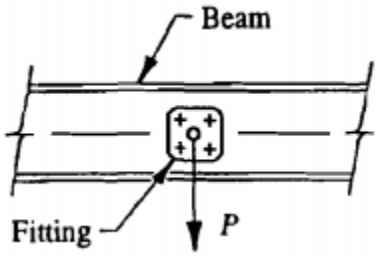
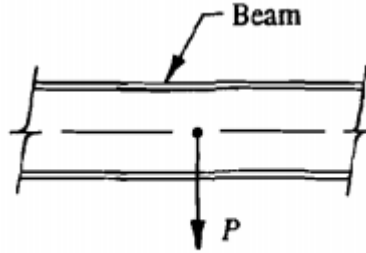
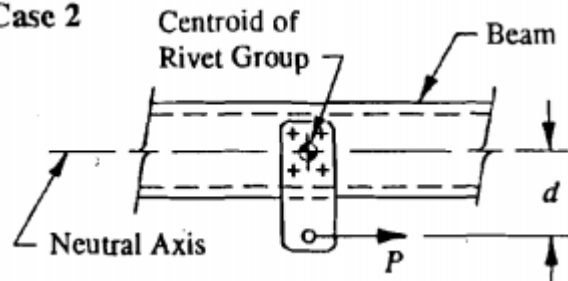
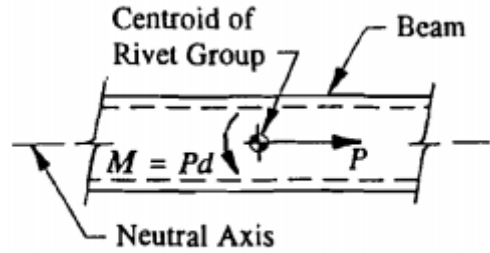


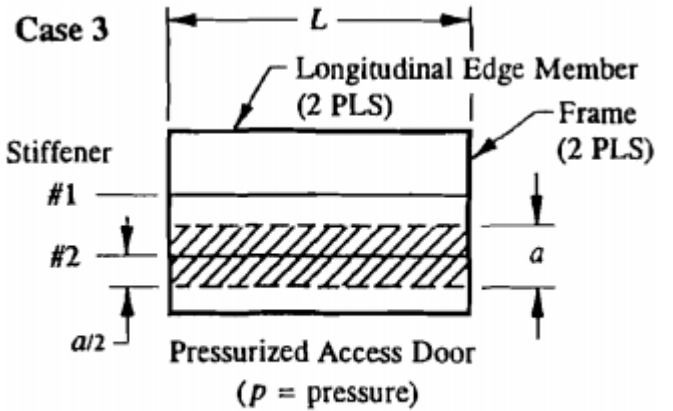
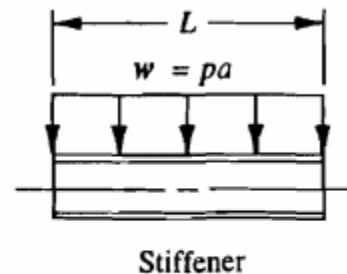
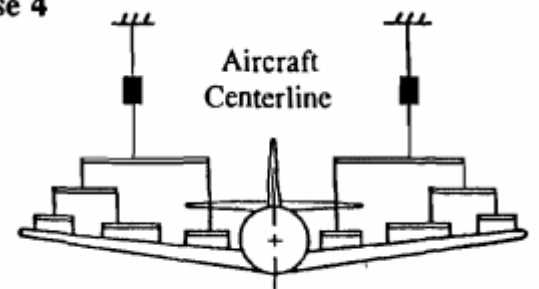
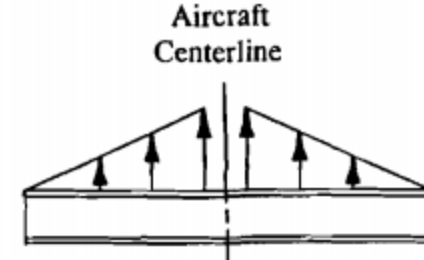
FIGURE 1-10 Representation of distributed loading types.

