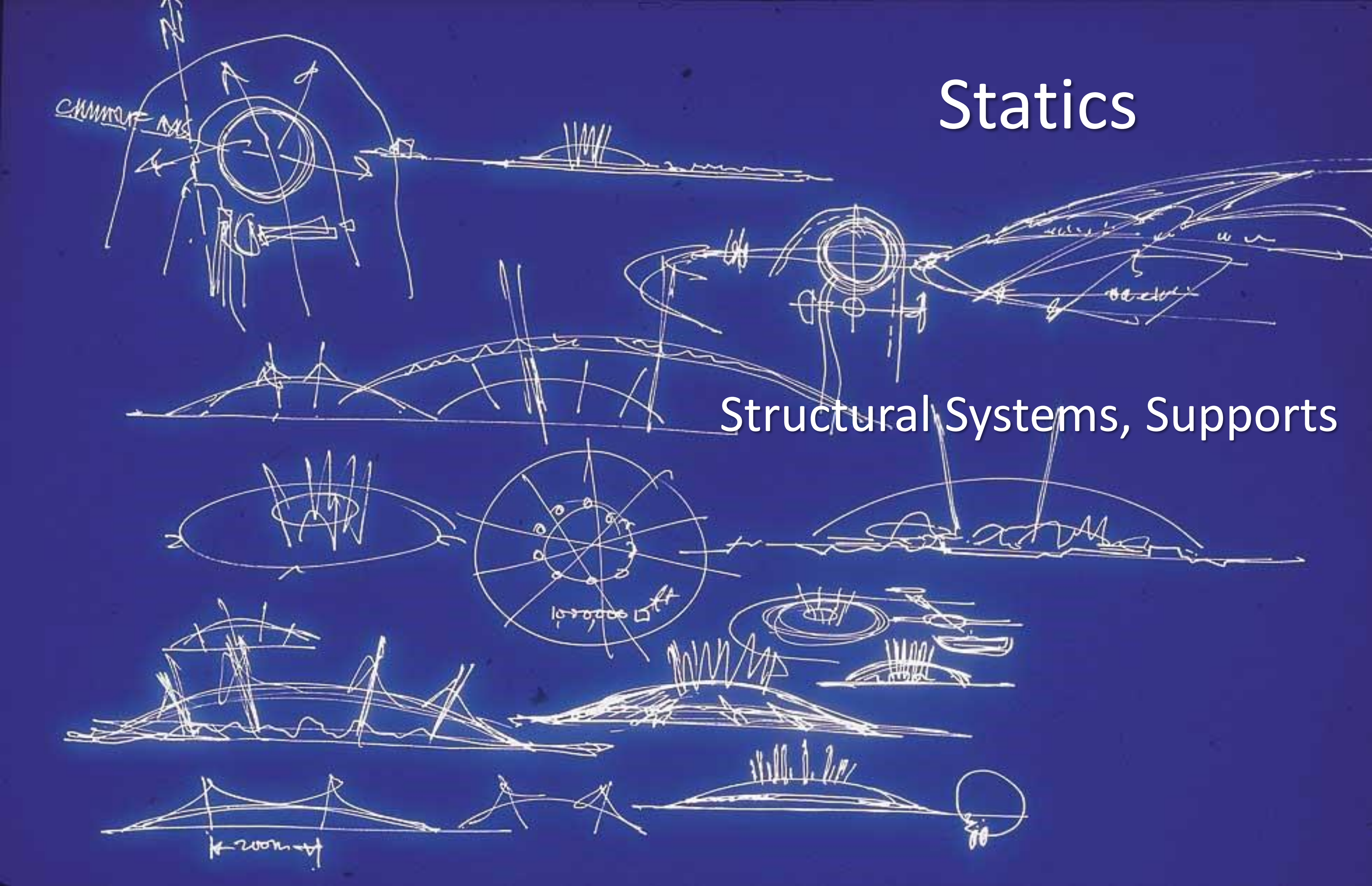


Statics

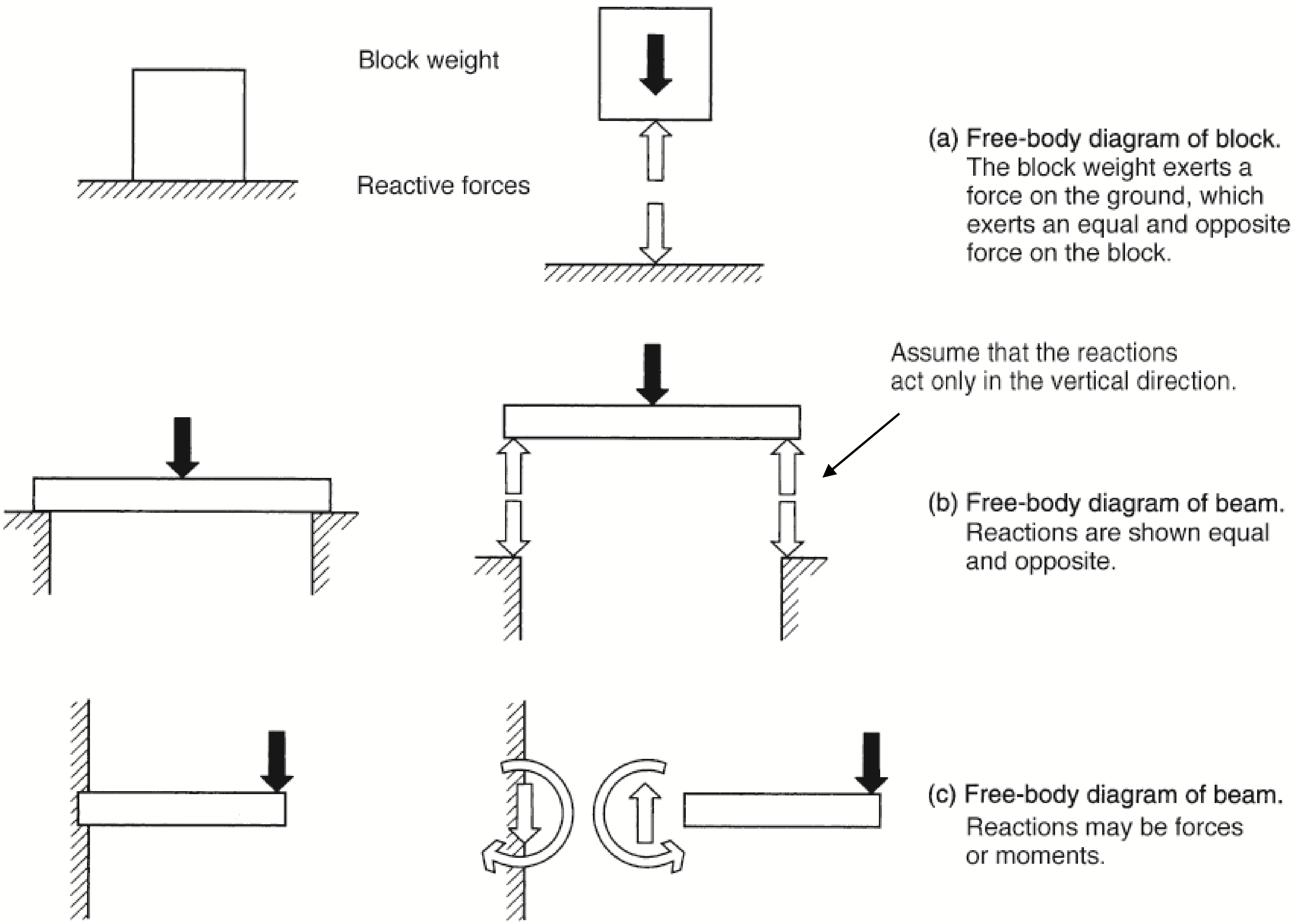
Structural Systems, Supports

Dr. Haluk Sesigür

I.T.U. Faculty of Architecture

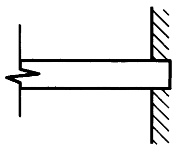
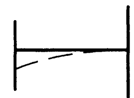
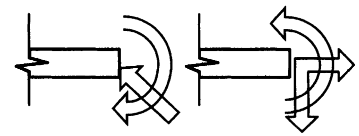
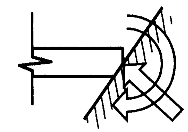
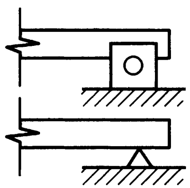
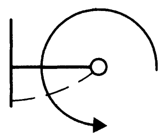
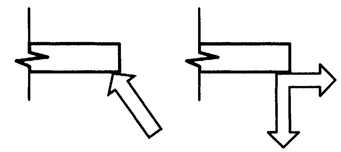
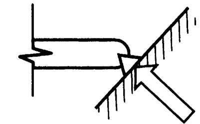
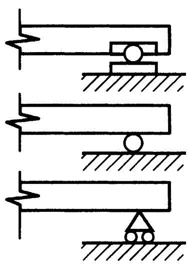
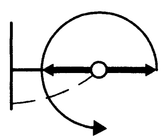
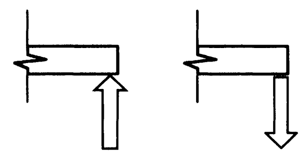
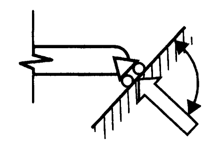
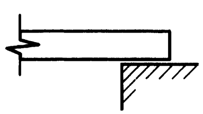
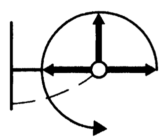
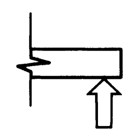
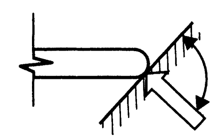
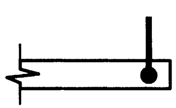
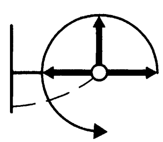
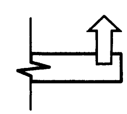
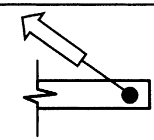
Structural and Earthquake Engineering WG

Reactions and free-body (or equilibrium) diagrams.



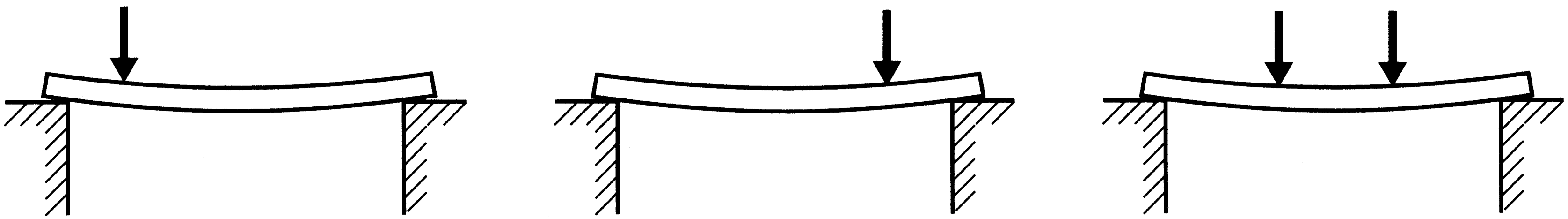
Reference: Structures, Daniel Schodek, Martin Bechthold.

Types of support conditions: idealized models.

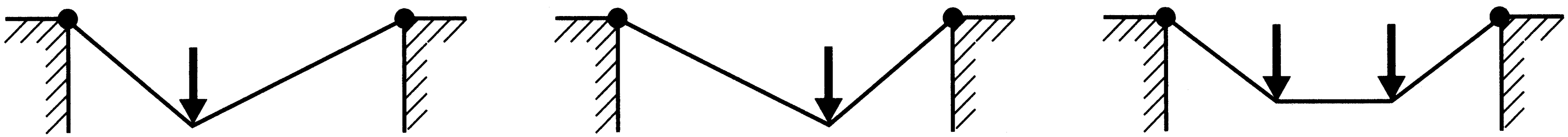
Type of connection	Typical symbols	Types of translations and rotations the connection allows	Type of forces that can be developed at the connection	Types of forces that can be developed when the support is inclined
Fixed support				
Pinned support				
Roller support				
Simple support				
Cable support				

Reference: Structures, Daniel Schodek, Martin Bechthold.

Nonrigid and rigid structures.



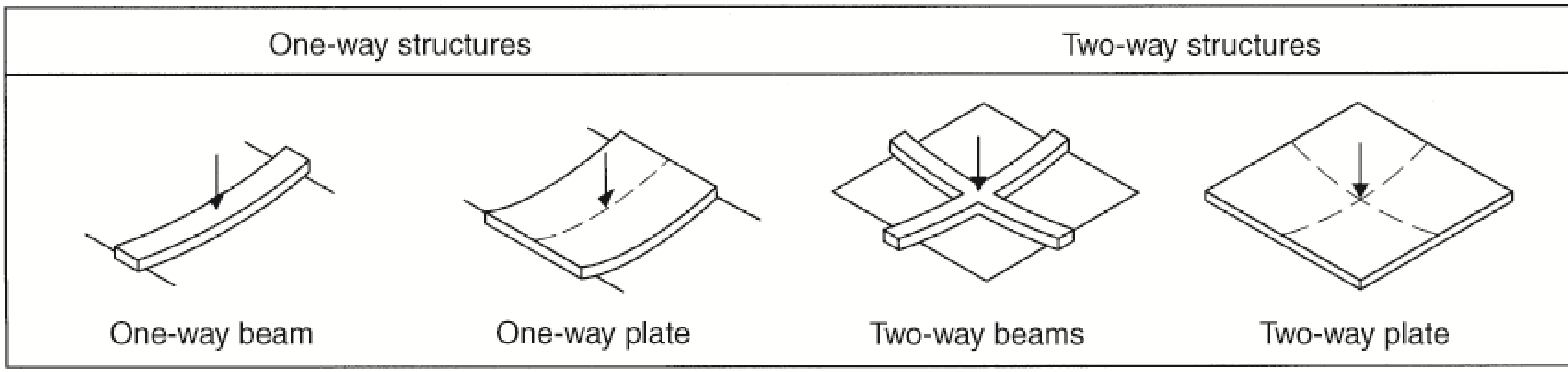
(a) Rigid structure (e.g., a beam). The structure is stiff and does not undergo appreciable changes in shape with changes in the loading condition.



