Aircraft Structural Analysis

Chapter 2

Statically Determinate Structures

2.1 Introduction

The purpose of this chapter is to review and Reinforce the principle of static equilibrium within the context of some basic types of aircraft structures. A structure may be defined as an assemblage of materials that is intended to sustain loads. How well the intention is realized depends on the design, and that depends (among other things) on how well the shape of the structure and the properties of the selected materials accommodate the predicted internal loads.

Therefore, it is important for a structural designer, in spite of—and aided by—digital computers, to develop a keen insight for predicting and visualizing load paths throughout a structure. The ability to do so largely depends on <u>how well one has mastered the skills of sketching accurate free-body diagrams and properly applying the equilibrium equations to them, which will be one of our primary concerns here.</u>

2.1 Introduction

- Statically determinate structures
  - Pinned and rigid-jointed frames
  - Stiffened shear webs
  - Thin-Walled beams and torque tubes

But, most real structures are statically indeterminate with redundant elements.

2.2 Plane Trusses

A truss, also called a pin-jointed bars, is an idealized skeletal or "stick-like" structure composed of slender rods joined together by smooth pins at the joints, also called nodes.

None of the smooth pins can apply a "couple" to the rods connected to it. Each member withstands tensile and compressive forces can not transfer couple moment.

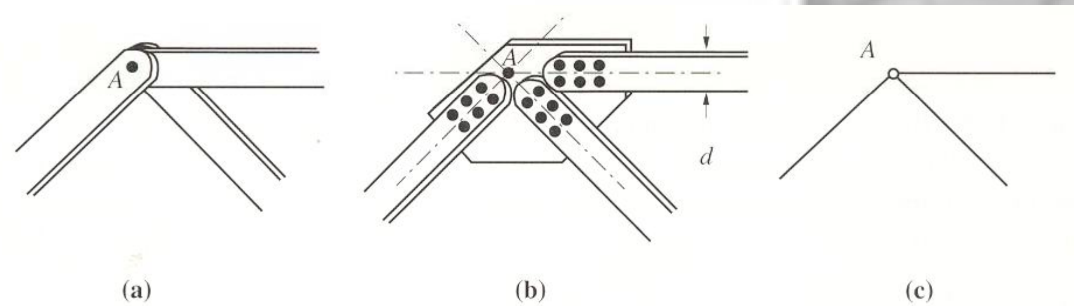


Figure 2.2.1 (a) Plane frame members held together by a single pin. (b) A riveted or bolted connection. (c) The idealized pin joint.

2.2 Plane Trusses

Statically determinated Truss :

Number of Triangles	1	2	3	4	. . .	i
Number of Joints	3	4	5	6	. . .	j = i+2
Number of members	3	5	7	9	. . .	m = 2i+1

$$\therefore\ 2j = m + 3$$

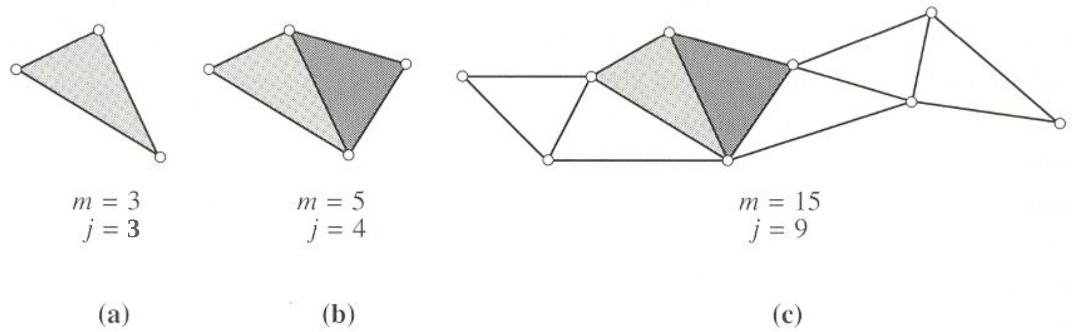


Figure 2.2.2 Stable trusses composed of triangular "building blocks."

2.2 Plane Trusses

- Externally statically determinate
- Minimally stable
- Internally statically determinate

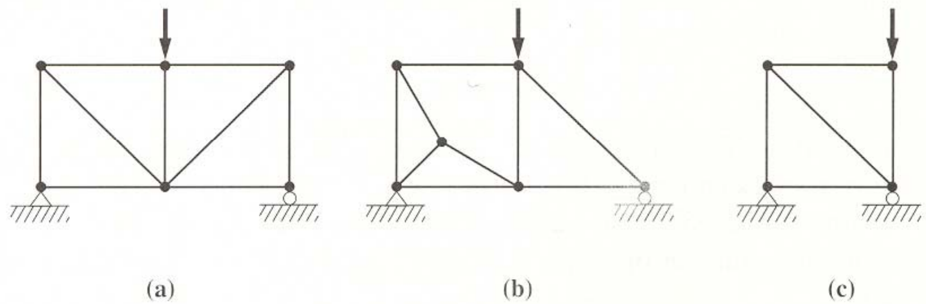


Figure 2.2.3 Examples of statically determinate, minimally stable trusses.

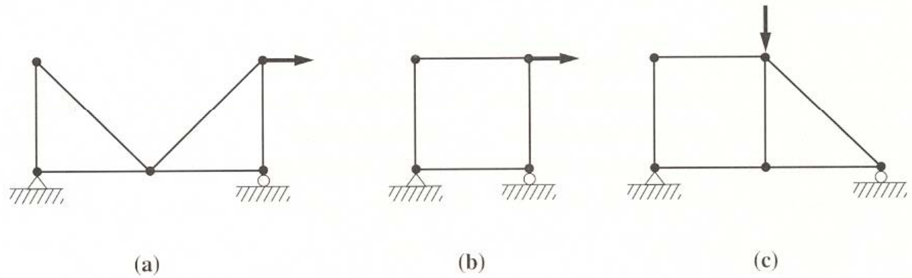
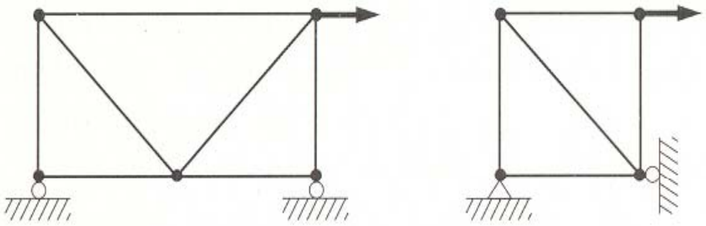


Figure 2.2.4 Examples of unstable trusses.

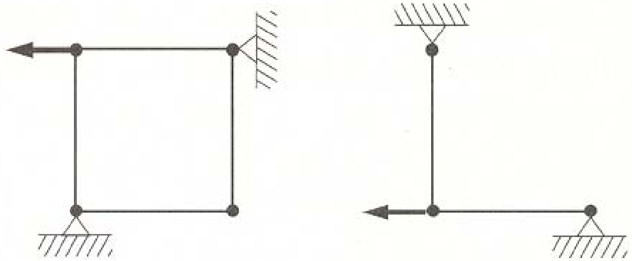
$2j > m + 3$

2.2 Plane Trusses



(a) (b)

Figure 2.2.5 Examples of supports inadequate to restrain rigid-body translation (a) and rotation (b).



(a) (b)

Figure 2.2.6 Unstable trusses made rigid by properly located additional supports.

$2j = m + r$, and the supports restrain rigid-body motion

(r : The total number of reactions)

-> Statically determinate

2.2 Plane Trusses

After obtaining of internal forces in the bar elements, we can compute stresses by

$$\sigma = \frac{N}{A}$$

With compressive load, check buckling by the *Euler Column formular*

$$N_{CY} = \frac{\pi^2 EI}{L^2}$$

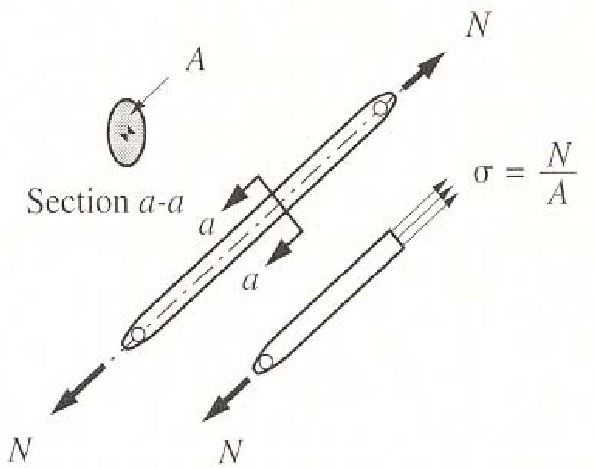
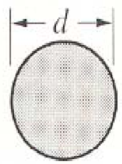
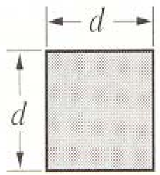
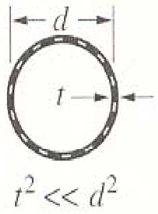
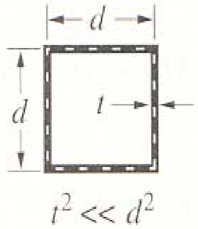


Figure 2.2.7 Uniform, uniaxial stress in a two-force rod element.

2.2 Plane Trusses

Table 2.2.1 Moments of inertia for some simple sections.

Cross section				
Area	$\frac{\pi d^2}{4}$	d^2	πtd	$4td$
Moment of inertia	$\frac{\pi d^4}{64}$	$\frac{d^4}{12}$	$\frac{\pi td^3}{8}$	$\frac{2td^3}{3}$

2.2 Plane Trusses

Solution of SD Truss Structures

1. Make equilibrium at nodes with unknown member forces and solve the obtained simultaneous equations.

2. Find the reaction forces at the supports by equilibrium of whole structures(Utilize FBD) and get the values of member loads through the equilibrium at node by using the known support reaction forces.

2.2 Plane Trusses

Example 2.2.1

All members of the truss in Figure 2.2.8 are to be fabricated from the same stock of thin-walled, round, steel tubing, the section properties of which are listed in Table 2.2.2. Select the lightest weight tubing for which the axial stress in any rod of the truss does not exceed 25,000 psi in tension or compression and the critical buckling load is not exceeded. For steel, $E = 30 \times 10^6\ psi.$

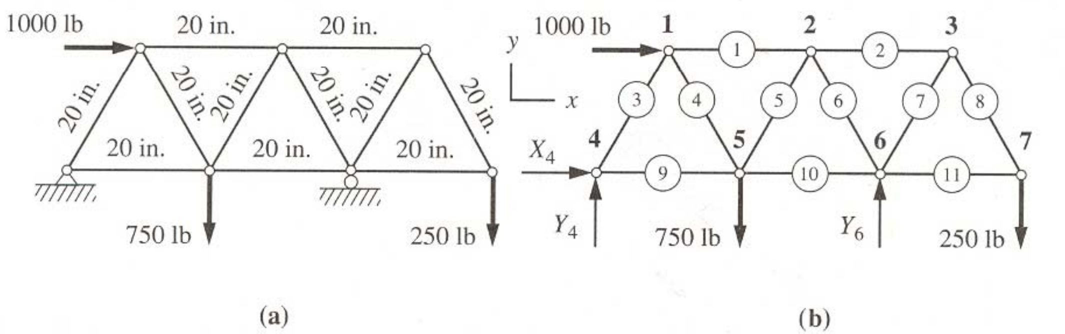
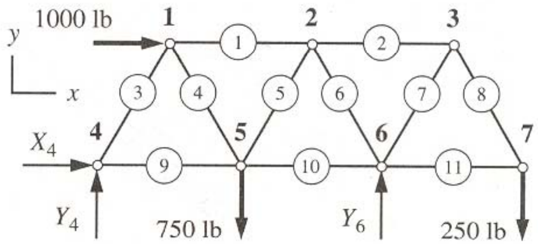


Figure 2.2.8 (a) Truss with loads and dimensions. (b) Truss as a free body, showing support reactions, and the chosen joint and member numbering scheme.