Distributed Load:

**FIGURE 1-11** Idealization of distributed loading types.

CALCULATION OF BEAM REACTIONS

Actual Loading Structure	Idealized Loading Structure
<p>Case 1</p> 	 <p>CONCENTRATED LOAD</p>
<p>Case 2</p> 	 <p>CONCENTRATED MOMENT</p>

Actual Loading Structure	Idealized Loading Structure
<p>Case 3</p>  <p>UNIFORM PRESSURE DISTRIBUTION</p>	 <p>UNIFORMLY DISTRIBUTED LOAD (looking at panel in section)</p>
<p>Case 4</p>  <p>WING UP-BENDING</p>	 <p>UNIFORMLY VARYING DISTRIBUTED LOAD</p>

Example 1-1:

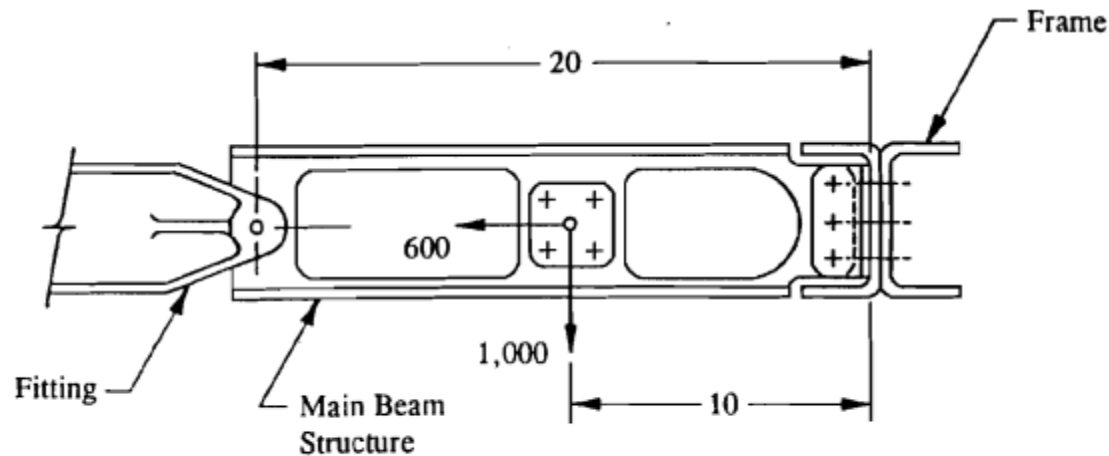


FIGURE 1-12 Beam structure loaded by two concentrated loads.

Find the magnitude and direction of the beam reactions at the supports. Then, draw a free-body diagram of the structure with the balanced set of applied loads and reaction forces properly indicated.

Solution:

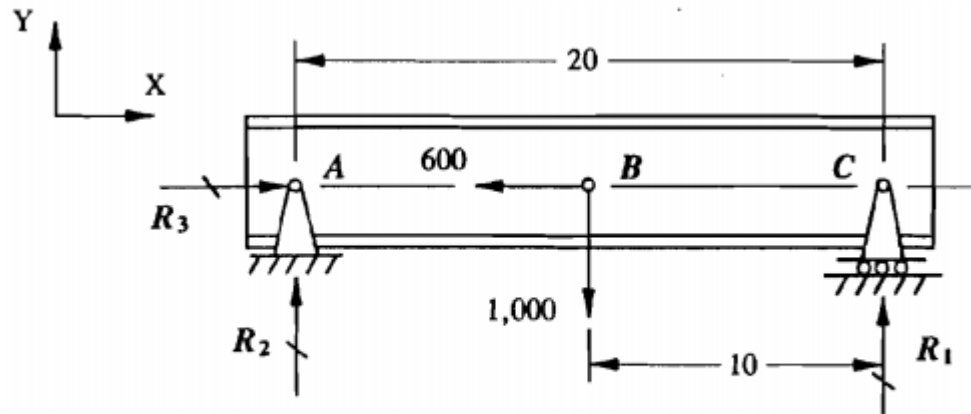


FIGURE 1-13 Free-body diagram of unknown reaction forces.