(b) Nonrigid or flexible structure (e.g., a cable). The shape of the structure changes with changes in the loading condition.

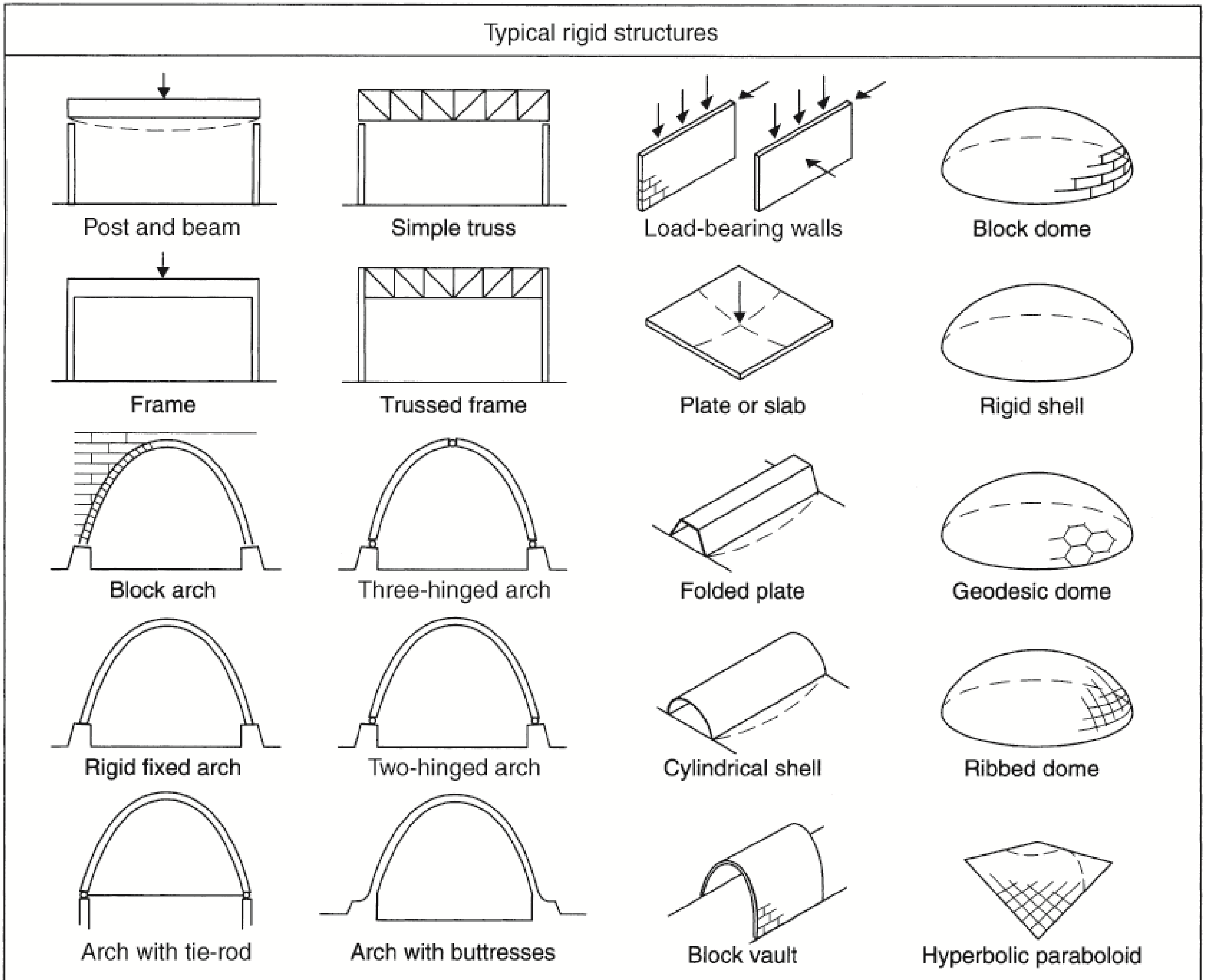
Reference: Structures, Daniel Schodek, Martin Bechthold.

Types of structural elements.



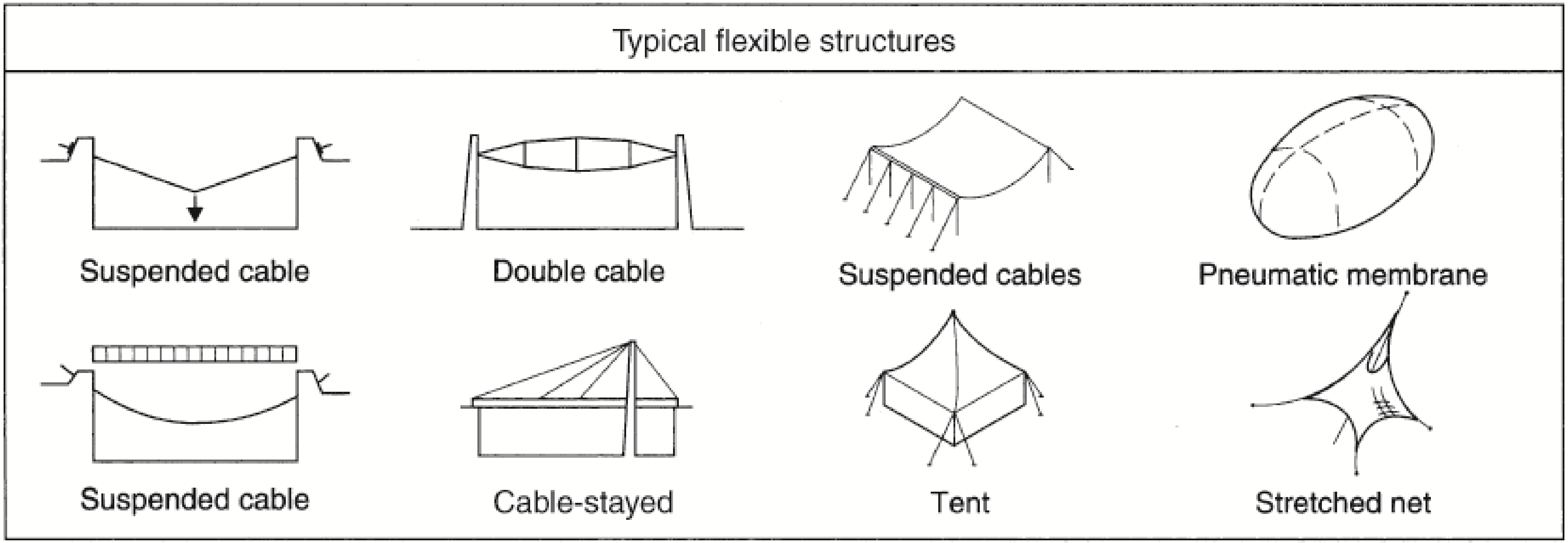
Reference: Structures, Daniel Schodek, Martin Bechthold.

Types of structural elements.



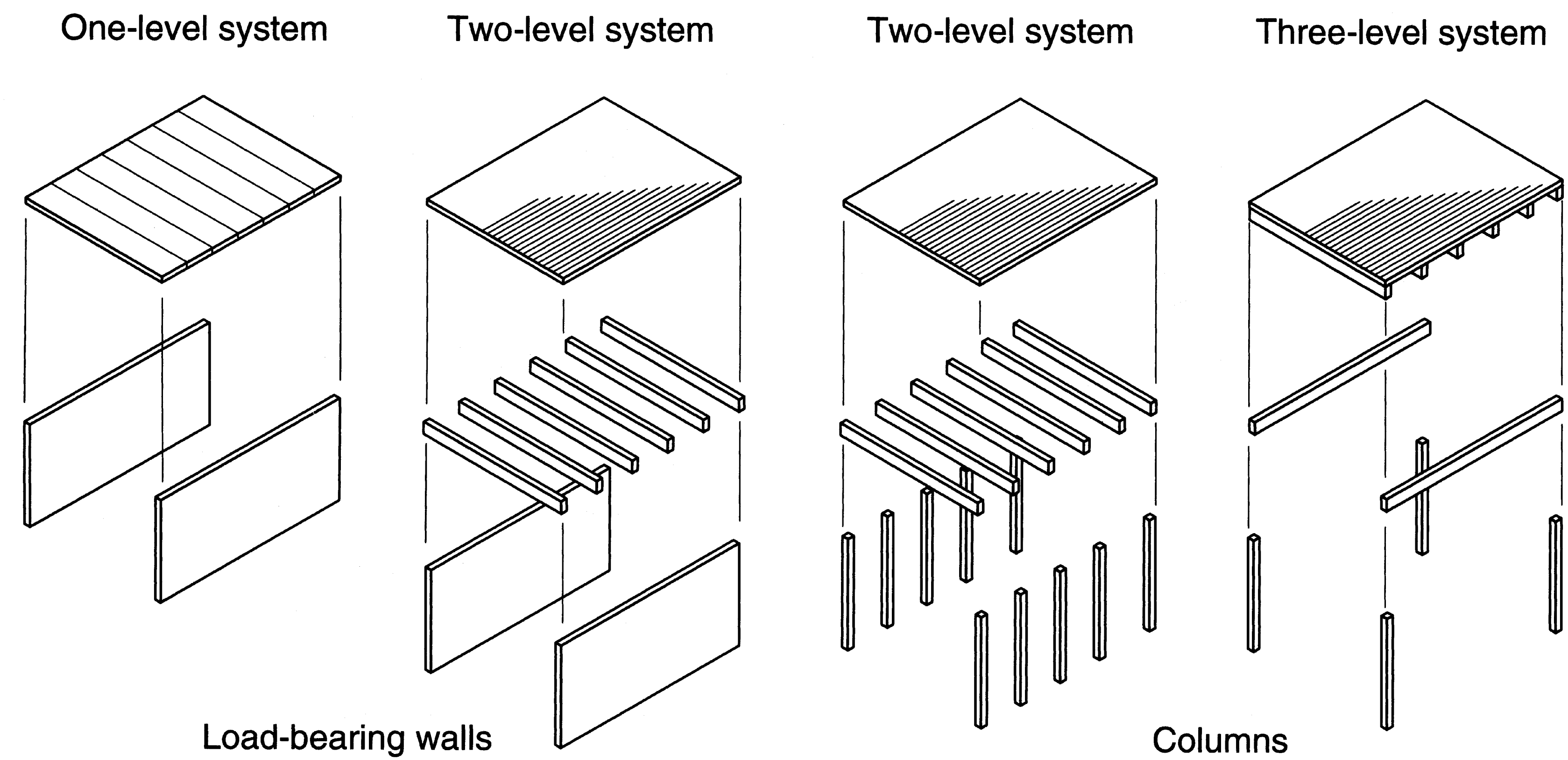
Reference: Structures, Daniel Schodek, Martin Bechthold.

Types of structural elements.



Reference: Structures, Daniel Schodek, Martin Bechthold.

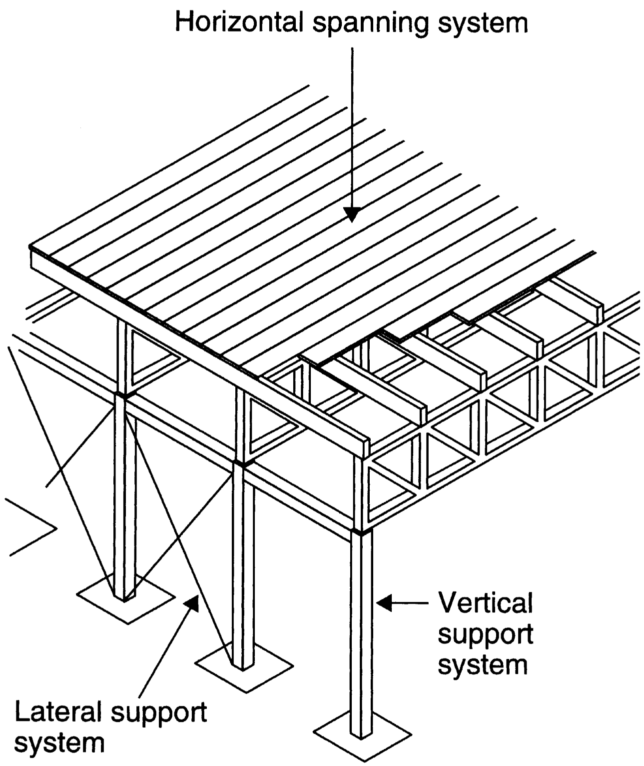
Typical structural units.