2.2 Plane Trusses

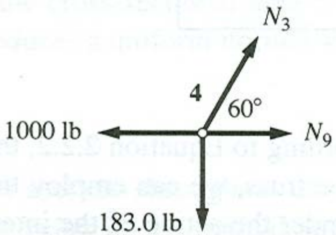


(b)

$$\sum F_x = 0: \quad X_4 + 1000 = 0 \quad X_4 = -1000 \text{ lb}$$

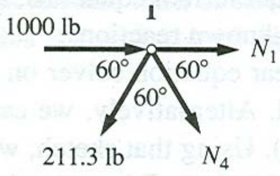
$$\sum M_4 = 0: \quad 40Y_6 - 20 \times 750 - 60 \times 250 - (20 \sin 60) \times 1000 = 0 \quad Y_6 = 1183 \text{ lb}$$

$$\sum F_y = 0: \quad Y_4 - 750 + 1183 - 250 = 0 \quad Y_4 = -183.0 \text{ lb}$$



$$\sum F_y = 0: \quad 0.8660N_3 - 183.0 = 0 \quad N_3 = 211.3 \text{ lb}$$

$$\sum F_x = 0: \quad 0.5000(211.3) + N_9 - 1000 = 0 \quad N_9 = 894.2 \text{ lb}$$



$$\sum F_y = 0: \quad -0.8660(211.3) - 0.8660N_4 = 0 \quad N_4 = -211.3 \text{ lb}$$

$$\sum F_x = 0: \quad 1000 + N_1 - 0.5000(211.3) + 0.5000(-211.3) = 0 \quad N_1 = -788.8 \text{ lb}$$

2.2 Plane Trusses

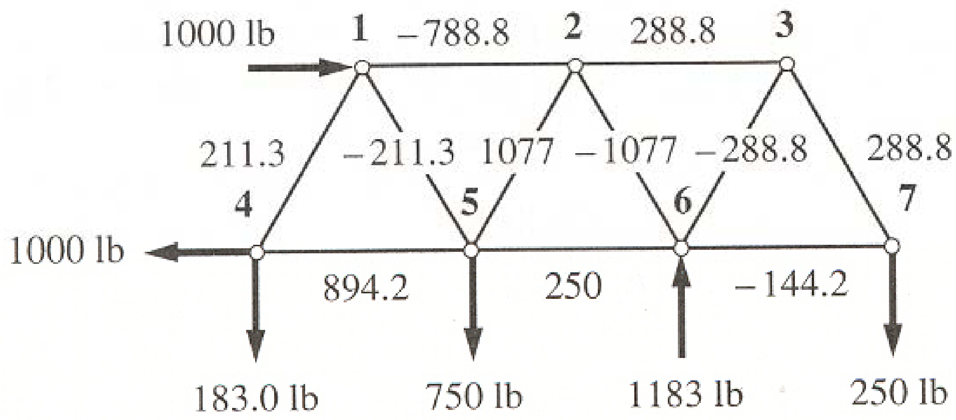


Figure 2.2.9 Solution of the truss problem in Figure 2.2.7.

Member loads are given in pounds (+ = tension, − = compression).

2.2 Plane Trusses

3. Method of Section

Section the truss into two bodies so as to expose the force in that member.

Then write the equilibrium equations for the free body on either side of the section and solve them for the unknown force.

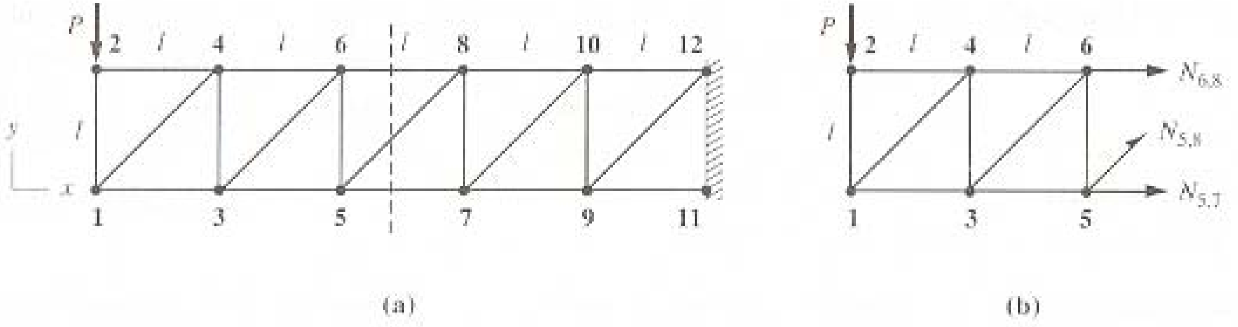


Figure 2.2.10 (a) Cantilevered truss with a transverse section through the center bay. (b) Free-body diagram to the left of the cut, revealing the member forces in that bay.

$$\sum F_y = 0 \quad \Rightarrow \quad N_{5.8} = \sqrt{2}\,P$$
$$\sum M_5 = 0 \quad \Rightarrow \quad N_{6.8} = 2P$$
$$\sum F_x = 0 \quad \Rightarrow \quad N_{5.7} = -3P$$

2.3. Space Trusses

To avoid the rigid body motion, the structure should be constrained in three orthogonal translation and three rotational directions.

I	1	2	3	4	···	i
j	3	4	5	6	···	i+3=j
m	3	5	7	9	···	3i+3=m

$$\therefore\ 3j = m + 6$$

In three dimension, the structure is in SD if it satisfies

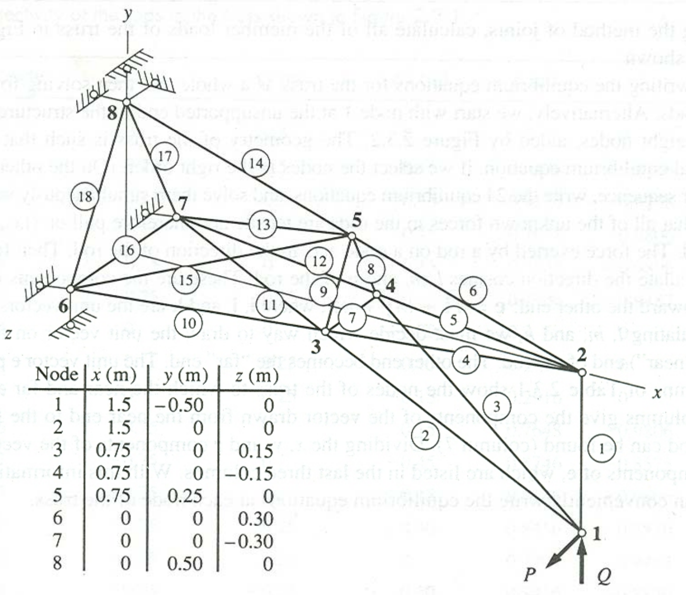
$3j = m + r$, r : support reaction

Since each node create three equilibrium equations.

2.3. Space Trusses

Example 2.3.1

Using the method of joints, calculate all of the member loads the truss in Figure 2.3.1 in terms of the loads P and Q applied as shown.



Node	x (m)	y (m)	z (m)
1	1.5	−0.50	0
2	1.5	0	0
3	0.75	0	0.15
4	0.75	0	−0.15
5	0.75	0.25	0
6	0	0	0.30
7	0	0	−0.30
8	0	0.50	0

Figure 2.3.1 A space truss that is both internally and externally statically determinate. The nodal coordinates are given in the table.

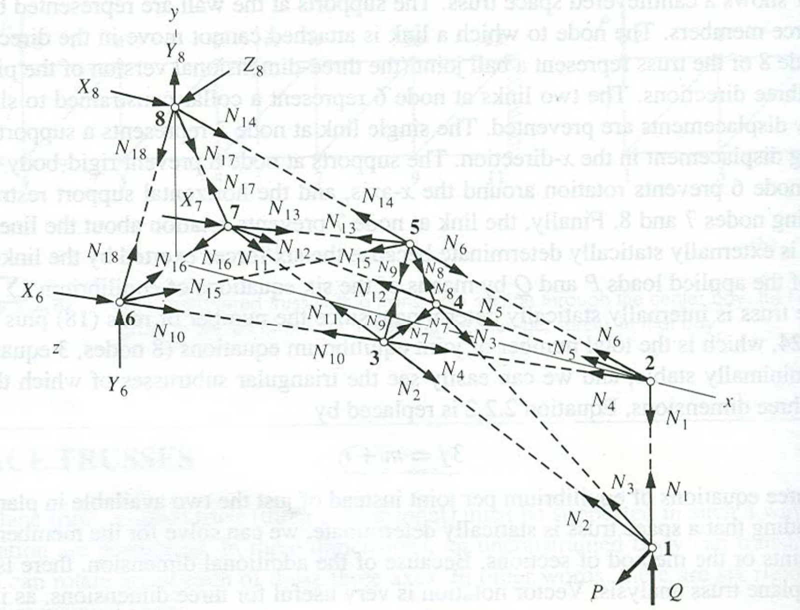


Figure 2.3.2 Free-body diagrams of nodes 1 through 5 of the truss in Figure 2.3.1.

2.3. Space Trusses

Node 1

The equilibrium of node 1,

$$N_1\mathbf{e}_1 + N_2\mathbf{e}_2 + N_3\mathbf{e}_3 + P\mathbf{k} + Q\mathbf{j} = 0$$

Substituting unit vectors into equilibrium equation,

$$\mathbf{e}_1 = \mathbf{j} \qquad \mathbf{e}_2 = -0.8208\mathbf{i} + 0.5472\mathbf{j} + 0.1642\mathbf{k} \qquad \mathbf{e}_3 = -0.8208\mathbf{i} + 0.5472\mathbf{j} - 0.1642\mathbf{k}$$

$$(-0.8208N_2 - 0.8208N_3)\mathbf{i} + (N_1 + 0.5472N_2 + 0.5472N_3 + Q)\mathbf{j} + (0.1642N_2 - 0.1642N_3 + P)\mathbf{k} = 0$$

Setting the x, y, and z components of this vector equation equal zero,

$$\begin{aligned} -0.8208N_2 - 0.8208N_3 &= 0 \\ N_1 + 0.5472N_2 + 0.5472N_3 &= -Q \\ 0.1642N_2 - 0.1642N_3 &= -P \end{aligned}$$

$$N_1 = -Q \qquad N_2 = -3.046P \qquad N_3 = 3.046P$$

2.4. Simple Beams

A simple beam is a slender, homogeneous bar that bends without twisting.

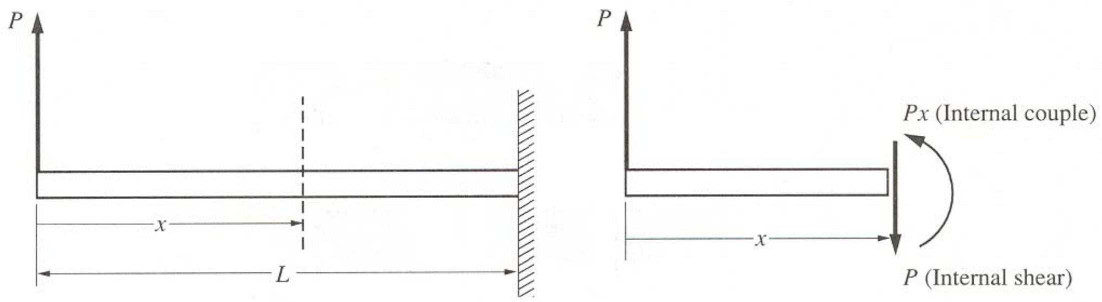


Figure 2.4.1 Cantilever beam and a free-body diagram showing the shear and moment at an arbitrary section.

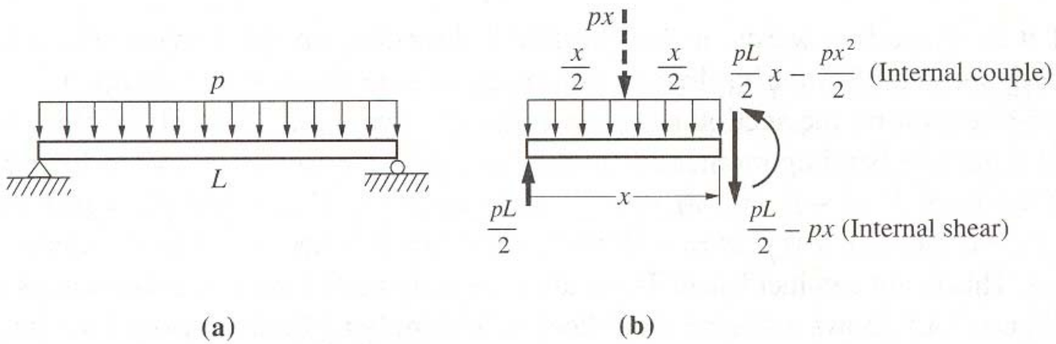


Figure 2.4.2 (a) Simply supported beam. (b) Internal shear and bending moment as a function of distance from the left end.