Assumptions:

- Coordinated system: Rectangular CS
- All the loads are in one plane (XY-plane)
 - Therefore, $\sum F_x = 0$, $\sum F_y = 0$ and $\sum M_z = 0$

Solution:

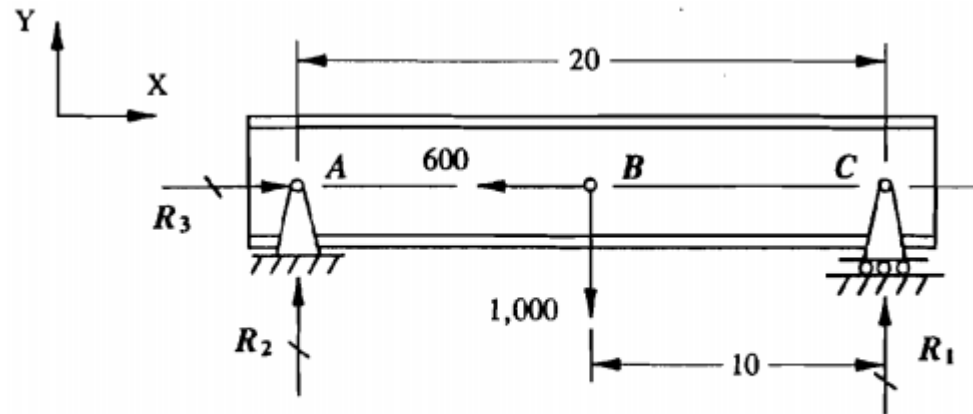


FIGURE 1-13 Free-body diagram of unknown reaction forces.

$$\sum F_x = 0 \rightarrow R_3 - 600 = 0 \text{ then } R_3 = 600 \text{ lb.}$$

$$\sum F_y = 0 \rightarrow R_2 + R_1 - 1000$$

Total moment at point C:

$$\sum M_z = 0 \rightarrow R_2 \cdot (20) - 1000 \cdot (10) = 0, \rightarrow R_2 = 500 \text{ lb and therefore}$$

$$500 + R_1 - 1000 = 0 \rightarrow R_1 = 500 \text{ lb}$$

Example 1-2:

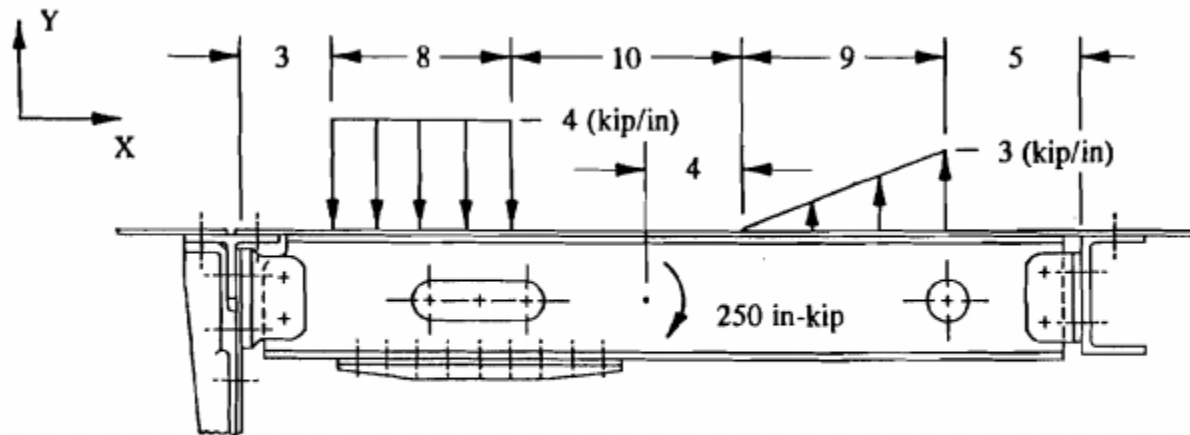


FIGURE 1-18 Beam structure loaded by a concentrated moment and two different distributed loading types.

Calculate the required beam reactions to maintain static equilibrium of this structure. Draw free-body diagram.