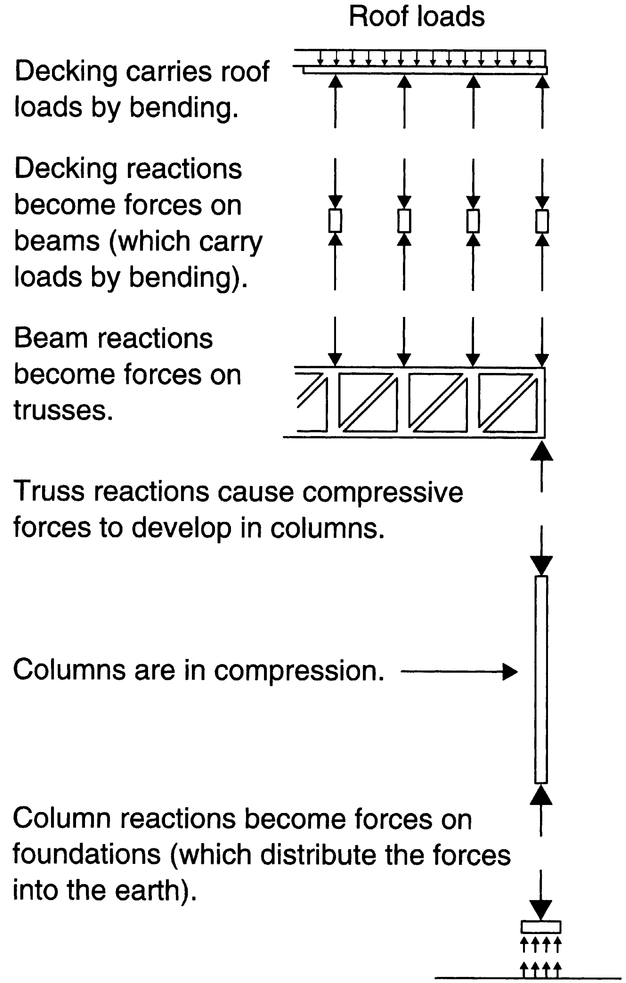
(a) Common types of horizontal spanning systems (one-, two-, and three-level systems) used in relation to different types of load-bearing wall and columnar vertical support systems.

Reference: Structures, Daniel Schodek, Martin Bechthold.

Typical structural units.



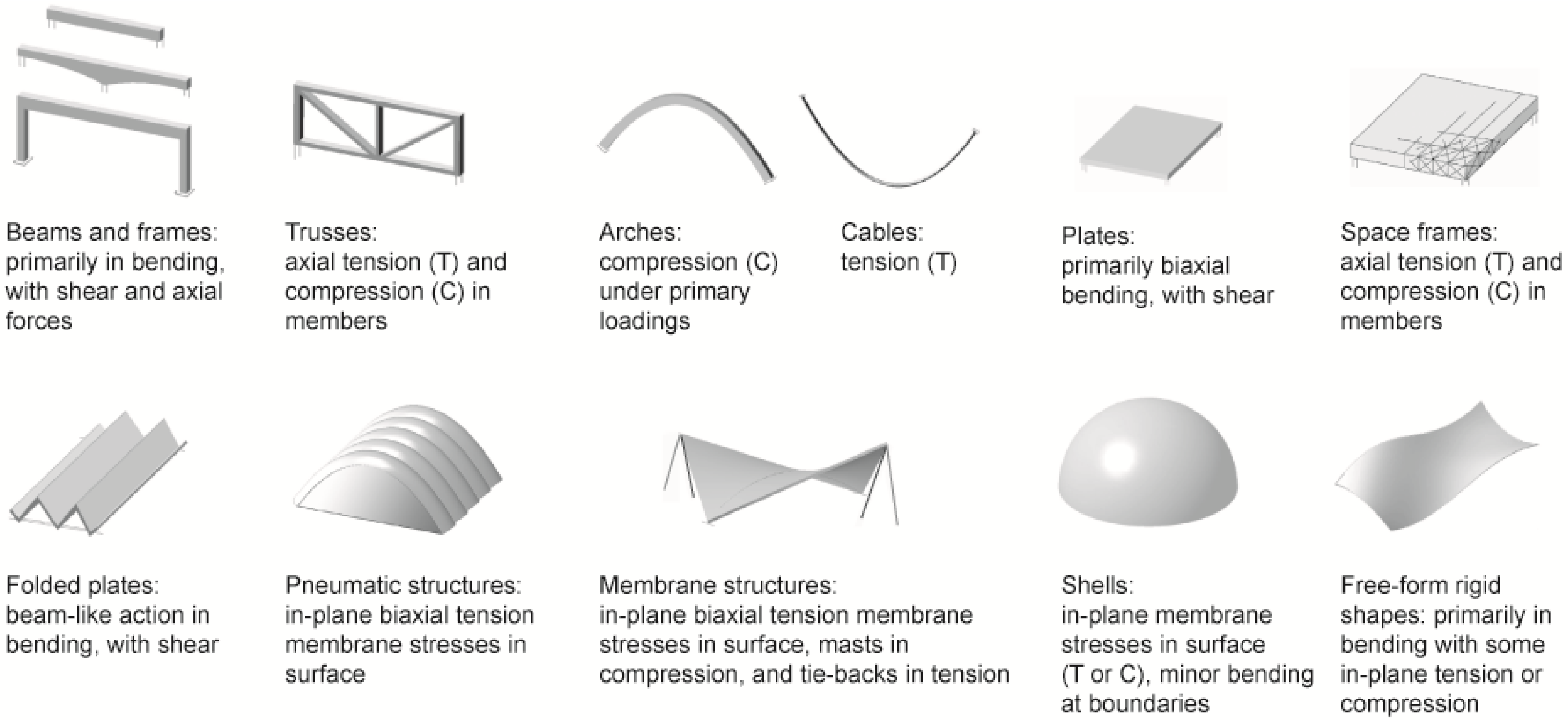
(b) Common assembly of elements. The surface-forming decking is supported by a secondary framing system consisting of closely spaced beams, which is in turn supported by a primary system of more widely spaced trusses. A one-on-one fit exists between the trusses and the supporting columns.



(c) The decking transfers roof loads to the secondary beams. The beams transfer the loads to the trusses, which in turn carry them to the columns. The columns transmit the loads to the foundations. These force transfers occur through the development of reactive forces between members and typically get progressively larger at lower levels.

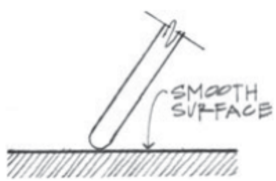
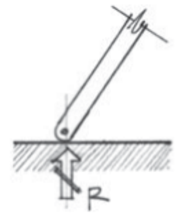
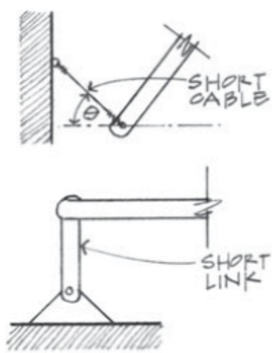
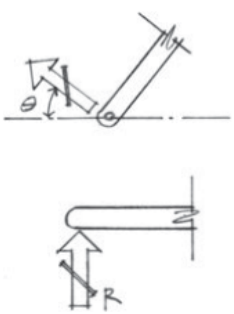
Reference: Structures, Daniel Schodek, Martin Bechthold.

Dominant stress states: bending, shear, and axial forces and stresses in common structural forms under primary loadings.



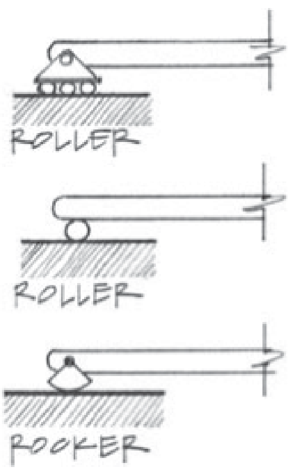
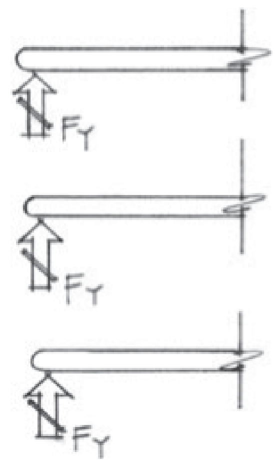
Reference: Structures, Daniel Schodek, Martin Bechthold.

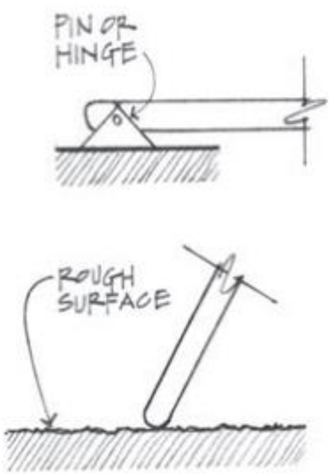
Table 2.1(a) Support conditions for coplanar structures.

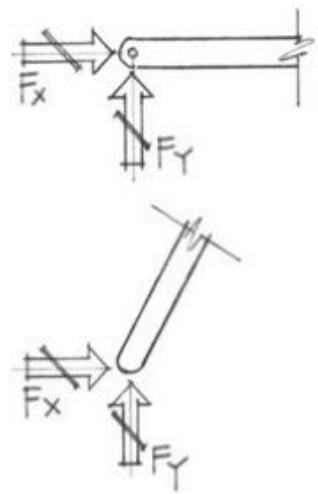
Idealized Symbol	Reactions	Number of Unknowns
		One unknown reaction. Reaction is perpendicular to the surface at the point of contact.
		One unknown reaction. The reaction force acts in the direction of the cable or link.

Ref.Book:Statics and Strength of Materials for Architecture and Building Construction

Table 2.1(b) Supports and connections for coplanar structures.

Idealized Symbol	Reactions	Number of Unknowns
		One unknown reaction. Reaction is perpendicular to the supporting surface.





Two unknown reactions.

Unknown reactions.
F_x and F_y.

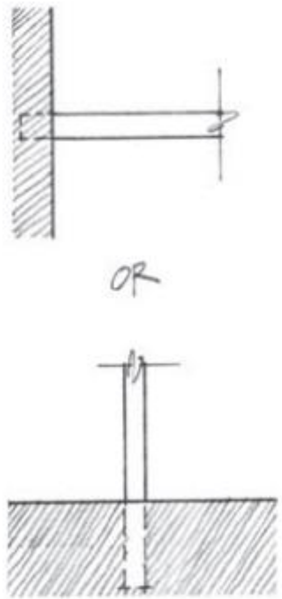
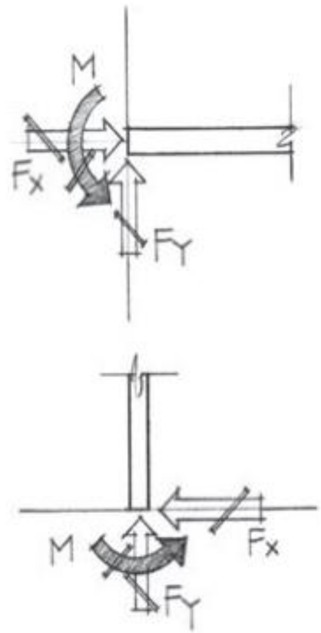
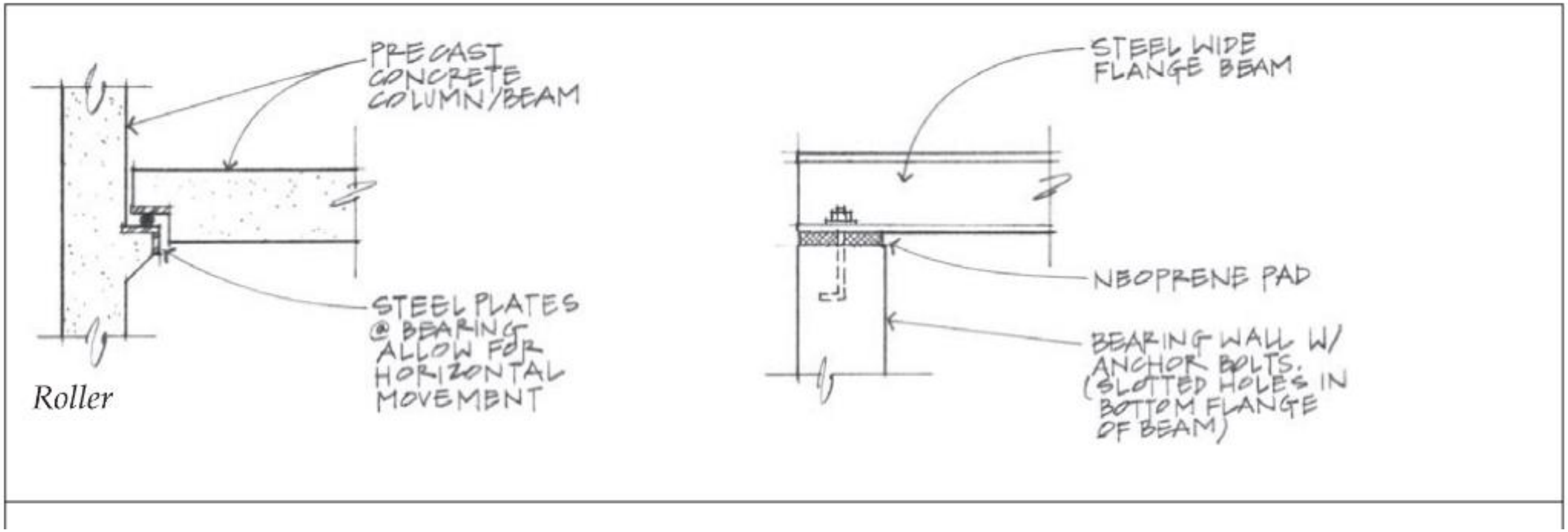
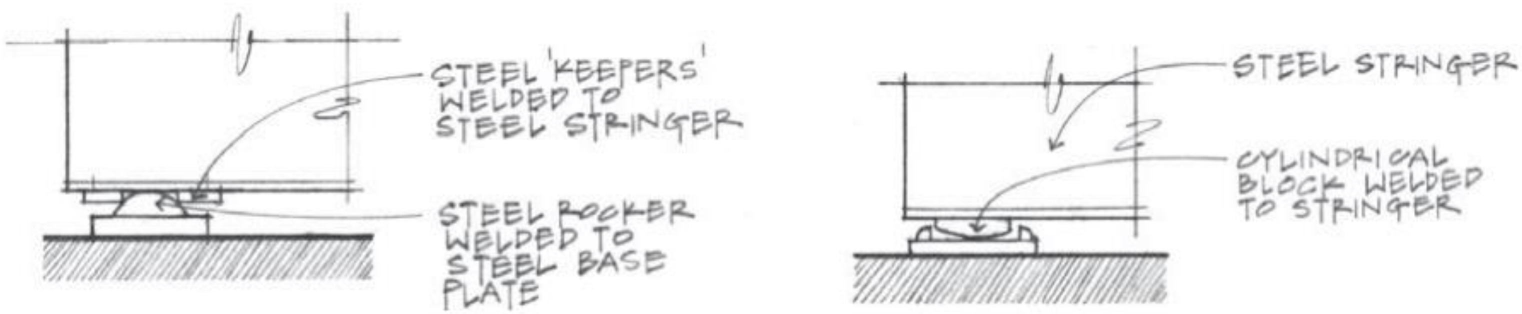
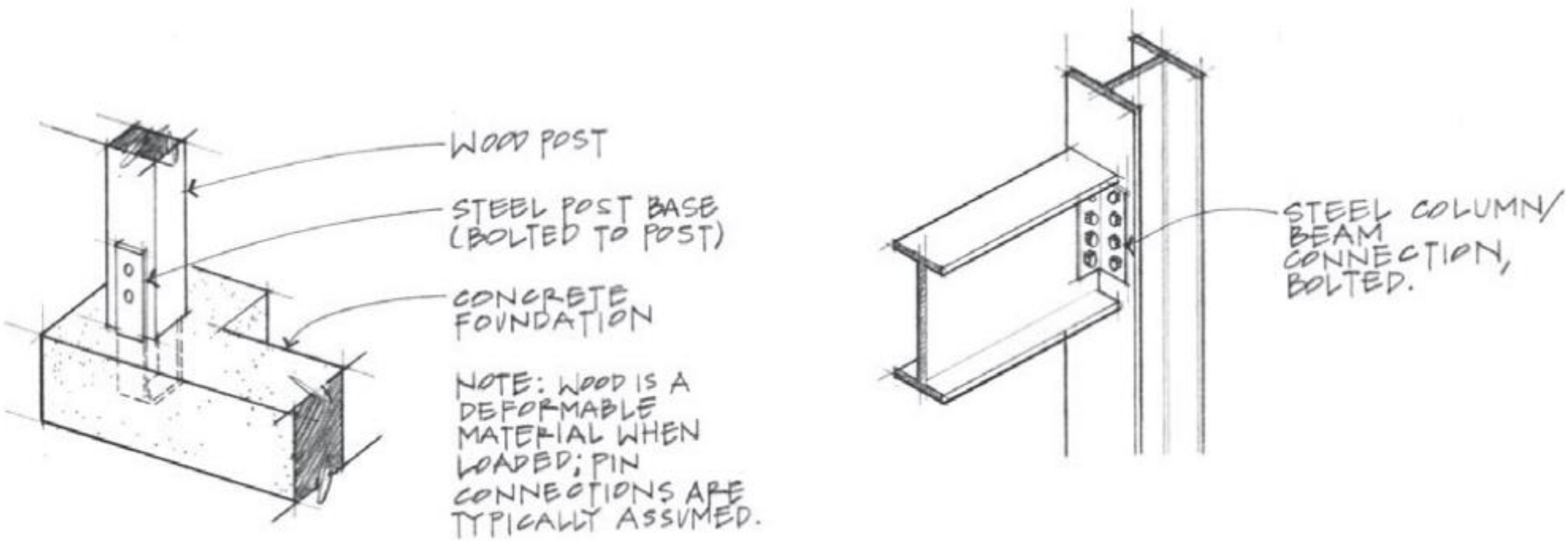
		Three unknown reactions. Unknown reactions. Forces F_x, F_y, and resisting moment *M*.