2.4. Simple Beams

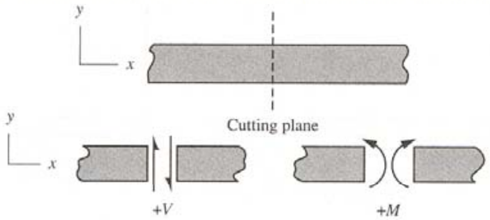


Figure 2.4.3 Sign convention for positive internal shear and bending moment.

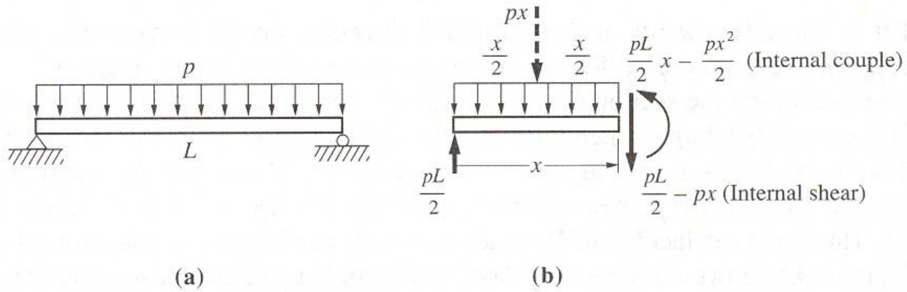


Figure 2.4.2 (a) Simply supported beam. (b) Internal shear and bending moment as a function of distance from the left end.

$$-V + (V + dV) + p\,dx = 0$$

$$dV = -p\,dx$$

$$\boxed{\frac{dV}{dx} = -p}$$

$$V_2 = V_1 - \int_{x_1}^{x_2} p(x)\,dx$$

$$\boxed{\frac{dM}{dx} = -V}$$

$$M_2 = M_1 - \int_{x_1}^{x_2} V(x)\,dx$$

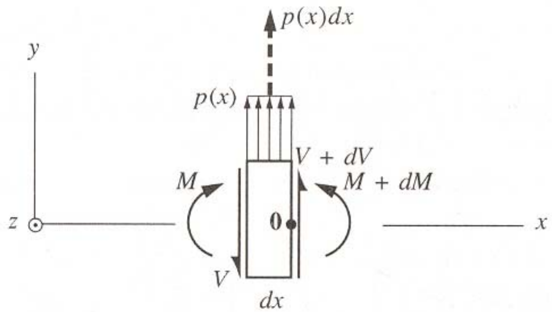


Figure 2.4.5 Free-body diagram of a differential beam segment, showing the internal shears and bending moments and a differential portion of the externally applied distributed load.

2.4. Simple Beams

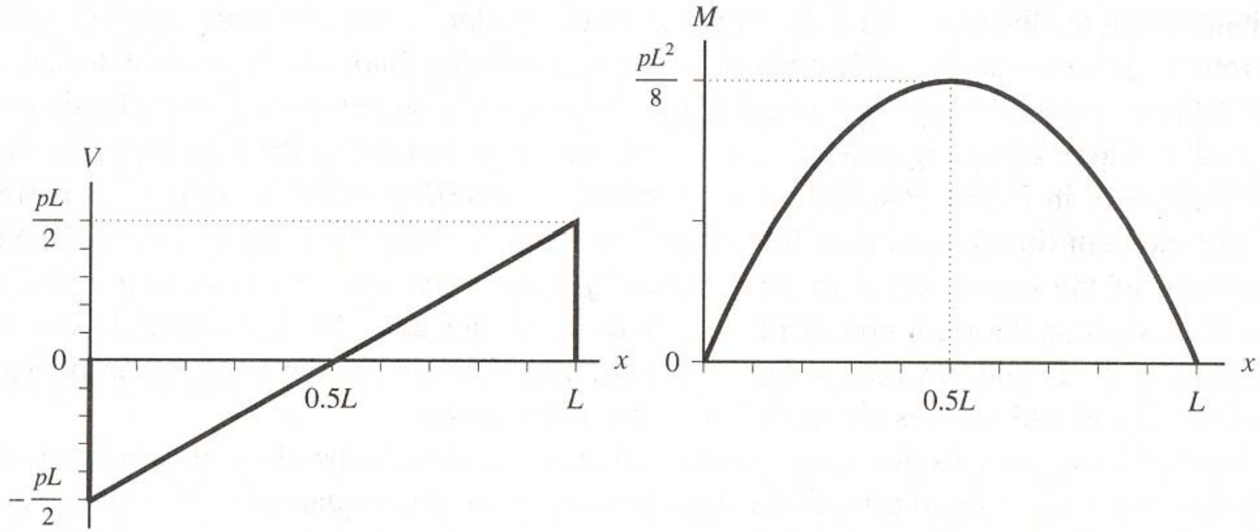


Figure 2.4.4 Shear (left) and moment diagrams for the beam in Figure 2.4.2.

2.5. Stiffened Shear Webs

- Shear Panel : The Structure with a thin sheet of materials to which a rod is bonded along each edge.
- If we assume the panel only carries shear forces, then the structure becomes SD.

  * Relaxing this assumption will be treated in Ch.4.
- Flange : top and bottom rods
- Web : the panel
- Stiffner : vertical rod

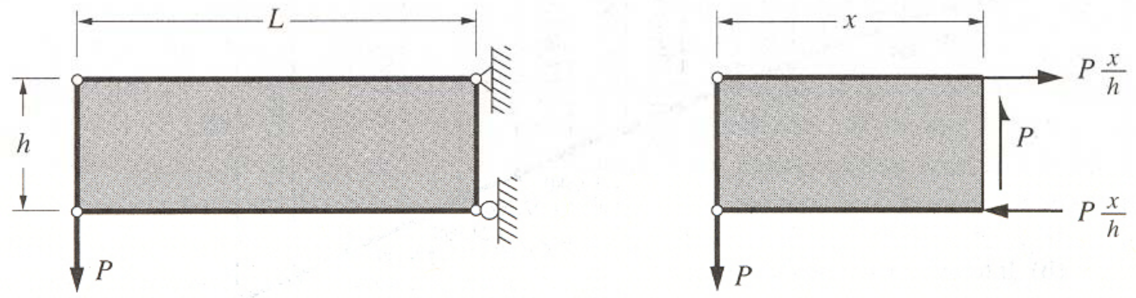


Figure 2.5.1 Stiffened shear web acting as an idealized beam.

2.5. Stiffened Shear Webs

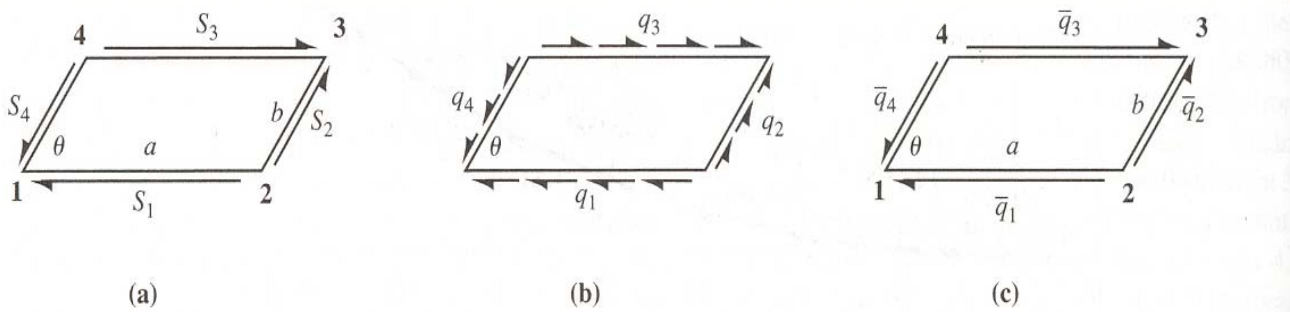


Figure 2.5.2 Parallelogram shear panel. (a) Shear forces on the edges. (b) Shear flows. (c) Average shear flows.

$$S = \int_0^l q\,ds$$

S : pure shear load

q : shear flow (shear force per unit length)

2.5. Stiffened Shear Webs

Summing moments about point 1,

$$(S_2 \sin\theta)a = S_3(b\sin\theta) \quad \Rightarrow \quad (\bar{q}_2 b)a = (\bar{q}_3 a)b \quad \Rightarrow \quad \bar{q}_2 = \bar{q}_3$$

Summing moments about any two of the remaining three corners,

$$\bar{q}_1 = \bar{q}_2 = \bar{q}_3 = \bar{q}_4 = \bar{q}$$

The average shear flow is constant around the panel.

If we extend the differential parallelogram in any direction and parallel to the sides of the panel, we see that the shear flow throughout and around the sides of a parallelogram panel is constant.

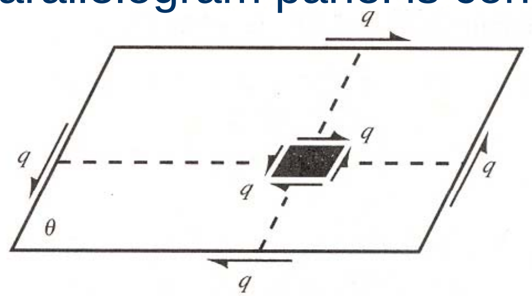


Figure 2.5.3 Shear flow on a differential parallelogram surrounding any point in a parallelogram shear panel.

2.5. Stiffened Shear Webs

Example 2.5.1

Find the shear flow in the structure shown in Figure 2.5.4 and the flange loads at a section 75cm from the left end.

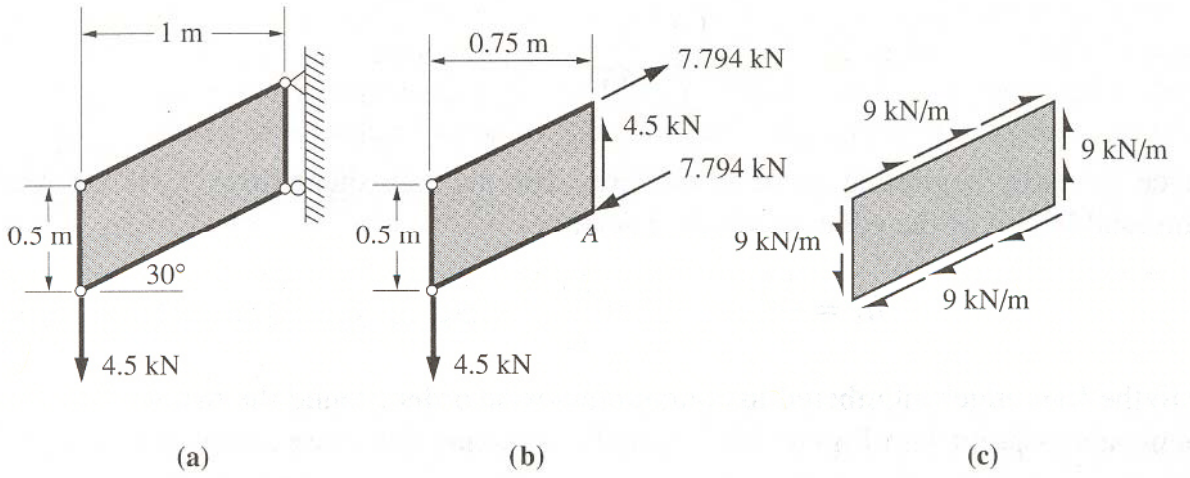


Figure 2.5.4 (a) Cantilevered parallelogram stiffened shear panel. (b) Shear and axial loads 0.75 m from free end. (c) Constant shear flows around the panel.