Solution:

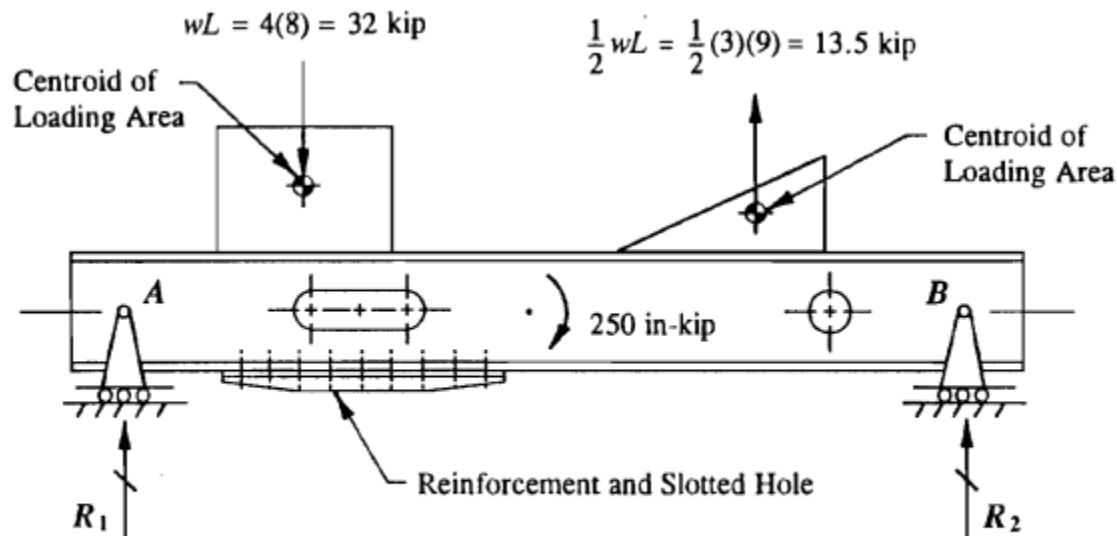


FIGURE 1-19 Idealization of the distributed loading types with unknown reaction forces depicted.

Assumptions:

- Coordinated system: Rectangular CS
- All the loads are in one plane (XY-plane)
 - Therefore, $\sum F_x = 0$, $\sum F_y = 0$ and $\sum M_z = 0$

Solution:

$$\sum F_x = 0 \rightarrow 0 = 0, \quad \sum F_y = 0 \rightarrow R_1 - 32 + 13.5 + R_2 = 0, R_1 = -R_2 + 18.5$$

Total moment at point A:

$$\sum M_z = 0 \rightarrow 32 \cdot (7) + 250 - 13.5 \cdot (27) + R_2 \cdot (35) = 0, \rightarrow R_2 = 3.129 \text{ kip}$$

$$R_1 = -(3.129) + 18.5 \rightarrow R_1 = 15.371 \text{ kip or } 15371 \text{ lb}$$

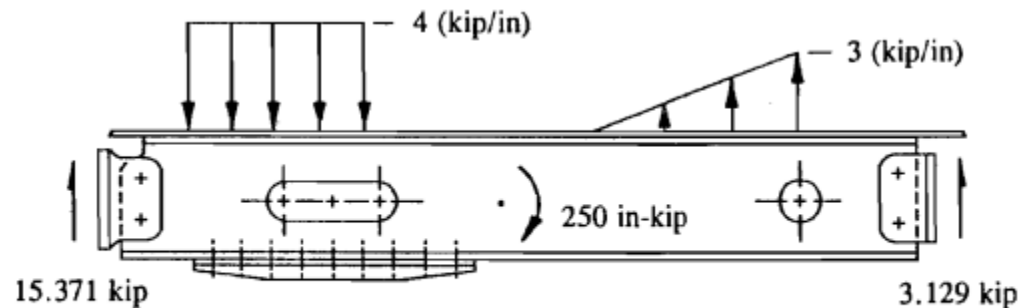


FIGURE 1-20 Free-body diagram of the loaded beam structure.