Table 2.2 Connection and support examples.



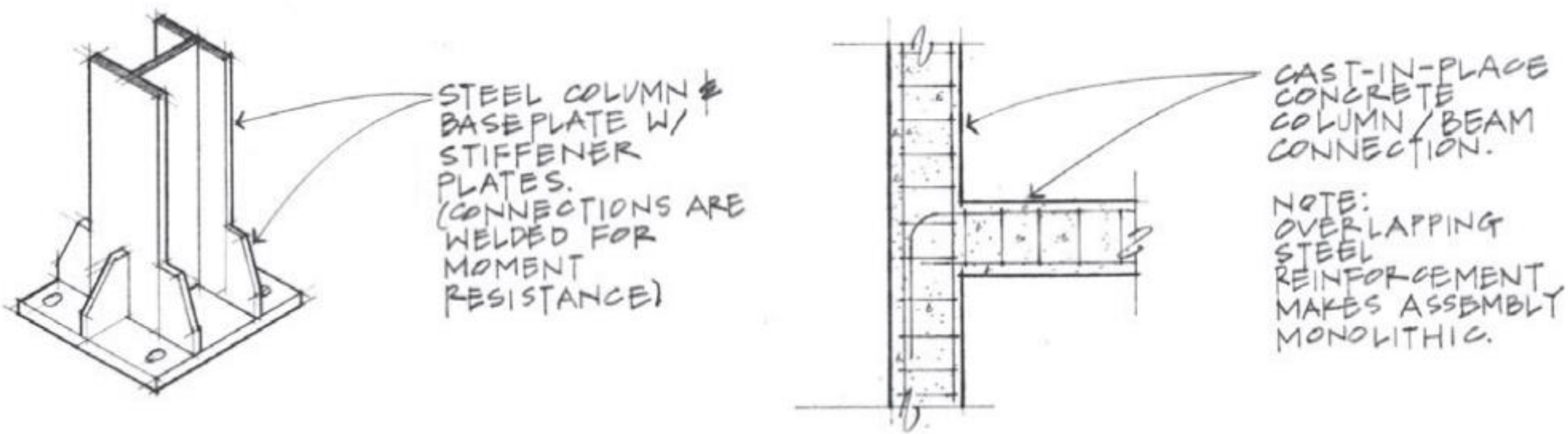


Rocker

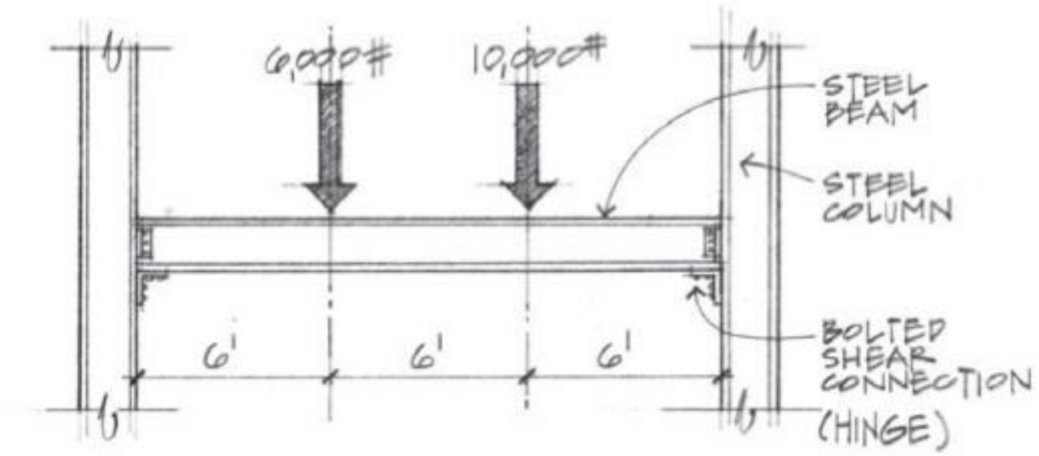


Pin

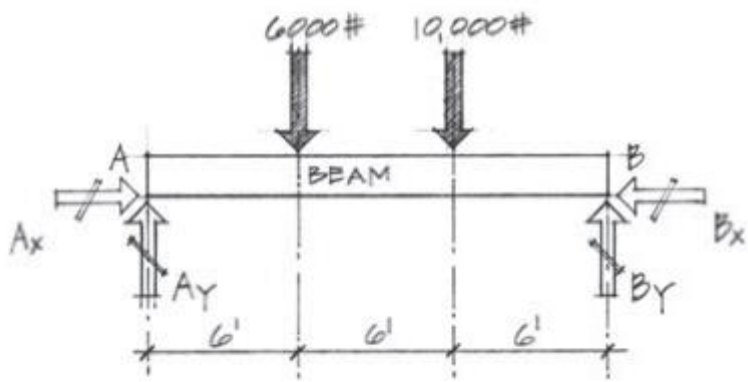
Ref.Book:Statics and Strength of Materials for Architecture and Building Construction


STEEL COLUMN & BASEPLATE W/ STIFFENER PLATES. (CONNECTIONS ARE WELDED FOR MOMENT RESISTANCE)
CAST-IN-PLACE CONCRETE COLUMN / BEAM CONNECTION.
NOTE: OVERLAPPING STEEL REINFORCEMENT MAKES ASSEMBLY MONOLITHIC.

Fixed



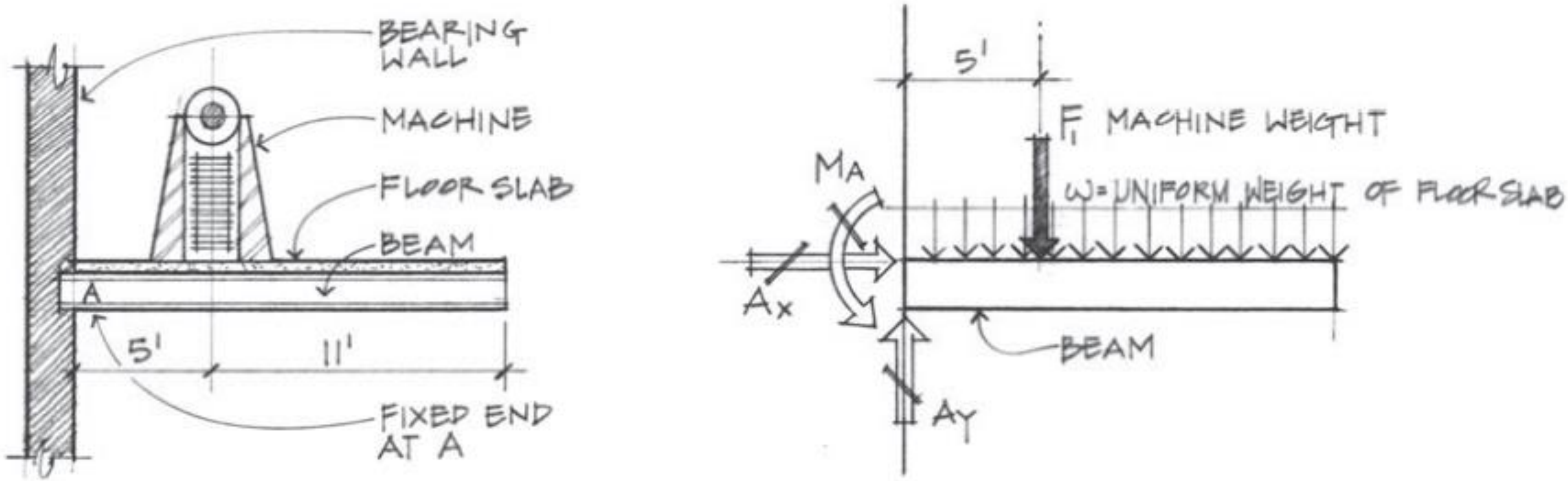
(a) Pictorial diagram.



(b) Free-body diagram of the beam.

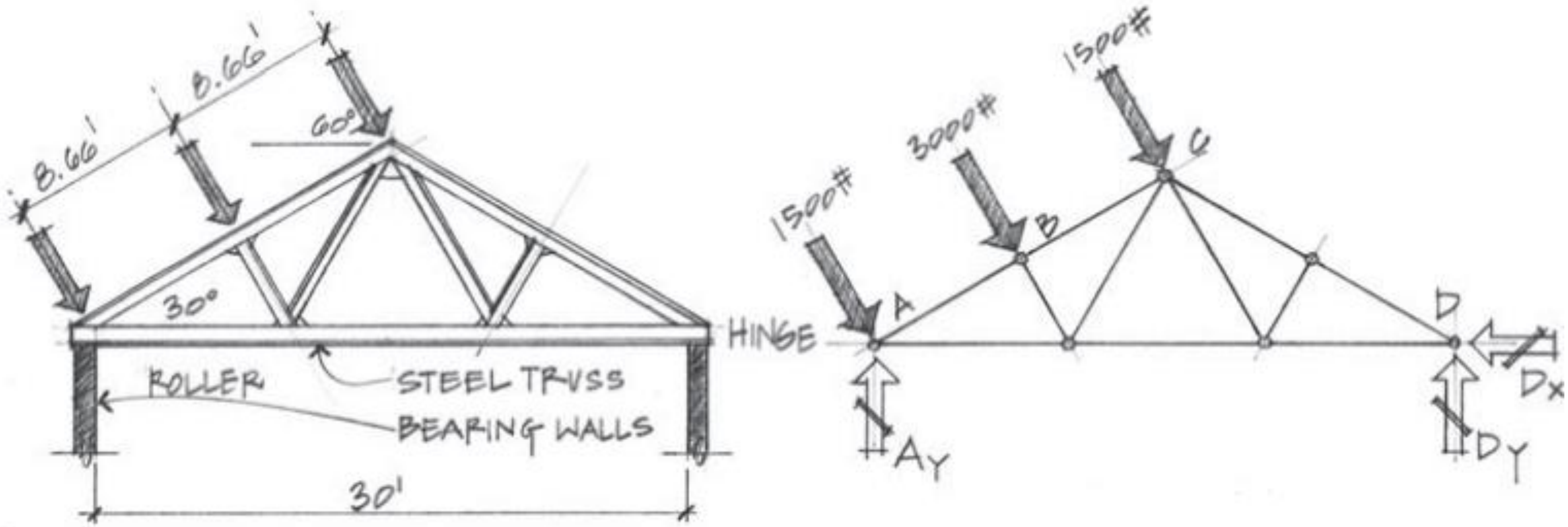
Figure 2.53 Simple beam with two concentrated loads.