2.5. Stiffened Shear Webs

Example 2.5.1

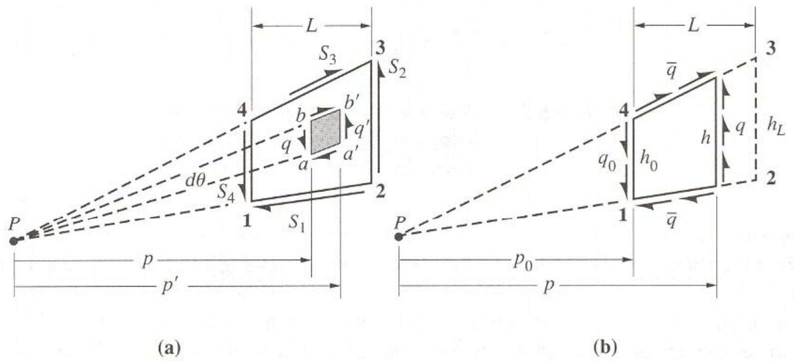


Figure 2.5.5 (a) Trapezoidal shear panel. (b) Internal shear flow q related to the base shear flow q_0.

$$p'\left(q'\overline{a'b'}\right) = p\left(q\overline{ab}\right), \quad \frac{\overline{a'b'}}{p'} = \frac{\overline{ab}}{p}$$

$$q = \frac{\beta}{p^2}$$

$$S = \int_0^l q\,ds = \int_{p_0}^{p_L} q\frac{dp}{\sin\alpha} = \int_{p_0}^{p_L} \frac{\beta}{p^2}\frac{dp}{\sin\alpha}$$

$$= \frac{p_L - p_0}{\sin\alpha}\frac{\beta}{p_L p_0}$$

$$S\Big/\frac{p_L - p_0}{\sin\alpha} = S/l = \bar{q}$$

$$\bar{q} = \frac{\beta}{p_0 p_L}$$

$$q = \bar{q}\frac{h_0 h_L}{h^2}$$

$$\bar{q}(h) = \frac{\beta}{p_0 p} = \frac{\bar{q}p_0 p_L}{p_0 p} = \bar{q}\frac{p_L}{p} = \bar{q}\frac{h_L}{h}$$

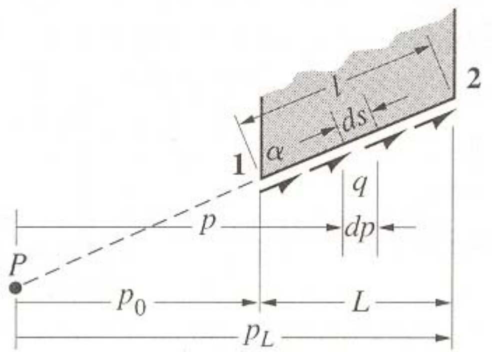


Figure 2.5.6 Shear flow along a tapered edge.

2.5. Stiffened Shear Webs

Example 2.5.2

Find the shear flow in the web of the tapered beam shown in Figure 2.5.7. Also, calculate the average shear flow on each of the panel.

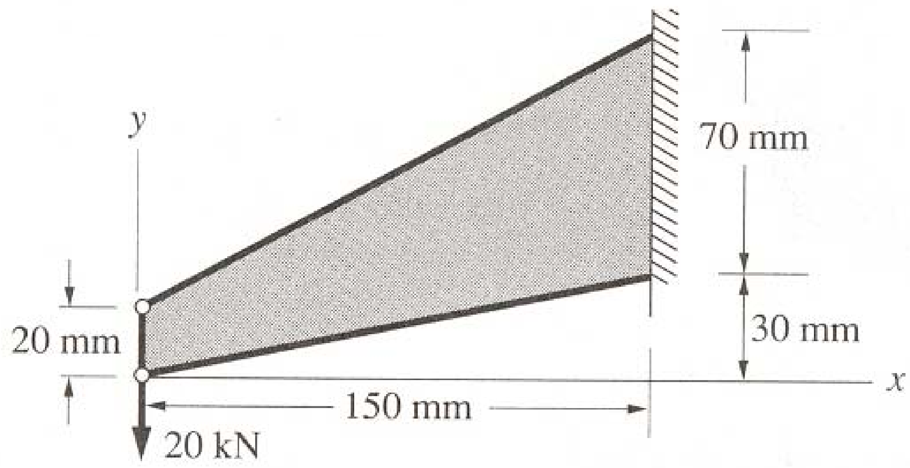


Figure 2.5.7 Idealized tapered, cantilevered beam.

2.5. Stiffened Shear Webs

Example 2.5.2

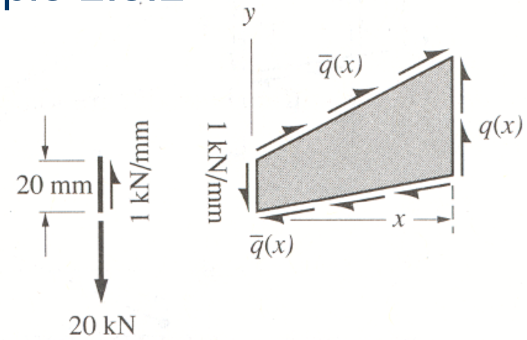


Figure 2.5.8 Free-body diagram of a portion of the web in Figure 2.5.7.

$$q(0) = 1000\ \frac{\text{kN}}{\text{m}}$$

$$\bar{q} = q_0 \frac{h_0}{h_L}$$

$$q(x) = \bar{q} \frac{h_0 h_L}{h^2(x)}$$

$$\bar{q}(x) = \bar{q} \frac{h(0.150)}{h(x)}$$

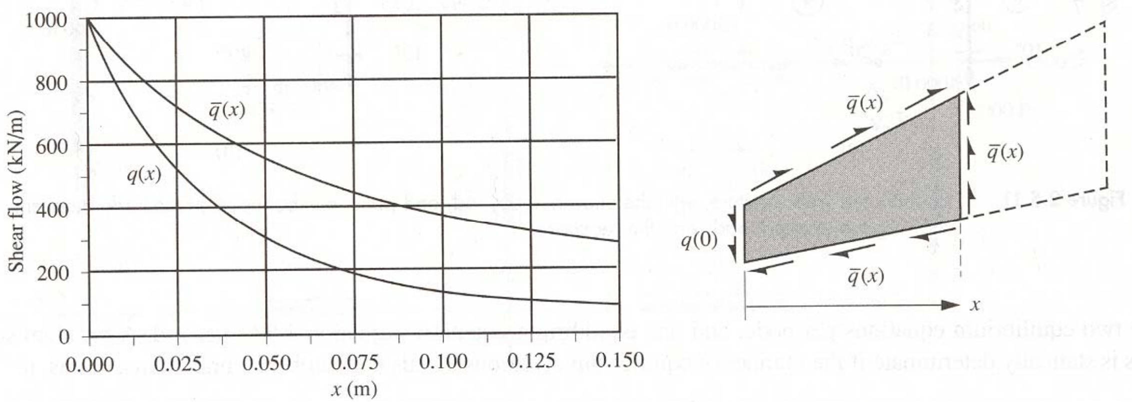


Figure 2.5.9 Shear flow on the edges of the shear panel in Figure 2.5.7

2.5. Stiffened Shear Webs

$$N_2 - N_1 + \int_0^L q(s)ds = 0 \qquad [2.5.6a]$$

$$N_2 - N_1 + \bar{q}\,L = 0 \qquad [2.5.6b]$$

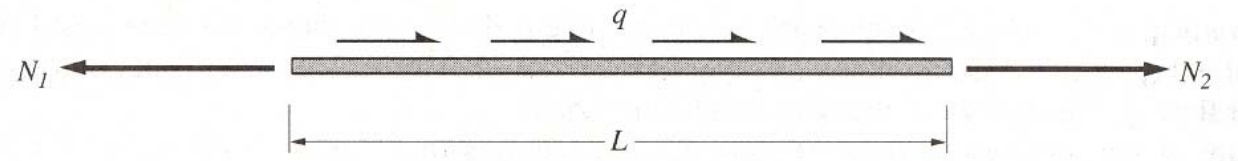
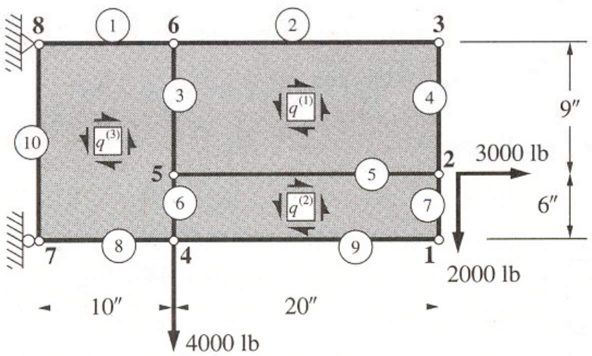


Figure 2.5.10 Rod in equilibrium under the direct loads applied at each end and the shear flow distributed along its length.



If the number of equilibrium equations equal the number of unknowns, the stiffened web structure is statically determinate.

$$n_{rods} + n_{panels} + n_{reactions} = 2n_{nodes} \qquad [2.5.7]$$

2.5. Stiffened Shear Webs

Example 2.5.3

Find the structure in Figure 2.5.11, calculate the shear flows in each of the three panels and the maximum load in the stiffeners.

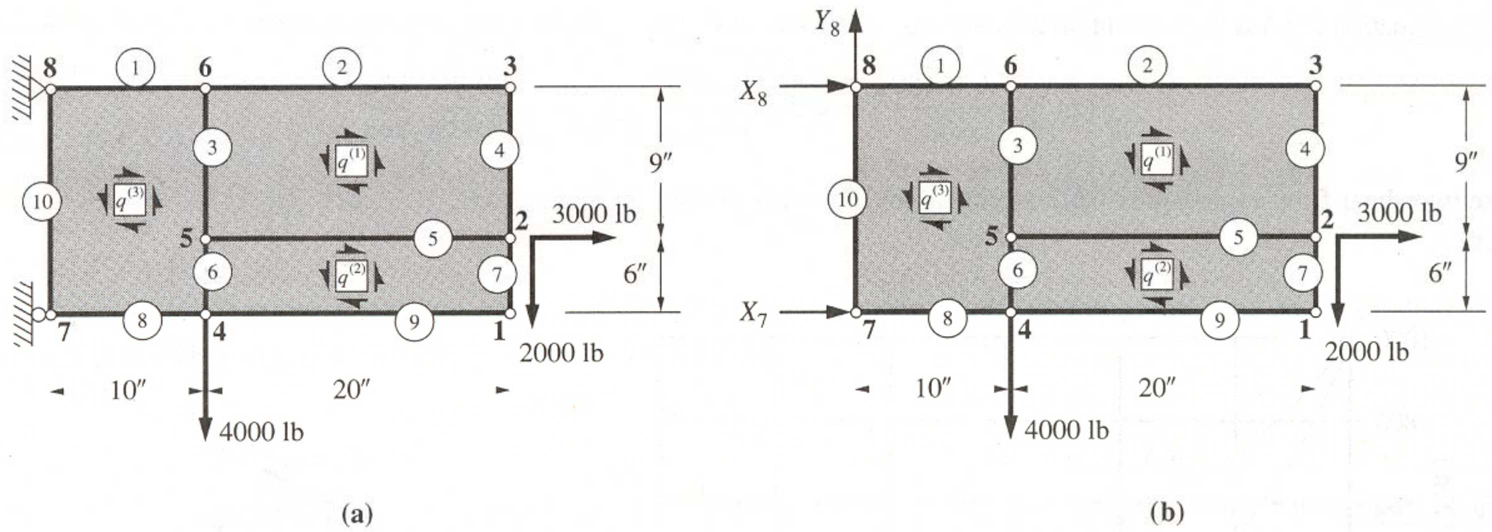


Figure 2.5.11 (a) Stiffened web structure, with the chosen node, rod, and panel numbering. (b) Free-body diagram, showing the applied loads and the reactions.

2.5. Stiffened Shear Webs

Example 2.5.3

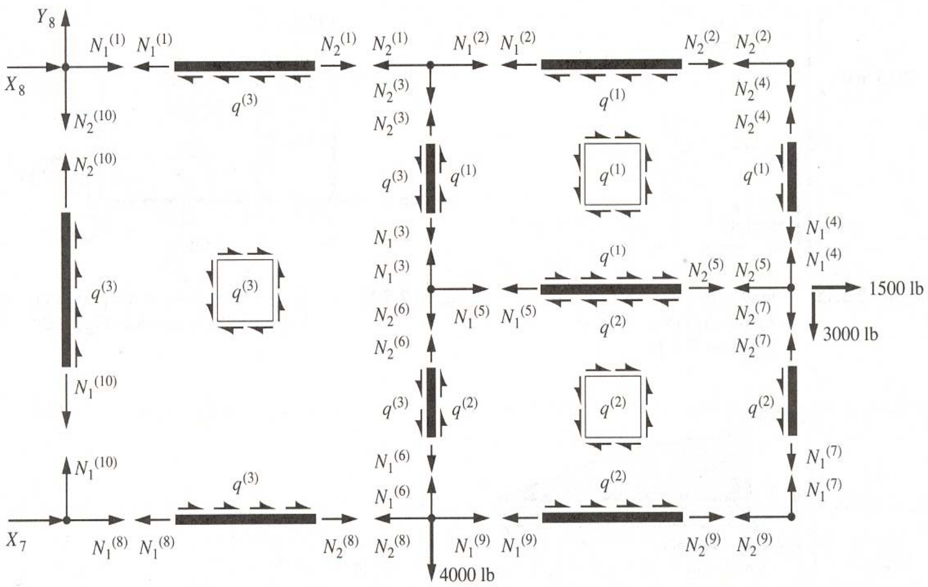


Figure 2.5.12 The unknown member forces and reactions in the stiffened web structure of Figure 2.5.11.

