Chapter 2: Determinate Structural Systems Summary - Rajan's Book

Determinate System

of equilibrium equations = # of unknown forces
Unknown forces can be determined by using the equilibrium equations alone: summation of forces and moments about a point equal to zero.

Indeterminate System

of equilibrium equations < # of unknown forces
Externally determinate/indeterminate
Internally determinate/indeterminate

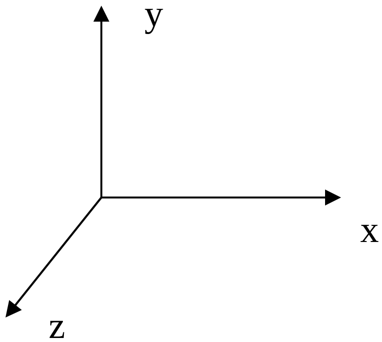
m = total number of unknowns
n = number of independent FBDs (planar)

if $m < 3n$, the structure is unstable
if $m = 3n$, the structure is determinate if stable
if $m > 3n$, the structure is indeterminate if stable

Free Body Diagram

FBD is essential to write the equilibrium equations – summation of forces and moments equal to zero. When a structure is in equilibrium, any part of the structure is also in equilibrium.

For planar (2D) structures: 3 independent equations
For space (3D) structures: 6 independent equations



Types of supports

Table 2.1.31
Rocker support: reaction force is normal to the surface
Roller support: reaction force is normal to the surface
Pin support: two reactive forces orthogonal to each other
Fixed support: three reactions – two orthogonal forces and a moment
Partially fixed (restrained) supports (connections)

Planar Truss Analysis

Method of Joints: Determine the support reactions; then use the equilibrium equations for each joint to determine the member forces.

Method of sections: Used when forces in a few members are needed. Take a section through at the most three members. Write the moment equation that involves only one unknown; then use the other two equilibrium equations.

m = number of members
r = number of support reactions
j = number of joints
m + r = number of total unknowns
2j = number of equations available

If $(m + r) < 2j$, the truss is unstable
If $(m + r) = 2j$, the truss is determinate
If $(m + r) > 2j$, the truss is indeterminate;
Degree of indeterminacy = $(m + r) - 2j$

Planar Frame Analysis

Member forces: axial, shear and moment
Derivation of beam equations: page 71
Shear force and bending moment diagrams: these give a graphical view of the variations of the internal forces; pages 73, 74

m = number of members
3m = number of internal unknowns, axial force, shear and moment
r = number of support reactions
j = number of joints
c = number of equations of condition
3m + r = number of total unknowns
c + 3j = number of equations available

If (3m + r) < (c + 3j), the frame is unstable
If (3m + r) = (c + 3j), the frame is determinate, if it is stable
If (3m + r) > (c + 3j), the frame is indeterminate; if it is stable
Degree of indeterminacy = (3m + r) – (c + 3j)

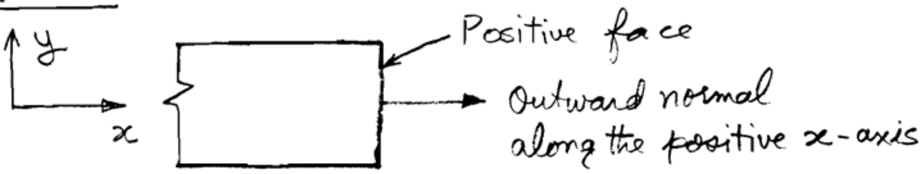
Beam Equations

1. $\frac{dV}{dx} = -w(x)$: Slope of the shear force diagram at any point is equal to the negative of the intensity of the load at that point.
2. $\frac{dM}{dx} = V(x)$: The slope of the bending moment at any point on the beam is equal to the shear force at the point.
3. $EIy'' = \pm M(x)$: Beam deflection differential equation; sign depends on the sign of the curvature

Sign Convention

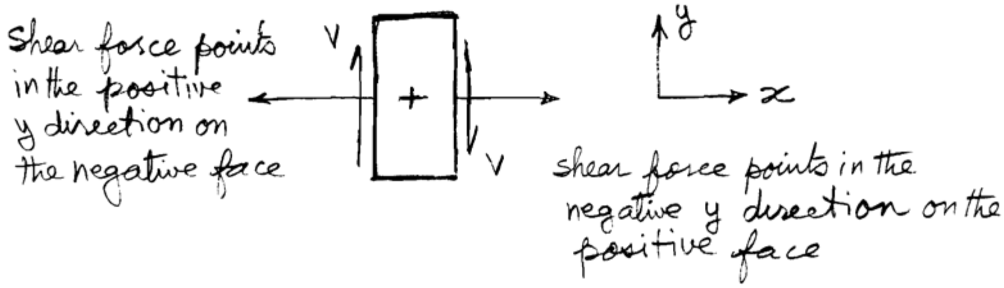
For shear
For moment

Positive Face:



Positive Shear:

For shear force diagram



Positive Moment:

Moment at a point is positive when it is counterclockwise

For bending moment diagram.