Ref.Book:Statics and Strength of Materials for Architecture and Building Construction



(a) Pictorial diagram. *(b) Free-body diagram.*

Figure 2.54 Cantilever beam with a concentrated and uniform load.

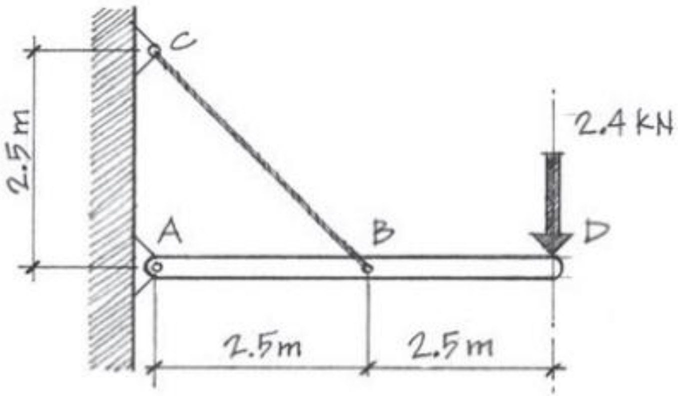


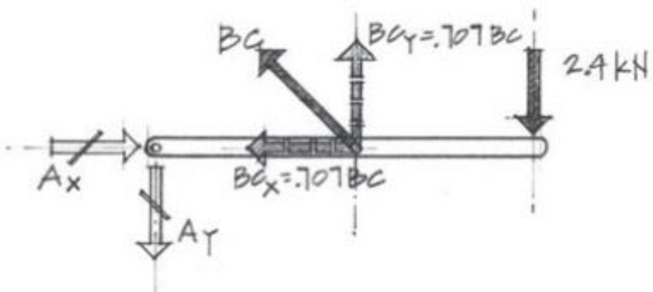
(a) Pictorial diagram.

(b) Free-body diagram.

Figure 2.55 Wind load on a pitched roof. Wind loads on pitched roofs are generally applied perpendicular to the windward surface. Another analysis would examine the uplift forces on the leeward slope. Purlins that run perpendicular to the plane of the truss are generally located at the truss joints to minimize bending in the top chord member.

Ref.Book:Statics and Strength of Materials for Architecture and Building Construction





2.28 Draw an FBD of member ABD. Solve for support reactions at A and the tension in cable BC.

Solution:

The directions for $A_x, A_y,$ and BC are all assumed. Verification will come through the equilibrium equations.

$$[\Sigma M_A = 0] + 0.707BC(2.5\text{ m}) - 2.4\text{ kN}(5\text{ m}) = 0 \quad (1)$$

$$BC = \frac{2.4\text{ kN}(5\text{ m})}{0.707(2.5\text{ m})} = 6.79\text{ kN}$$

$$\therefore BC_x = 0.707(6.79\text{ kN}) = 4.8\text{ kN}$$

$$\therefore BC_y = 0.707(6.79\text{ kN}) = 4.8\text{ kN}$$

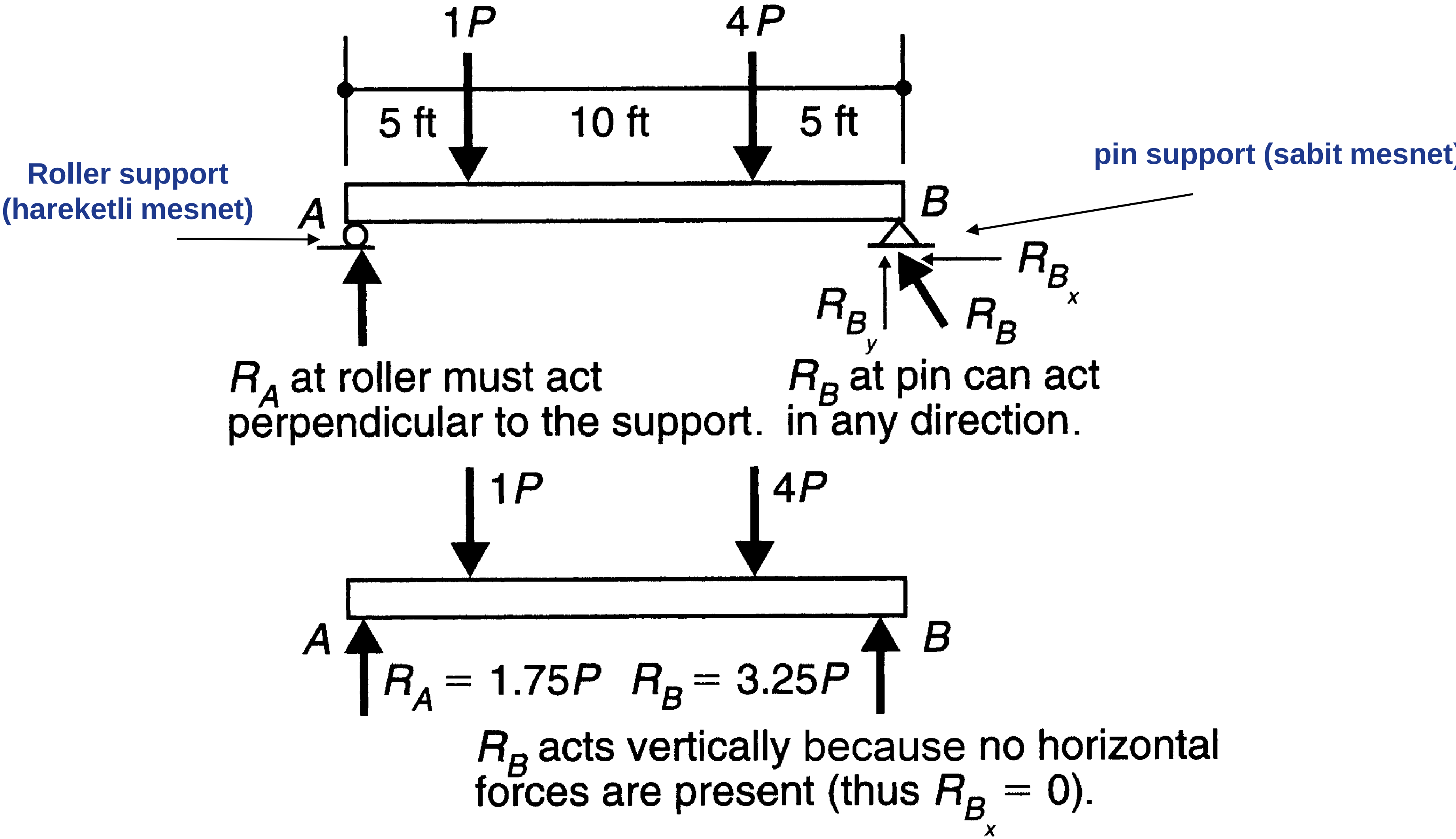
$$[\Sigma F_x = 0] + A_x - 4.8\text{ kN} = 0 \quad (2)$$

$$A_x = +4.8\text{ kN}$$

$$[\Sigma F_y = 0] - A_y + 4.8\text{ kN} - 2.4\text{ kN} = 0 \quad (3)$$

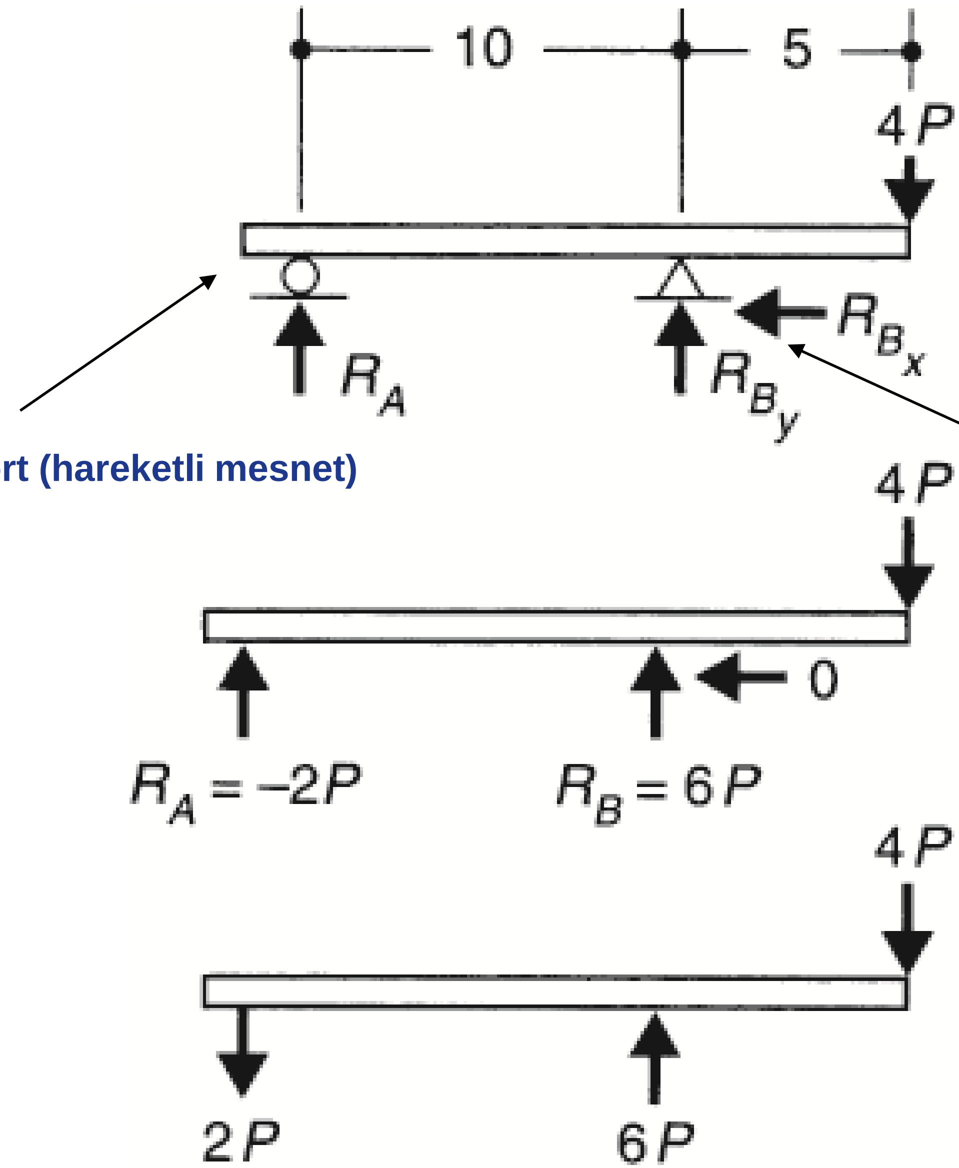
$$A_y = +2.4\text{ kN}$$

Reactions for a simple beam (basit kiriş) with vertical loads.



Reference: Structures, Daniel Schodek, Martin Bechthold.

Reactions for a cantilevering (overhang) beam / çıkmalı kiriş loaded with a point load.

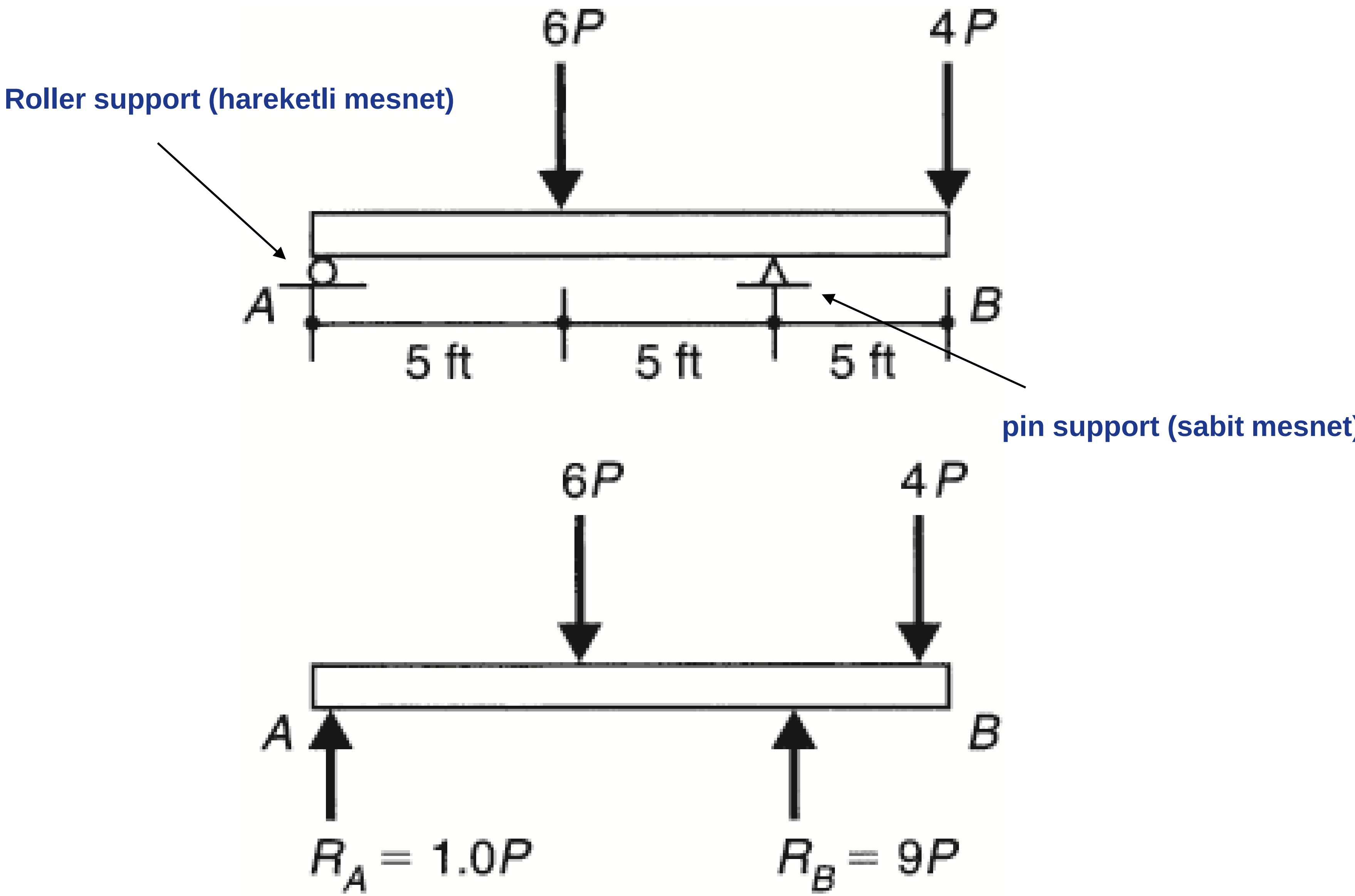


Roller support (hareketli mesnet)

pin support (sabit mesnet)