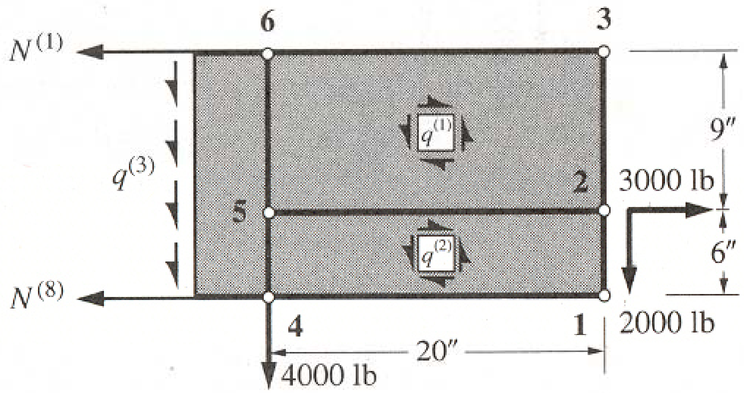


Figure 2.5.13 Free-body diagram resulting from a vertical section through panel 3.

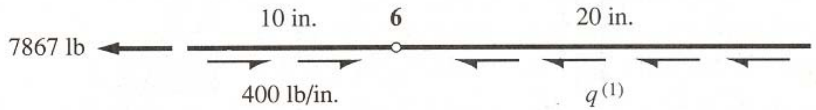


Figure 2.5.14 Free-body diagram of topmost stiffener in Figure 2.5.11.

2.5. Stiffened Shear Webs

Example 2.5.3

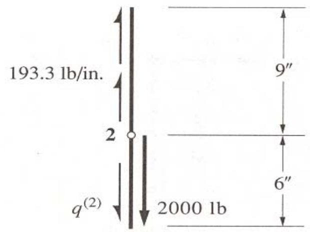


Figure 2.5.15 Free-body diagram of the rightmost vertical stiffener in Figure 2.5.11.

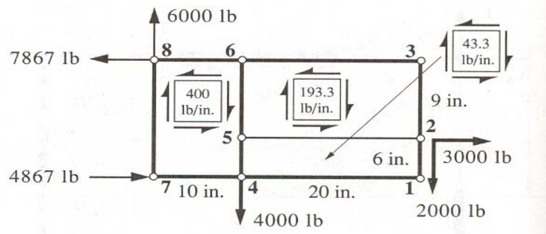


Figure 2.5.16 Constant shear flows in the panels and the reactions at the supports in Figure 2.5.11.

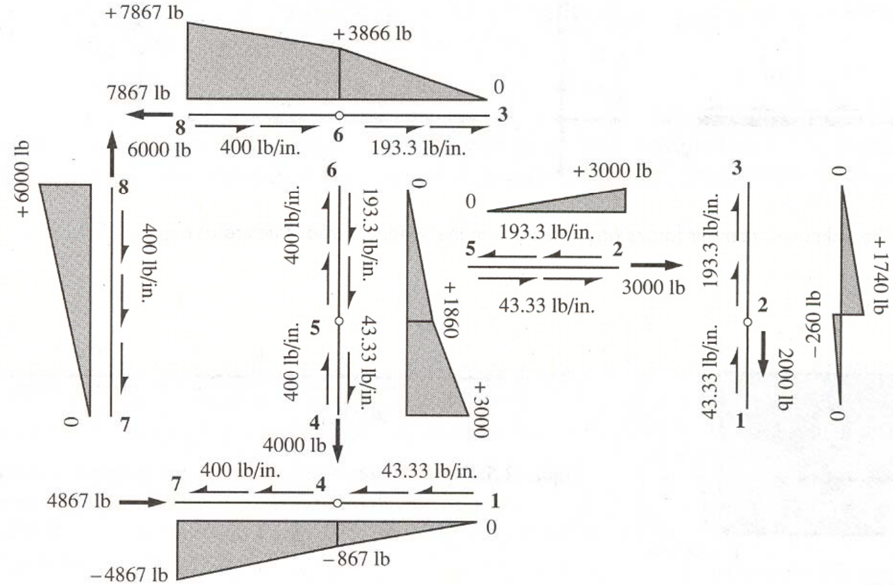


Figure 2.5.17 Axial load distribution in the stiffeners is Figure 2.5.11; negative indicates compression.

2.5. Stiffened Shear Webs

- Cylindrical sheet and Conical surface in pure shear

Element equilibrium in the axial direction,

$$\sum F_x = 0 : \quad \Rightarrow \quad -q\,dx + q'\,dx = 0 \quad \Rightarrow \quad q' = q \qquad \text{Cylindrical sheet}$$

$$\sum F_x = 0 : \quad \Rightarrow \quad (q'\,d\mathbf{l}')\cdot\mathbf{i} - (q\,d\mathbf{l})\cdot\mathbf{i} = 0 \quad \Rightarrow \quad q' = q \qquad \text{Conical surface}$$

-> Shear flow is constant around the cross section.

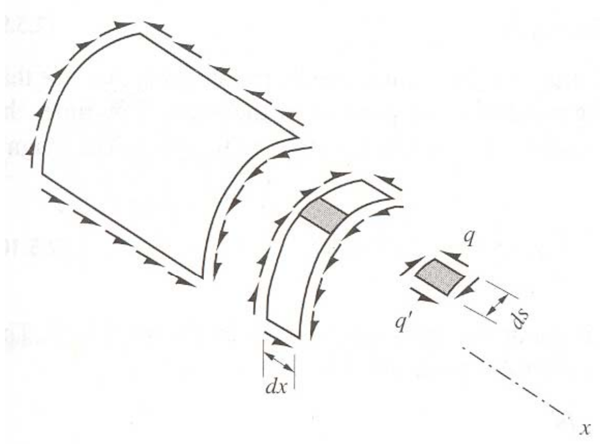


Figure 2.5.18 Cylindrical sheet in pure shear.

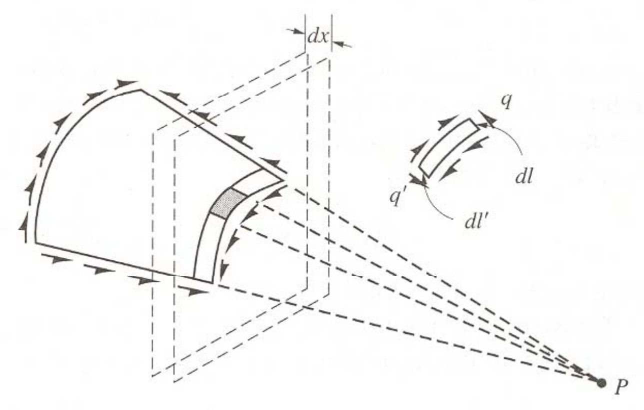


Figure 2.5.19 Conical surface, with vertex P, in pure shear.

2.5. Stiffened Shear Webs

Consider the curve with constant shear flow *q* joining points *B* and *C*

The y and z components of the resultant force R are

$$R_y = q\Delta y \qquad R_z = q\Delta z \qquad [2.5.9]$$

$$R = q\sqrt{\Delta y^2 + \Delta z^2} = qL \qquad [2.5.10]$$

The moment *d*T of the shear flow *q* acting on element *ds* at point *P* is

$$d\mathbf{T} = \mathbf{r} \times q ds$$
$$= q ds (r \sin\phi)\mathbf{i}$$
$$= q(h ds)\mathbf{i}$$

The total moment about *O* of the shear flow is

$$T = 2Aq \qquad [2.5.11]$$

From equation [2.5.10] and [2.5.11],

$$e = \frac{2A}{L} \qquad [2.5.12]$$

(*e* : perpendicular distance from point *O* to R)

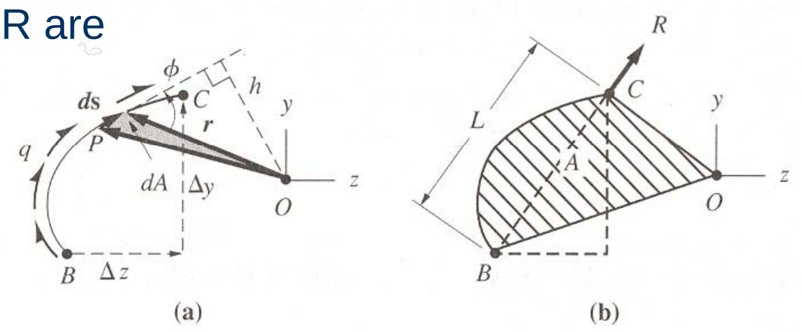


Figure 2.5.20 (a) Uniform shear flow *q* on a curved web. (b) Area enclosed by the web and the lines joining each end of the web to point *O*.

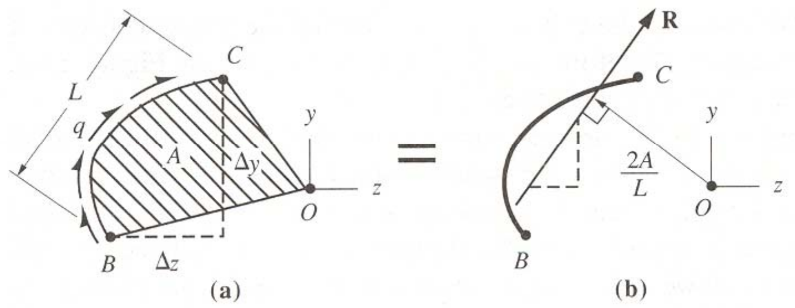


Figure 2.5.21 The resultant **R** of the constant shear flow in (a) has a line of action located as shown in (b).

2.6 IDEALIZED BEAMS : TORSIONAL AND SHEAR LOADING

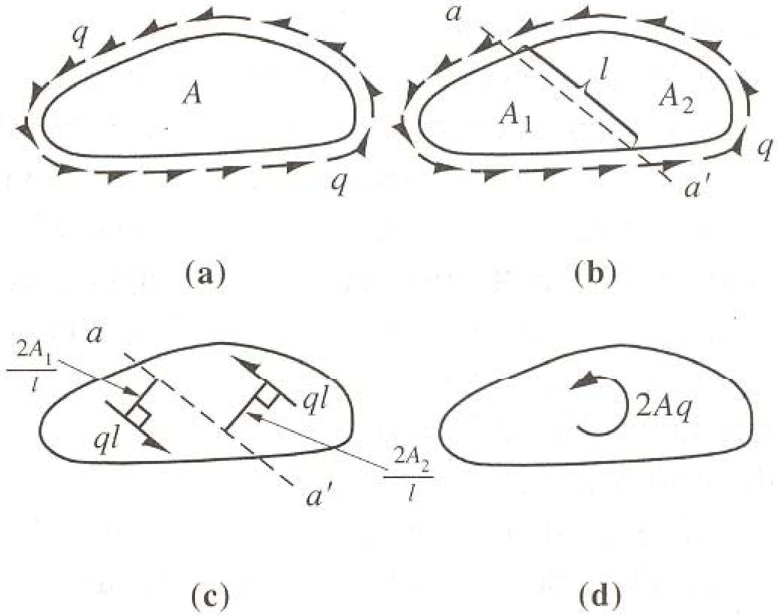


Figure 2.6.1 (a) Constant shear flow on a thin-walled closed section. (b) Closed section viewed as two open sections. (c) Shear flow resultants on each section. (d) Pure couple resultant for the closed section.

Constant shear flow q on a closed section is equivalent to a pure couple of magnitude 2Aq.