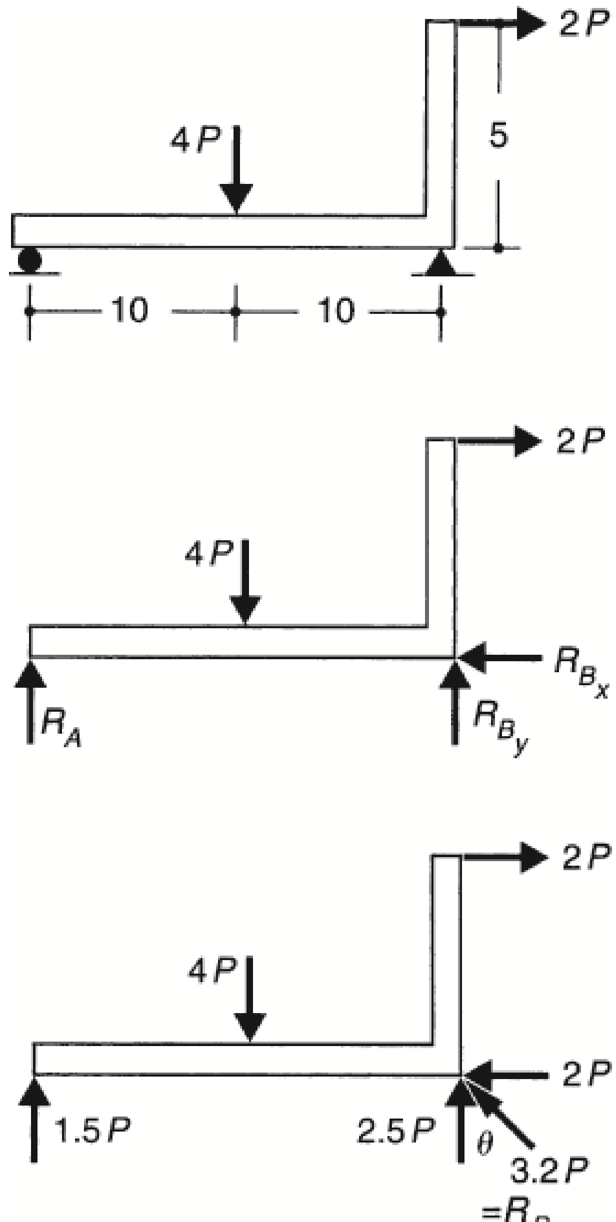
Reference: Structures, Daniel Schodek, Martin Bechthold.

Reactions for a cantilevering (overhang) beam loaded with two point loads.



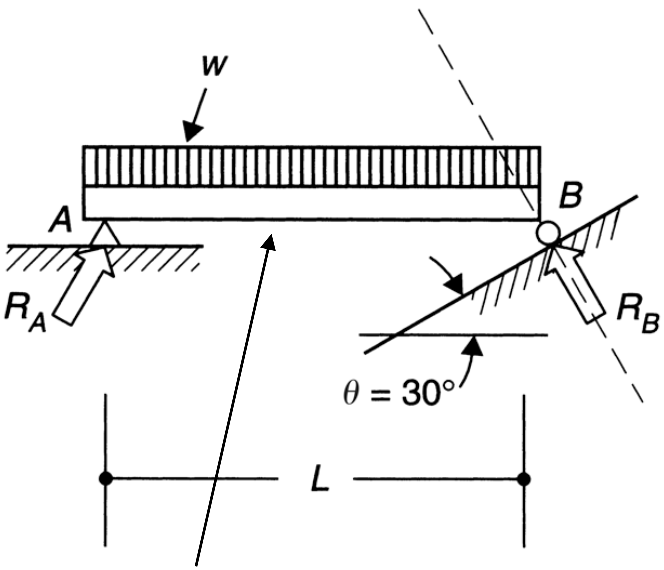
Reference: Structures, Daniel Schodek, Martin Bechthold.

Reactions for an L-shaped beam with horizontal and vertical point loads.

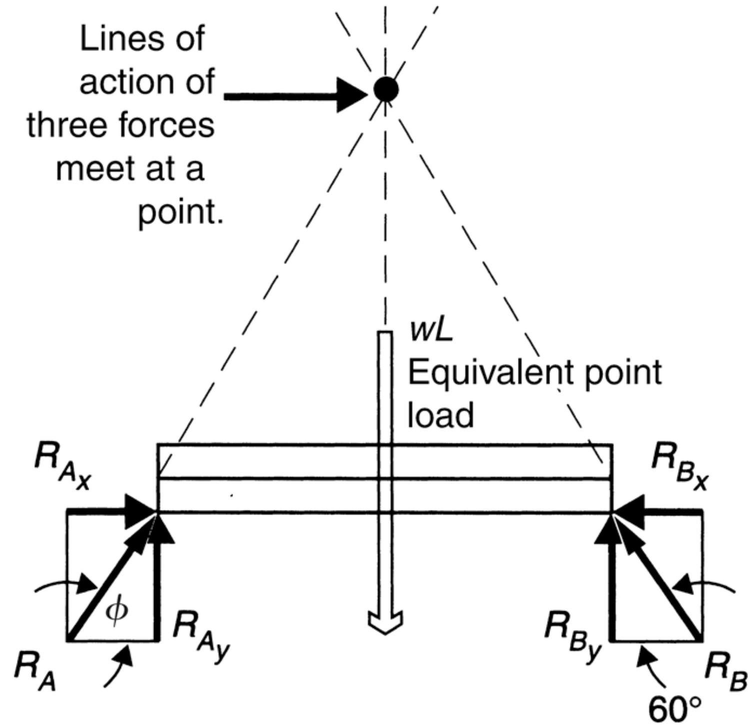


Reference: Structures, Daniel Schodek, Martin Bechthold.

Beam with roller resting on a sloped support.

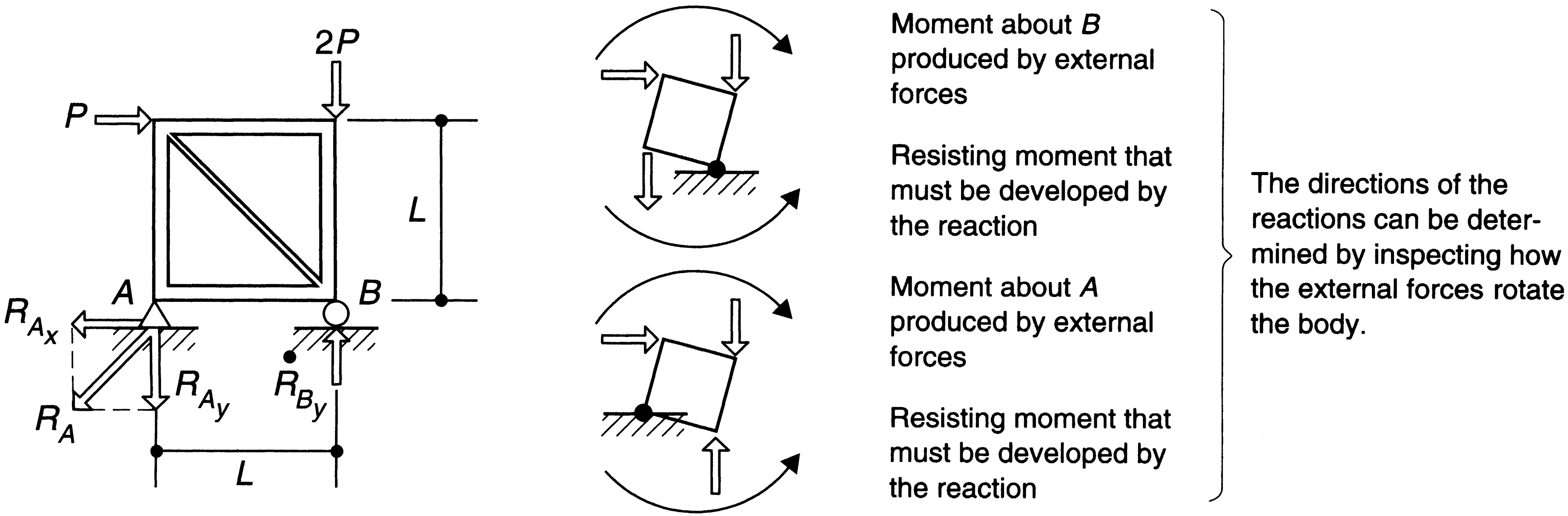


Simply supported beam (basit kiriş)



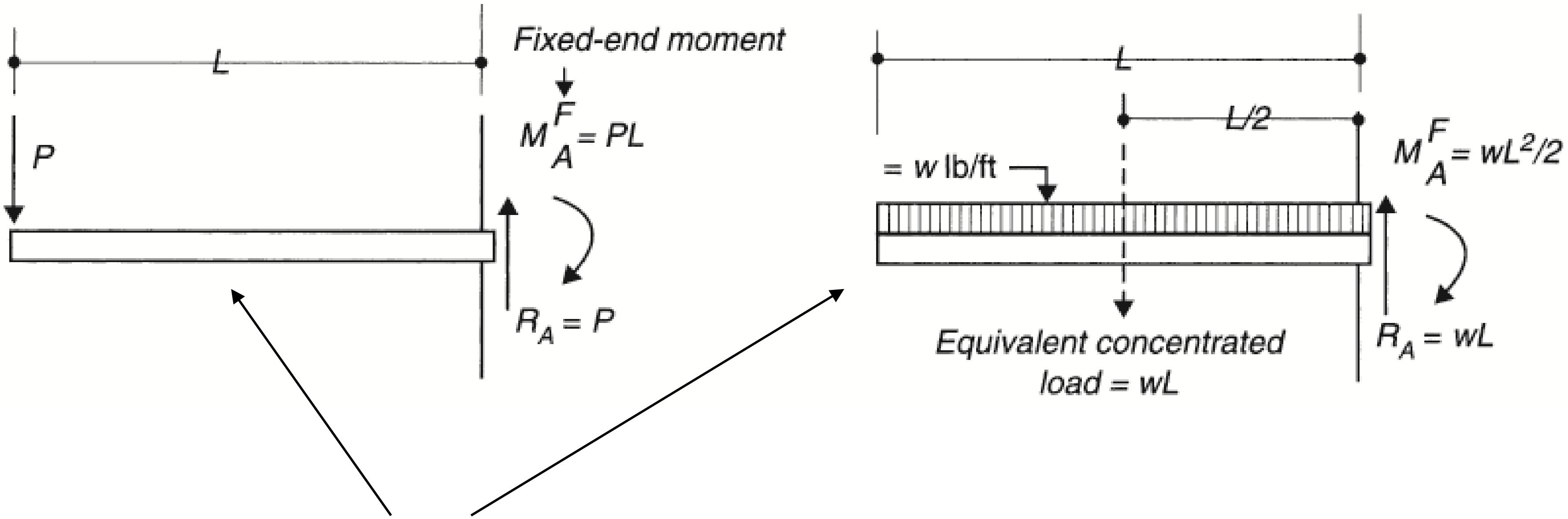
Reference: Structures, Daniel Schodek, Martin Bechthold.

Reaction for a truss-like structure.



Reference: Structures, Daniel Schodek, Martin Bechthold.

Fixed-end moments.

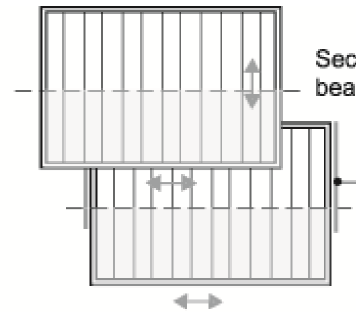


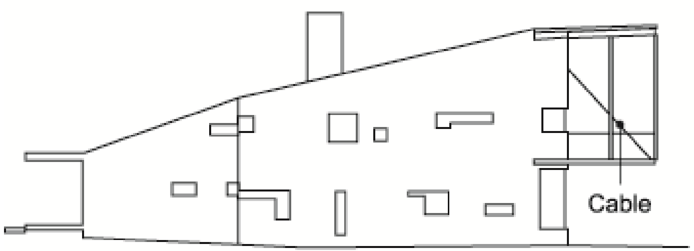
Cantilever (konsol kiriş)

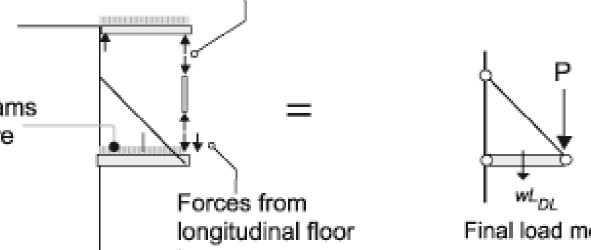
Reference: Structures, Daniel Schodek, Martin Bechthold.

Determination of the loading model for a cable-supported structure. The analysis is simplified and based on several assumptions.

Y-House Catskill Mountains, NY
Steven Holl Architects
Project Architect: Erik Langdalen
1999



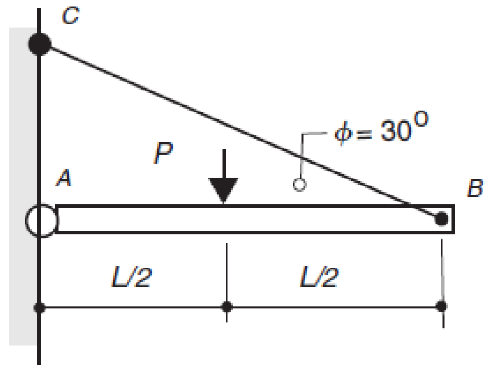




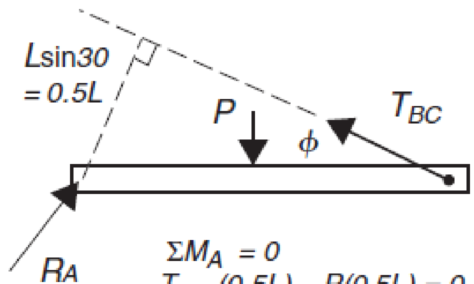
Load modeling is discussed extensively in Chapter 3.

Reference: Structures, Daniel Schodek, Martin Bechthold.

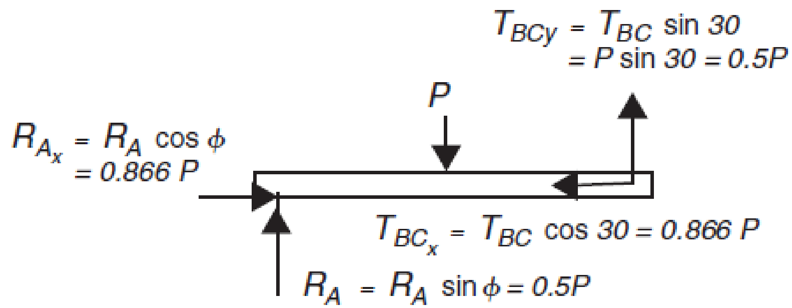
Cable-supported structure.



Cantilever beam supported by a cable.
An internal force T is developed within the cable.
This force T can be found directly by summing moments about point A.



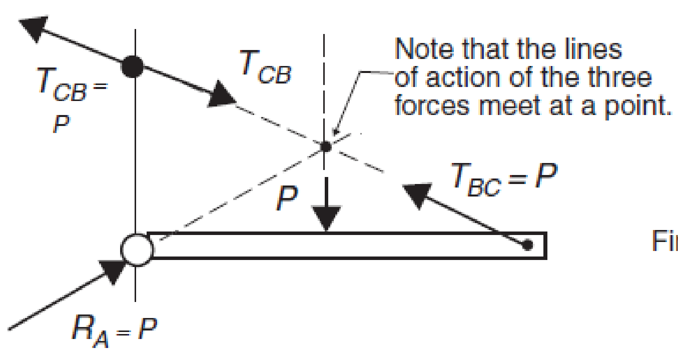
$\Sigma M_A = 0$
$T_{BC}\,(0.5L) - P(0.5L) = 0$
$T_{BC} = P$ (Tension)



$\Sigma\ Fy = 0$
$T_{BC} \sin 30 + R_A - P = 0$
$R_{A_y} = 0.5\ P$

$\Sigma\ Fx = 0$
$-T_{BC} \cos 30 + R_A = 0$
$R_{A_x} = 0.866\ P$

$R_A = P\ @\ \phi = 30$



Final equilibrium diagram showing final forces

Reference: Structures, Daniel Schodek, Martin Bechthold.

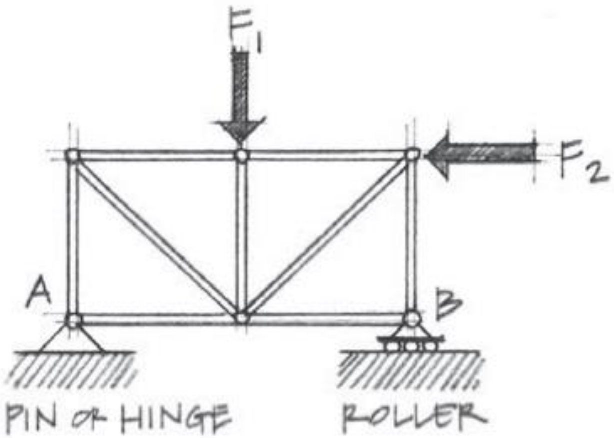


Figure 2.56(a) Truss with hinge and roller support.

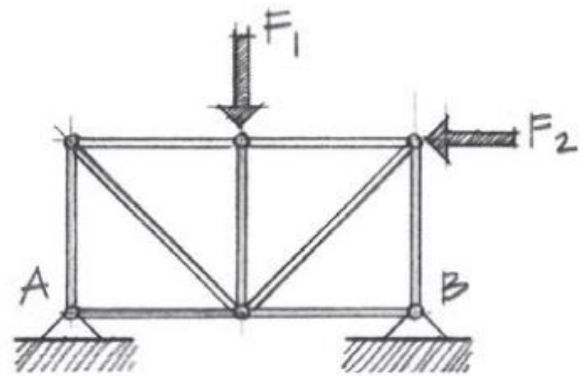


Figure 2.57(a) Truss with two hinged supports.

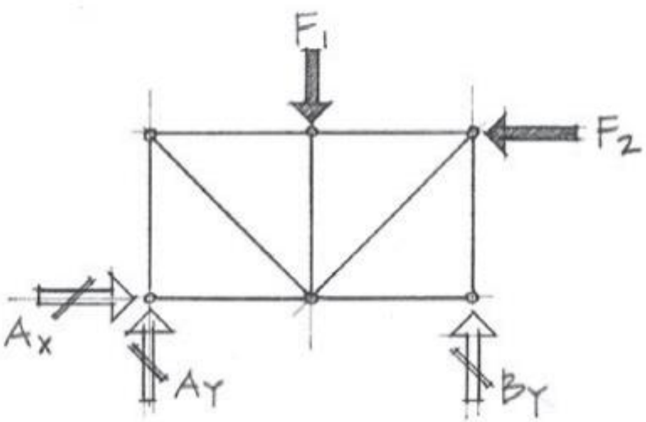


Figure 2.56(b) FBD—Determinate and constrained.

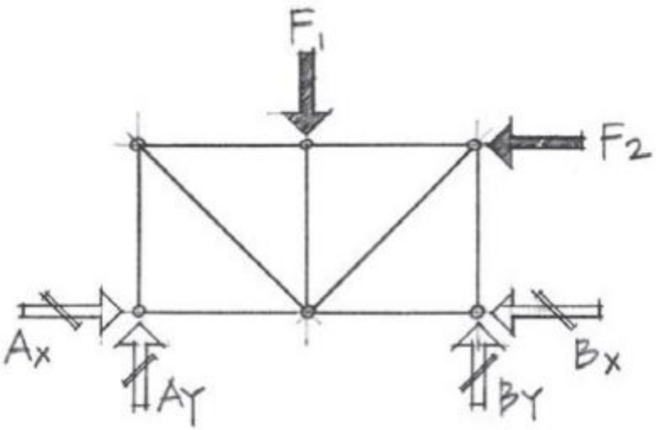


Figure 2.57(b) FBD—Statically indeterminate externally.

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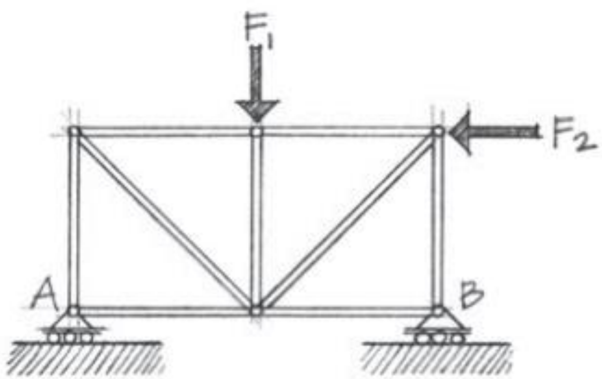
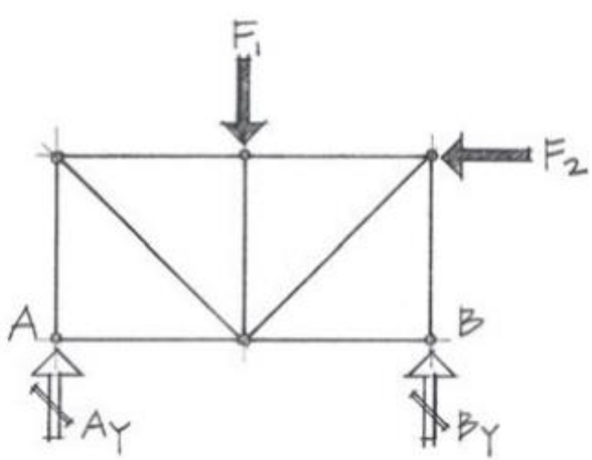
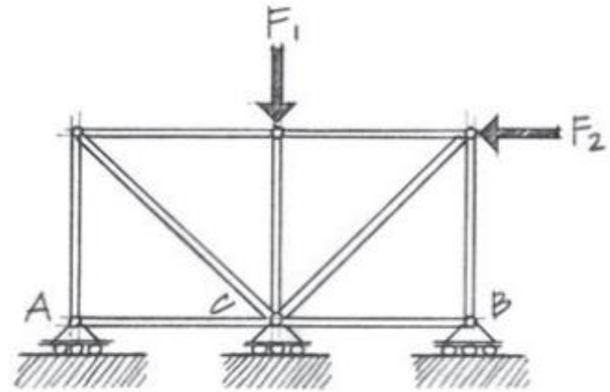


(a) Pictorial diagram.

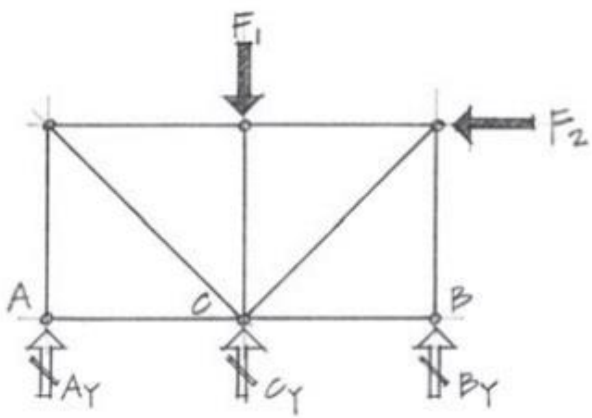


(b) Free-body diagram.

Figure 2.58 Two rollers—partially constrained/unstable.



(a) Pictorial diagram.



(b) Free-body diagram.

Figure 2.59 Two rollers—partially constrained/unstable.

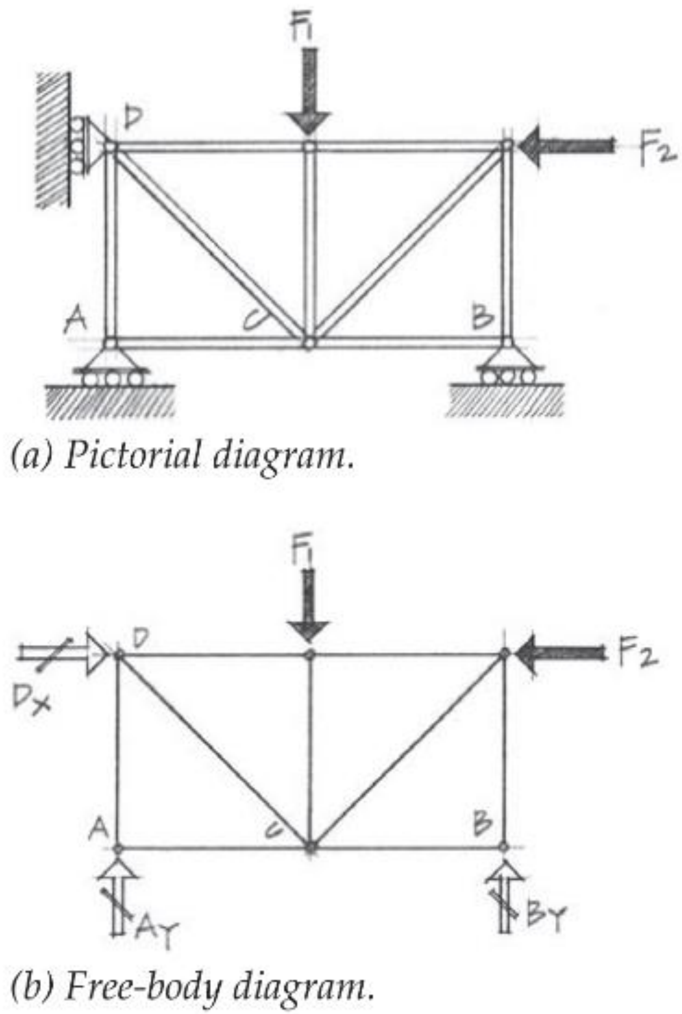
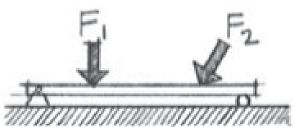
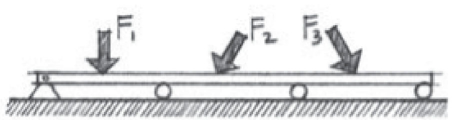
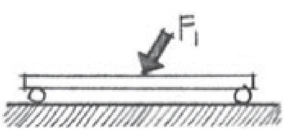
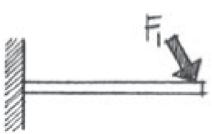
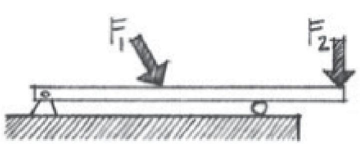


Figure 2.60 Three supports—stable and determinate.