2.6 IDEALIZED BEAMS : TORSIONAL AND SHEAR LOADING

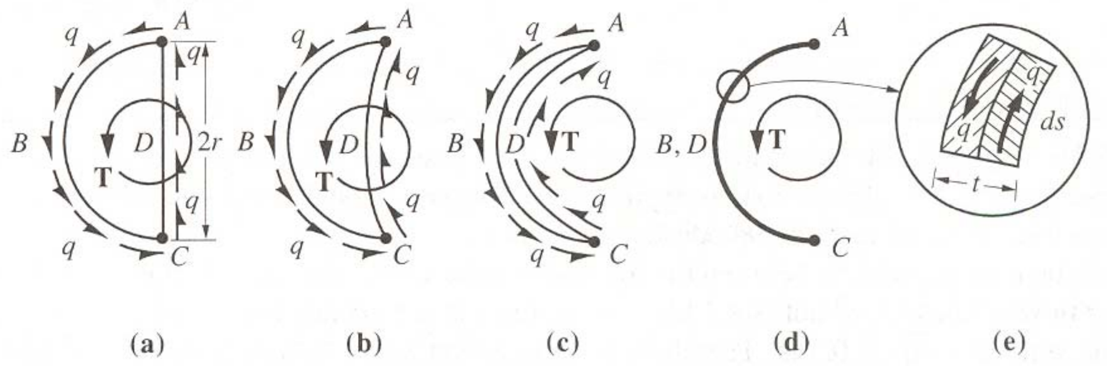


Figure 2.6.2 The same torque **T** is applied to a closed thin-walled section whose enclosed area approaches zero, moving from (a) to (d).

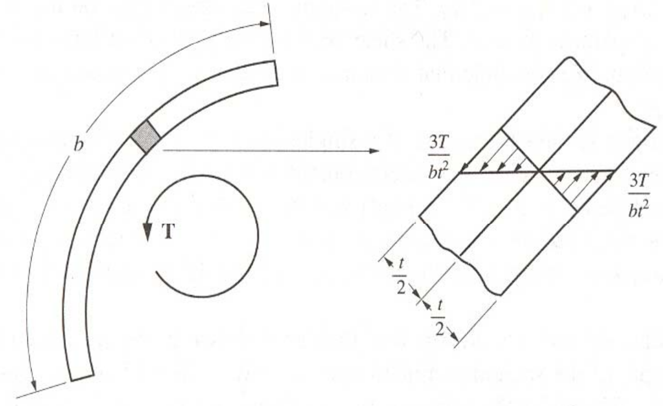


Figure 2.6.3 Shear stress due to torsion in a thin-walled open section.

An exact approach using the theory of elasticity

2.6 IDEALIZED BEAMS : TORSIONAL AND SHEAR LOADING

Example 2.6.1

Figure 2.6.4 shows an idealized beam comprised of two flanges and a curved, thin web that has a semi-elliptical shape. A 3 kN vertical shear load is applied to the free end. Calculate the shear flow and find the horizontal location where the shear force bust be applied to produce no torsion.

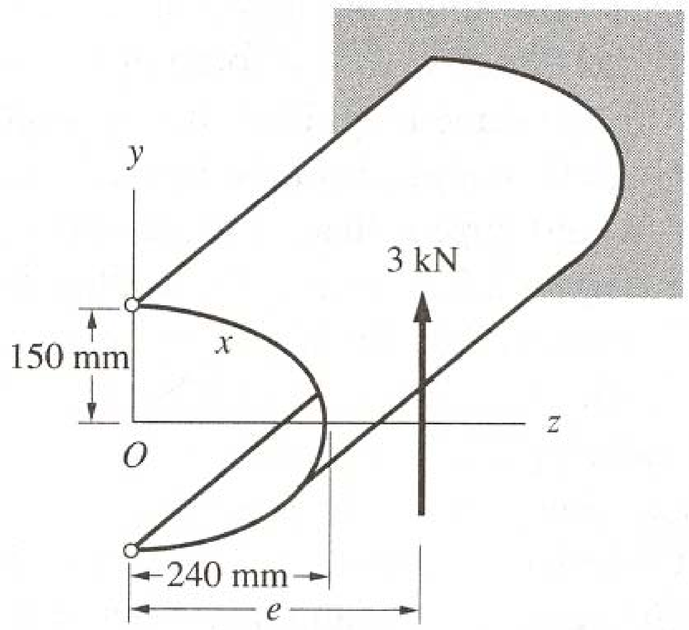


Figure 2.6.4 Idealized cantilever beam with a semielliptical web.

A 500 lb shear load is applied at the free end.

2.6 IDEALIZED BEAMS : TORSIONAL AND SHEAR LOADING

Example 2.6.2

Calculate the shear flow in the walls of the closed section subjected to pure torsion, shown in Figure 2.6.6.

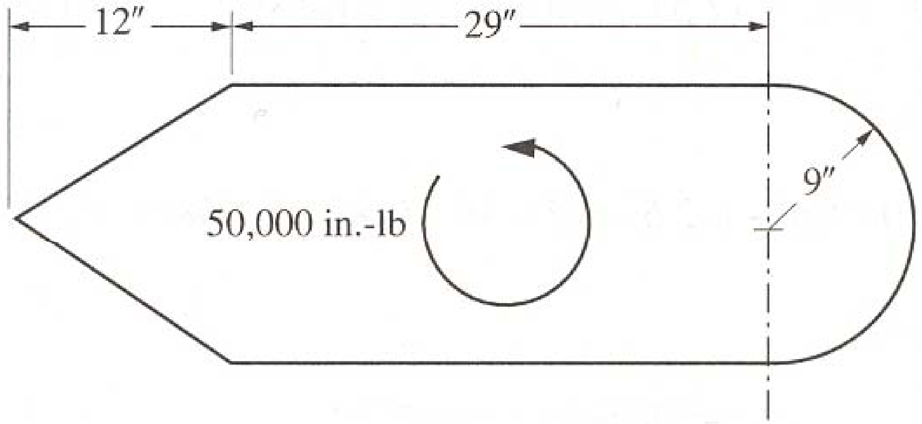


Figure 2.6.6 Closed section under pure torsion.

Example 2.6.3

Figure 2.6.7 shows a 50-inch span of a tapered box beam. At the left end, where the indicated loads are applied, there is a rigid rib at which the flange loads are zero. Other ribs (not shown) of varying size are spaced along the beam to maintain the form of the cross section. Calculate the shear flows and flange loads at the 50-inch station, which lies between two ribs.

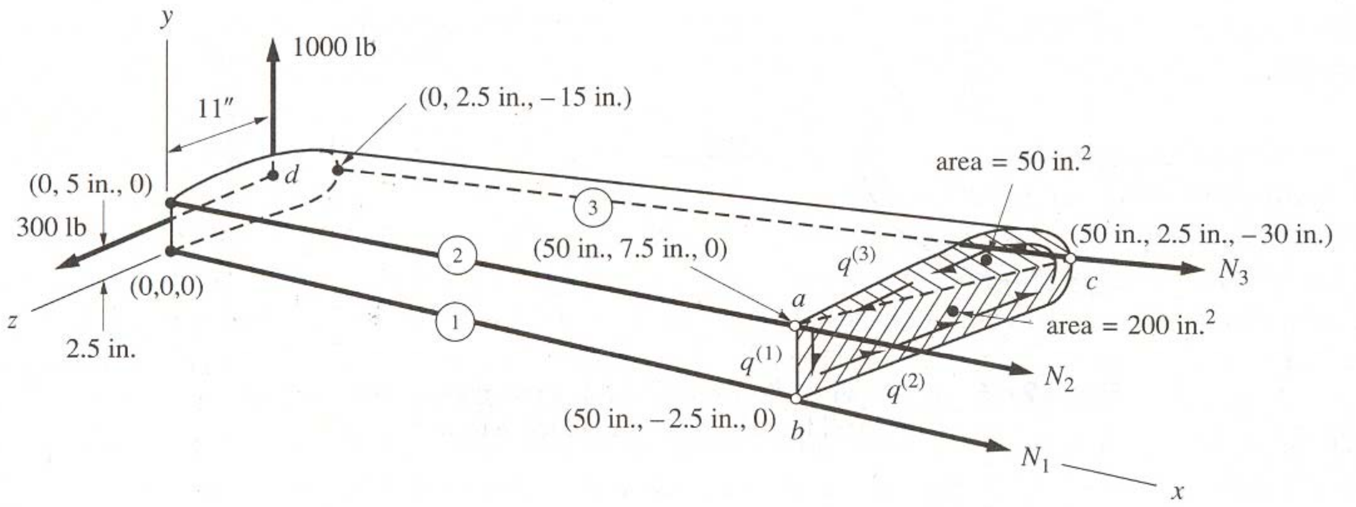


Figure 2.6.7 Free-body diagram of a tapered box beam, showing the three flange loads and three shear flows at the 50-inch station.

2.6 IDEALIZED BEAMS : TORSIONAL AND SHEAR LOADING

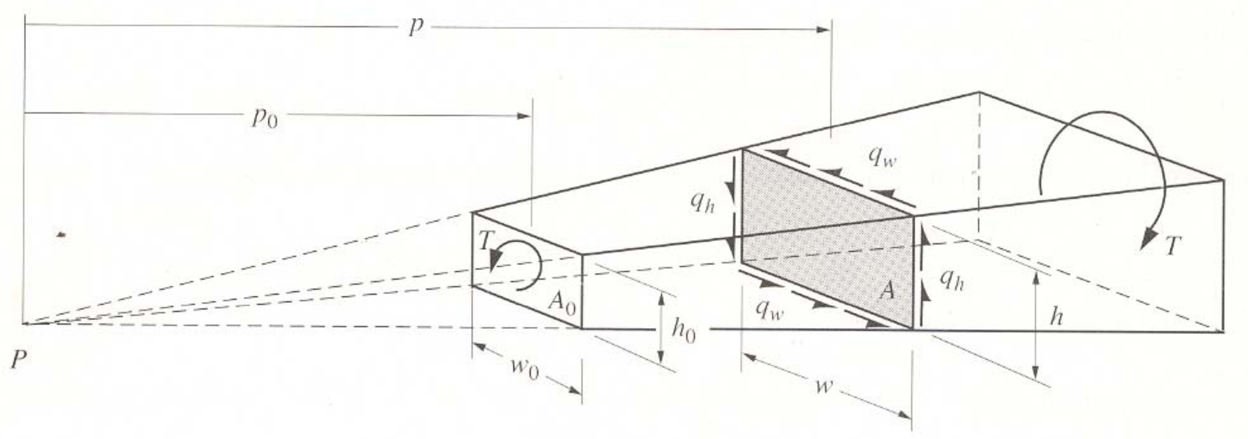


Figure 2.6.9 Torque box in which all four corners intersect in a common point *P*.

$$\frac{h}{h_0} = \frac{w}{w_0} \qquad [2.6.1]$$

2.6 IDEALIZED BEAMS : TORSIONAL AND SHEAR LOADING

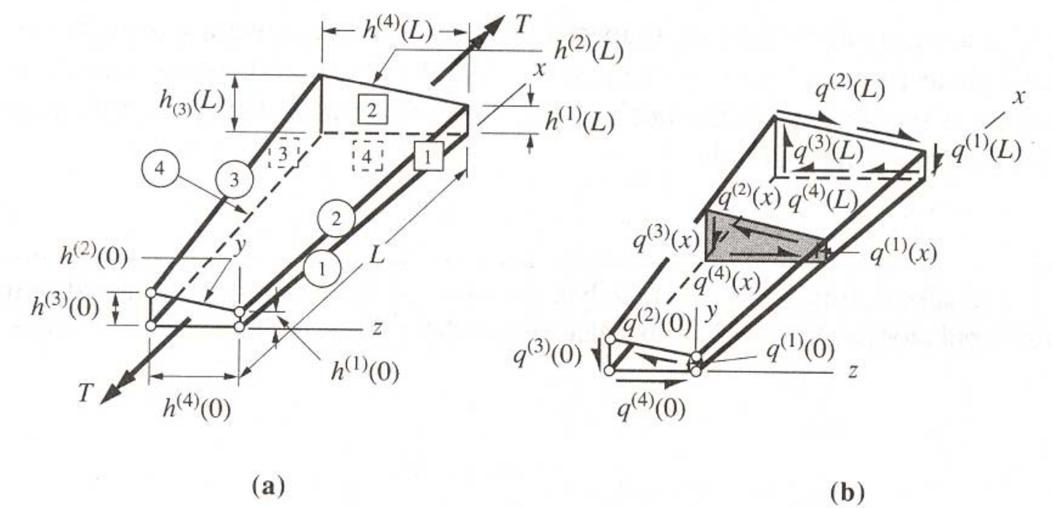


Figure 2.6.10 (a) Idealized torque box with pure torsion applied to each end. Webs are referenced by numbers enclosed by squares. Flange members are referenced by numbers enclosed by circles. (b) The corresponding shear flows at each end and on an intermediate section.

$$q^{(1)}(x) = \bar{q}^{(i)} \frac{h^{(i)}(0)h^{(i)}(L)}{h^{(i)}(x)^2} \qquad [2.6.2]$$

$$\bar{q} = \frac{T}{2\bar{A}} \qquad [2.6.3]$$

$$\bar{A} = \left[\frac{h^{(1)}(L)h^{(2)}(0) + h^{(2)}(L)h^{(3)}(0)}{2}\right]\frac{h^{(4)}(0)}{h^{(2)}(0)} \qquad [2.6.4]$$

2.6 IDEALIZED BEAMS : TORSIONAL AND SHEAR LOADING

Example 2.6.4

The idealized, stiffened web torque box structure in Figure 2.6.11(a) is span, depth, and chord. Given that it transmits a pure torque of 42,000 in-lb, calculate the shear flows and flange loads at 20-in intervals.

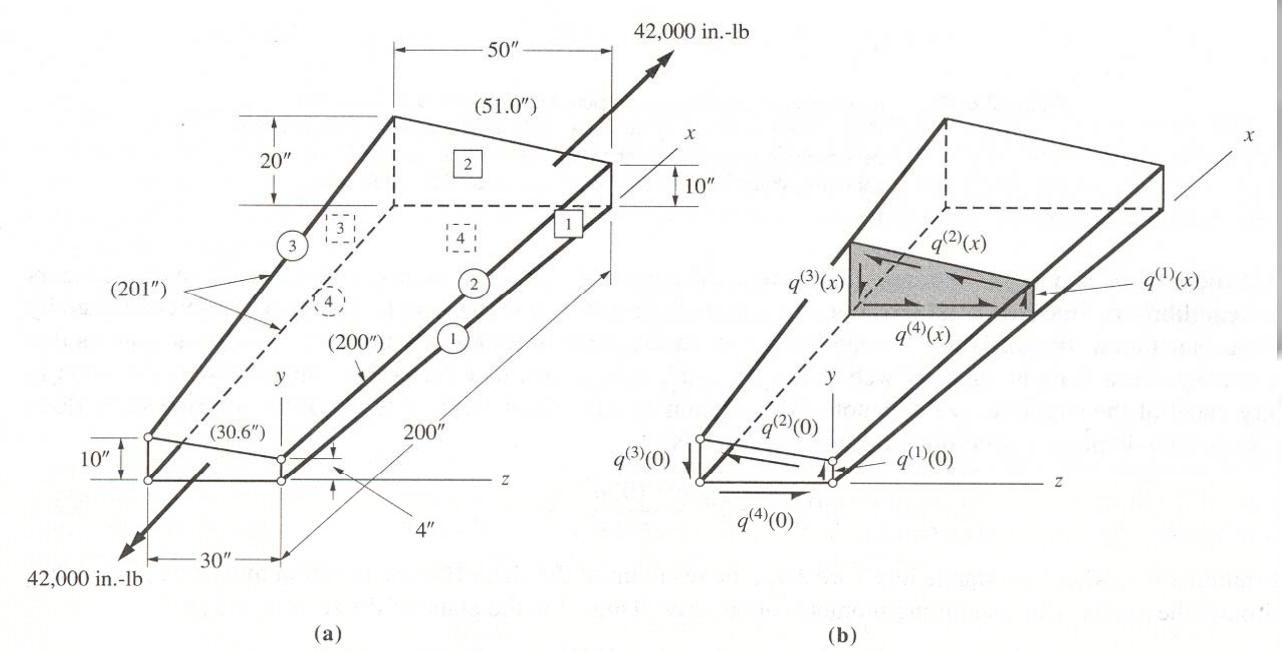


Figure 2.6.11 (a) Torque box with pure torsion applied to each end. (b) The shear flows on intermediate sections. Numbers in parentheses are the lengths, in inches, of the inclined edges of the box.

2.6 IDEALIZED BEAMS : TORSIONAL AND SHEAR LOADING

Example 2.6.4

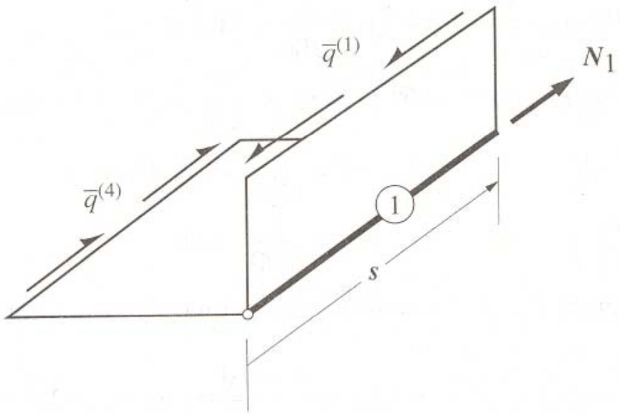


Figure 2.6.12 Relationship between flange load and average shear flows in adjacent webs (stringer 1 illustrated).

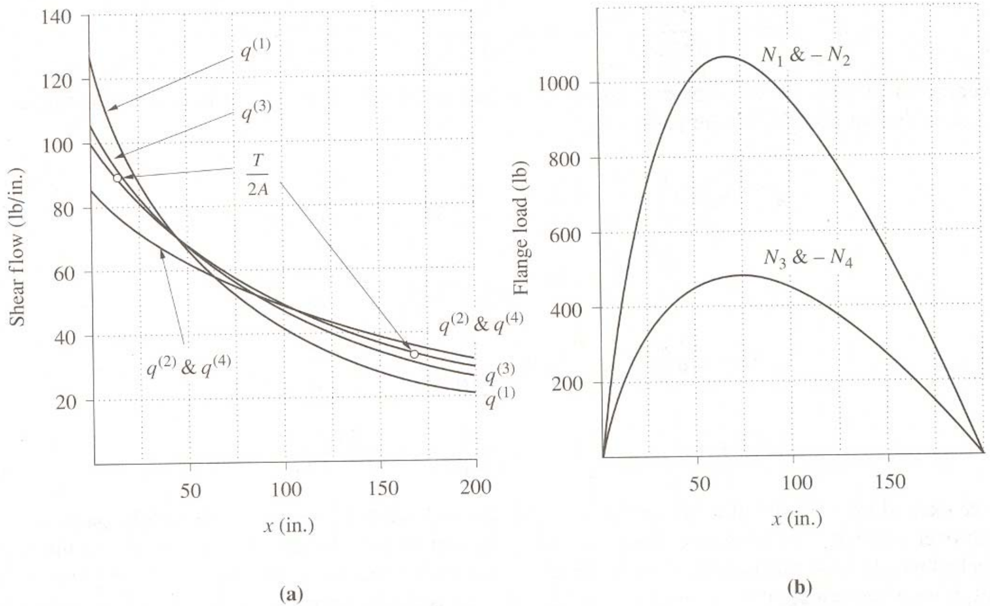


Figure 2.6.13 (a) Shear flow and (b) flange load variations with span for the torque box in Figure 2.6.11.

2.7 FRAMES

Frames, like trusses, are skeletal structures composed of slender member.

However, unlike trusses, the members of a frame transmit shear and bending, as well as axial loads.

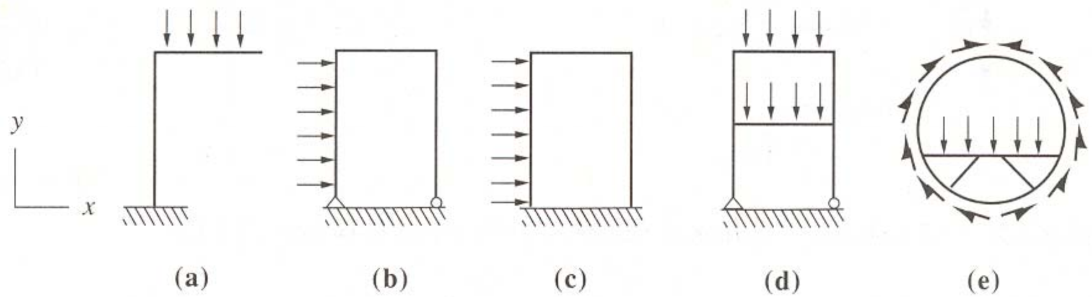
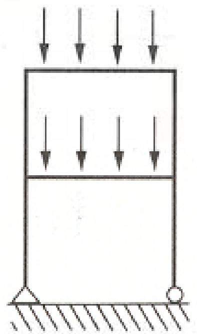


Figure 2.7.1 Examples of rigid-jointed plane frames.

2.7 FRAMES



(d)

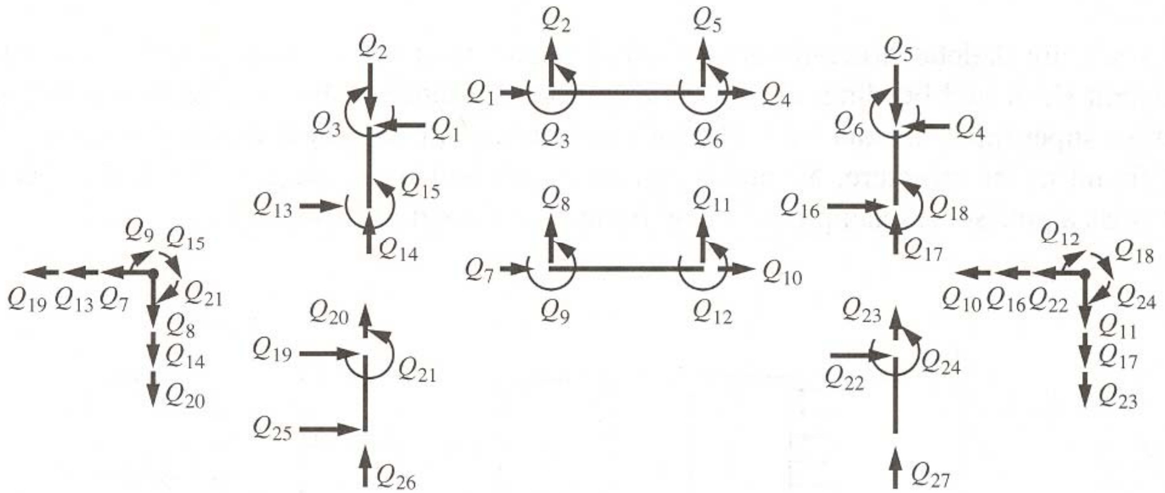


Figure 2.7.2 Free-body diagrams of elements of the frame in Figure 2.7.1(d).

24 equilibrium equations, 27 unknowns

-> Statically indeterminate

2.7 FRAMES

Example 2.7.1

Find the location and value of the maximum bending moment in the semicircular frame shown in Figure 2.7.3

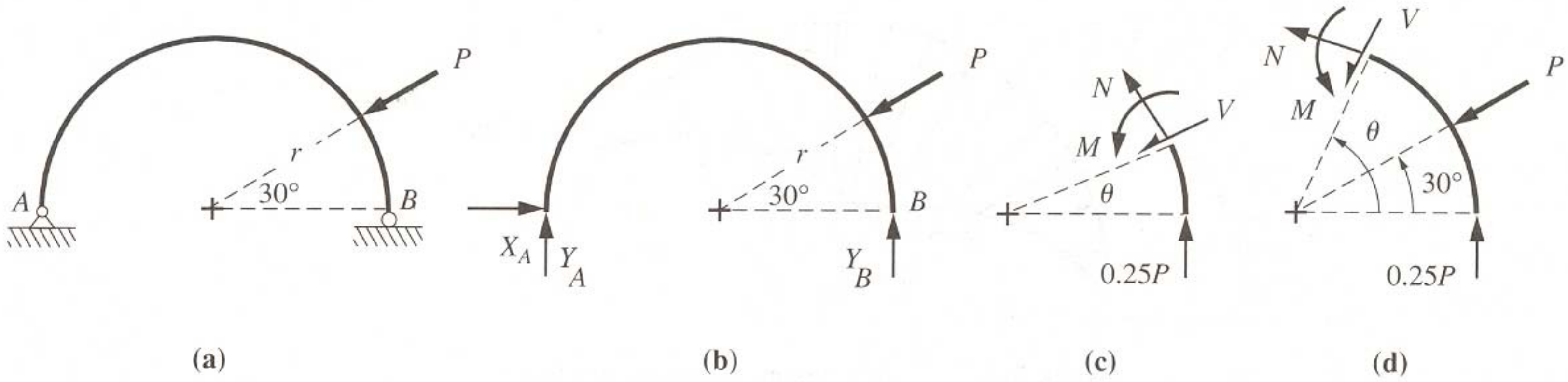


Figure 2.7.3 (a) Semicircular frame with an intermediate transverse point load. (b) Free-body diagram of the complete frame. (c) Free-body diagram of a section at $\theta < 30°$. (d) Free-body diagram for a section at $\theta > 30°$

2.7 FRAMES

Example 2.7.2

Find the location and value of the maximum bending moment in the frame in Figure 2.7.5. The semicircular portion of the structure is acted on by a uniform shear flow, while point loads are applied at the endpoints A and A’ of the horizontal elements. The given shear flow and point loads form a self-equilibrating set.

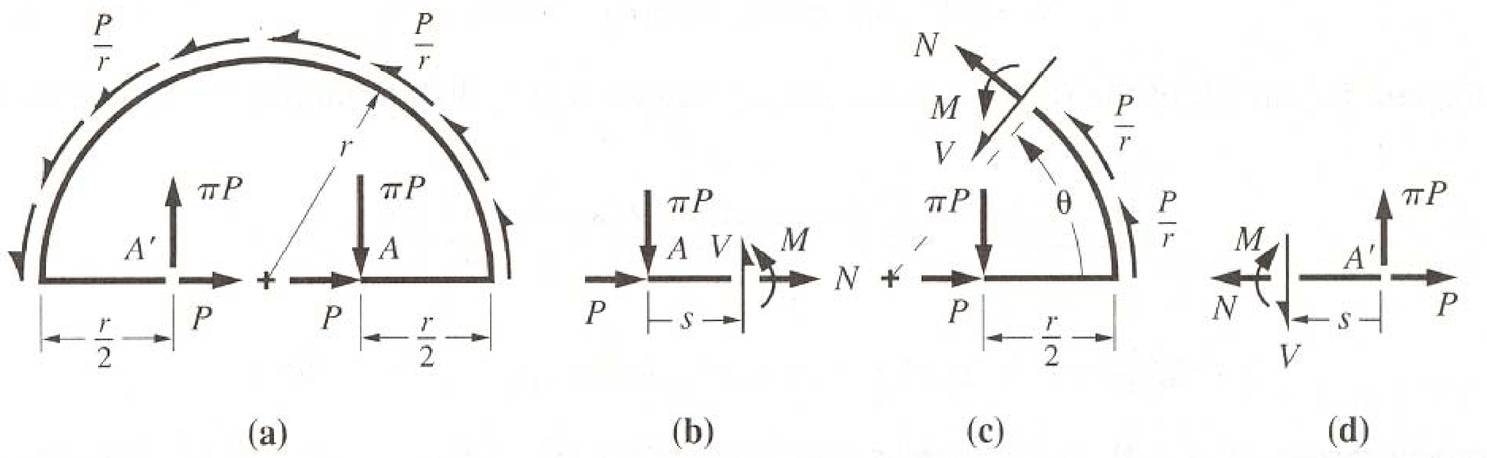


Figure 2.7.5 (a) Semicircular frame with self-equilibrating applied load system. (b), (c), & (d) Free-body diagrams of each element of the frame, revealing the internal forces on transverse sections.

2.7 FRAMES

Example 2.7.2

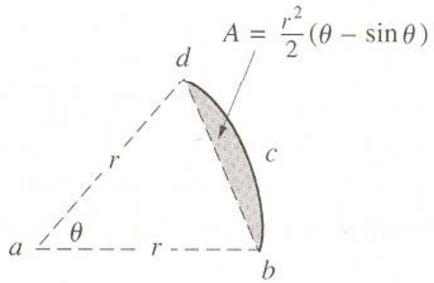


Figure 2.7.6 Area of the segment of a circle spanned by the angle θ.

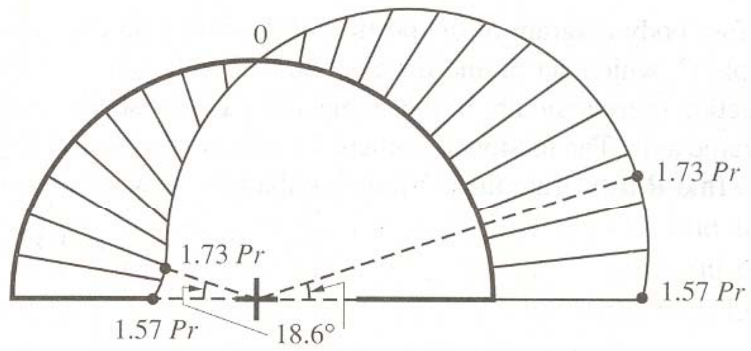


Figure 2.7.7 Bending moment distribution in the semicircular frame member.

Compression occurs on the side of the frame on which the bending moment diagram is plotted.

2.7 FRAMES

Example 2.7.3

Figure 2.7.8(a) shows a frame built into a wall at point W, with a 20 kN load P applied at point D. Calculate the magnitudes of the shear force, bending moment, and torsional moment acting on a transverse section through the frame at point O, located at some distance from the built-in support.

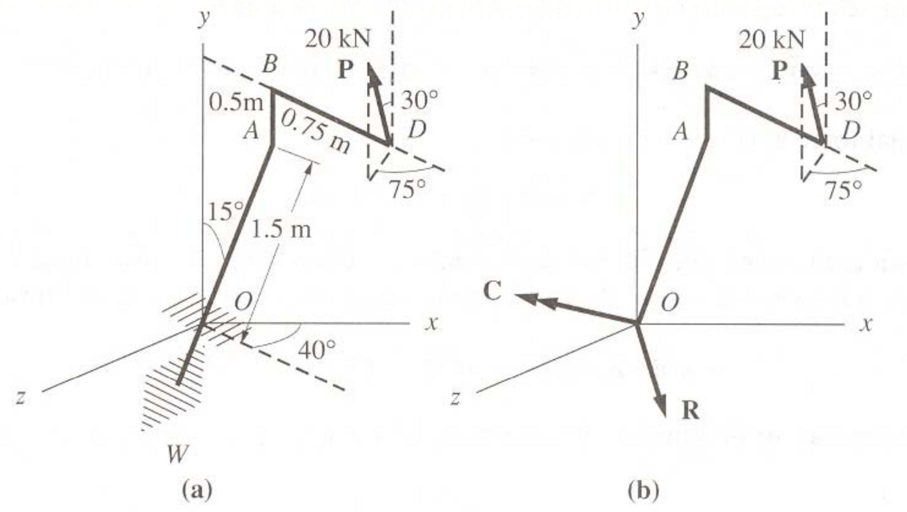


Figure 2.7.8 (a) A frame loaded at point *C* and built into the wall at *W*. (b) Free-body diagram of the frame to one side of the transverse section through *O*.

Use vector notation.

2.7 FRAMES

Example 2.7.4

Find the location and magnitude of the maximum bending moment in the frame of Figure 2.7.9. The support at 1 is capable of exerting reactive forces in y- and z-directions and couples about those axes. The support at 6 can exert forces only in the x- and y-directions.

<ins>*Vector notation unnecessary.*</ins>

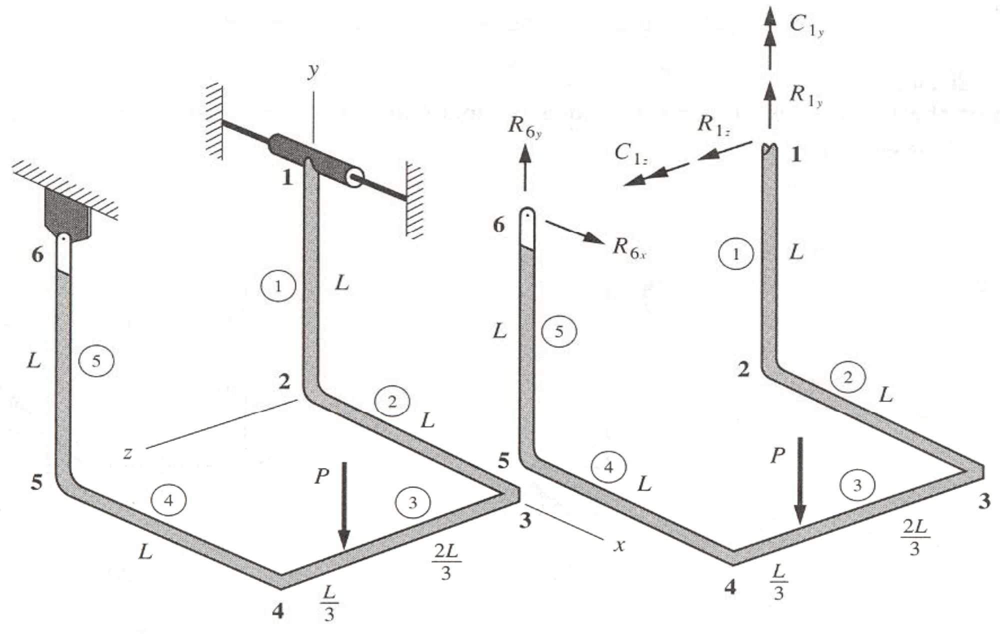


Figure 2.7.9 Statically determinate frame and its free-body diagram.

2.7 FRAMES

Example 2.7.4

Start at point 6 and move from member to member, calculating the forces and moments at each section using the free-body diagrams.

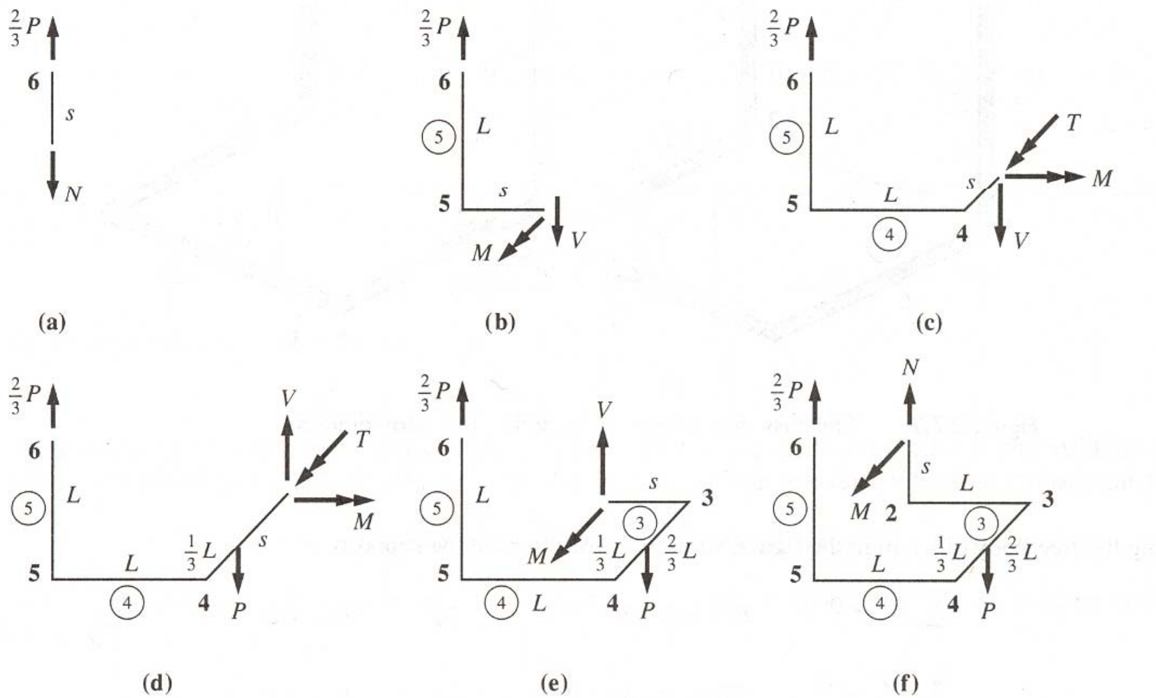


Figure 2.7.10 Free-body diagrams showing the internal forces acting on each transverse section of the frame in Figure 2.7.9.

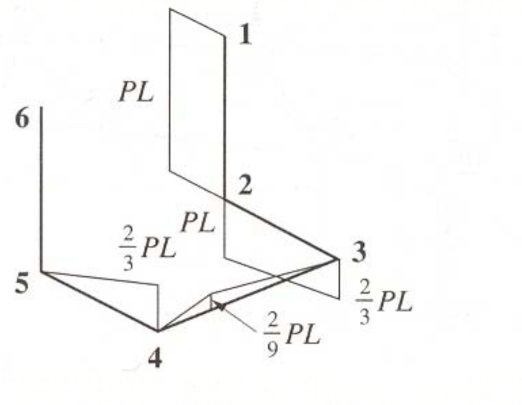


Figure 2.7.11 Bending moment distribution for the frame in Figure 2.7.9.