Three Equations of Equilibrium and Three Unknown Support Reactions

Classification of Structures Based on Constraints

	Structure	Number of Unknowns	Number of Equations	Statical Condition
1.		3	3	Statically determinate (called a *simple beam*)
2.		5	3	Statically indeterminate to the second degree (called a *continuous beam*)
3.		2	3	Unstable
4.		3	3	Statically determinate (called a *cantilever*)
5.		3	3	Statically determinate (called an *overhang beam*)

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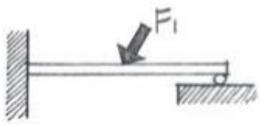
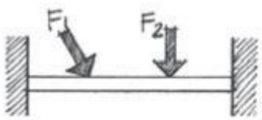
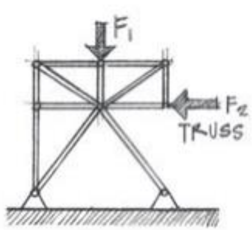
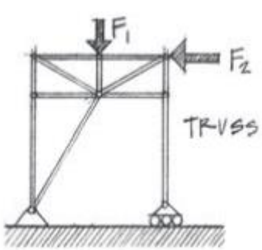
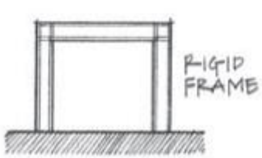
Three Equations of Equilibrium and Three Unknown Support Reactions

Classification of Structures Based on Constraints

	Structure	Number of Unknowns	Number of Equations	Statical Condition
6.		4	3	Statically indeterminate to the first degree (called a *propped beam*)
7.		6	3	Statically indeterminate to the third degree (called a *fixed-ended beam*)
8.		3	3	Statically determinate (see Example Problem 3.8)
9.		3	3	Unstable (improperly constrained)
10.		6	3	Statically indeterminate to the third degree

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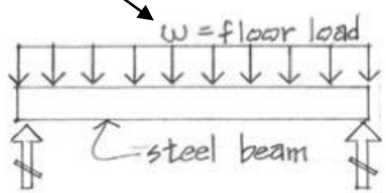
LOAD SYSTEMS

Distributed loads, as the term implies, act on a relatively large area—too large to be considered as a point load without introducing an appreciable error. Examples of distributed loads include:

- Furniture, appliances, people, etc.
- Wind pressure on a building.
- Fluid pressure on a retaining wall.
- Snow load on a roof.

Uniform distributed load (düzgün yayılı yük)



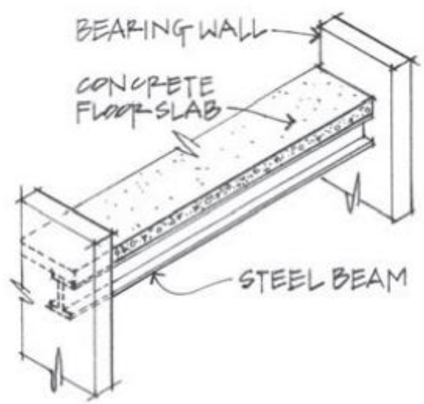


Figure 3.22 Uniformly distributed load with an FBD of the steel beam.

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Point or *concentrated loads* have a specific point of application, whereas *distributed loads* are scattered over large surfaces. Most common load conditions on building structures begin as distributed loads. (See Figures 3.20 to 3.24.)

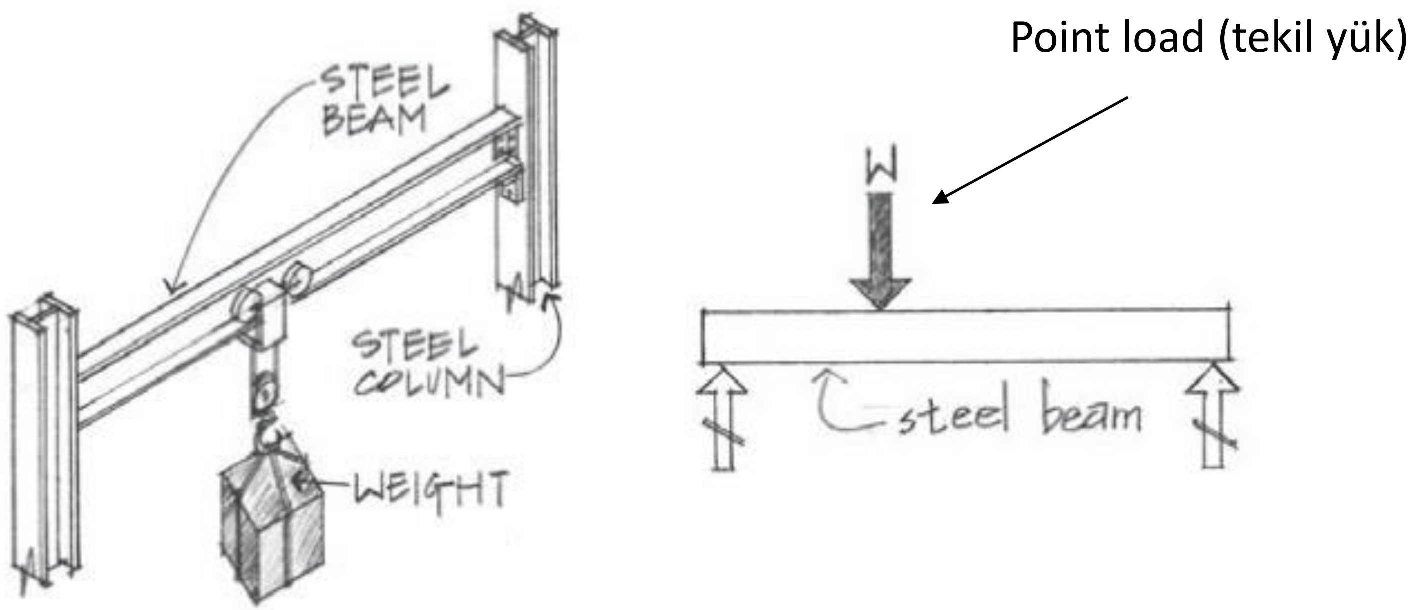


Figure 3.20 Single concentrated load, with an FBD of the steel beam.

Point or *concentrated loads* have a specific point of application, whereas *distributed loads* are scattered over large surfaces. Most common load conditions on building structures begin as distributed loads. (See Figures 3.20 to 3.24.)

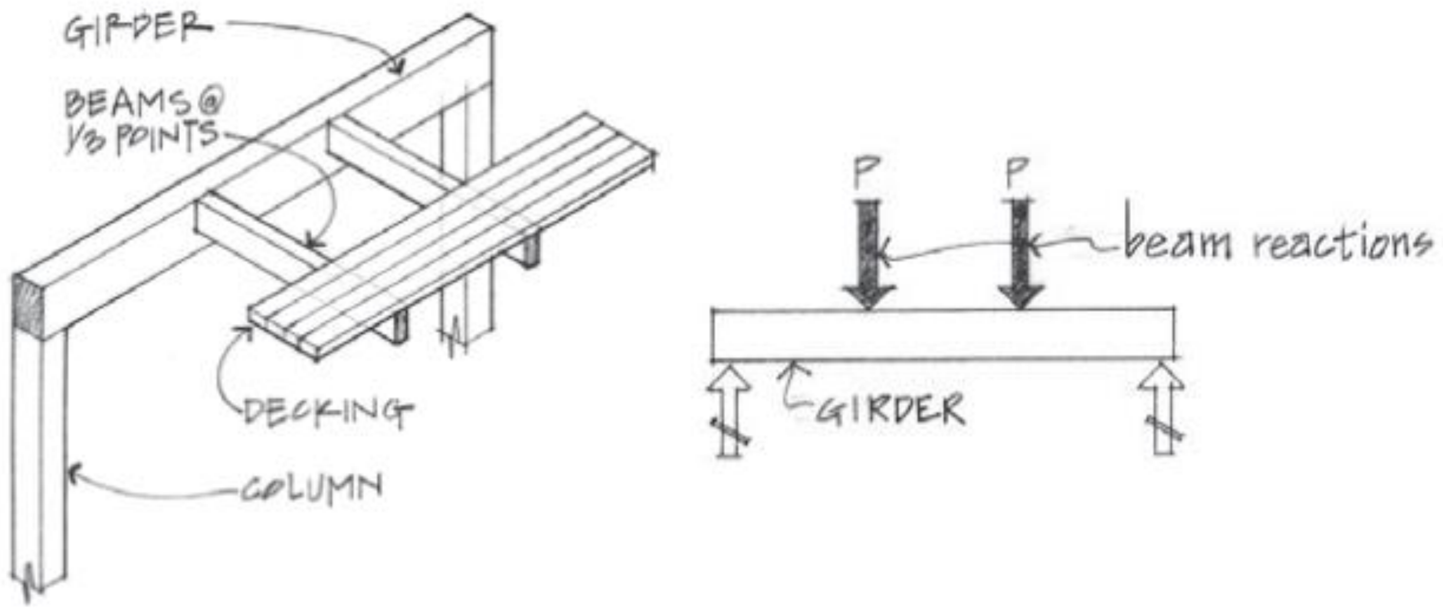
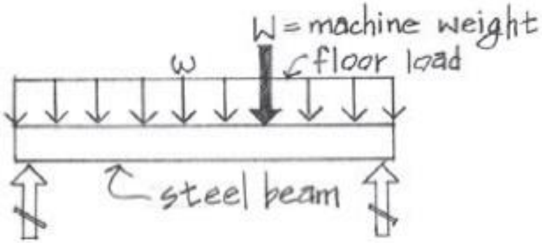


Figure 3.21 Multiple concentrated loads, with an FBD of the wood girder.



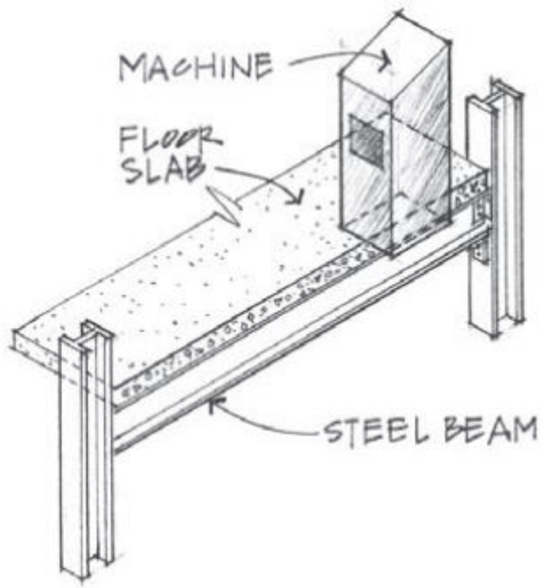


Figure 3.23 Uniformly distributed load, with a concentrated load, with an FBD of the steel beam.

Resultant Force (Bileşke kuvvet)

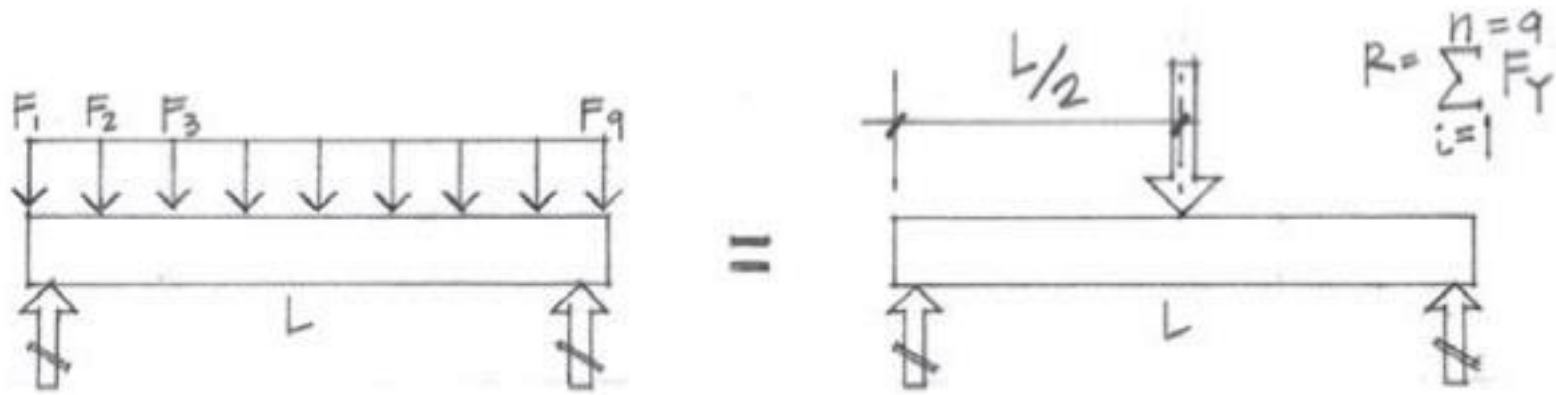


Figure 3.25 Equivalent load systems.

The location of the equivalent concentrated load is based on the centroid of the load area. By geometric construction, the centroids of two primary shapes are shown in Figures 3.26 and 3.27.

Resultant Force (Bileşke kuvvet)

Resultant Force (Bileşke kuvvet)

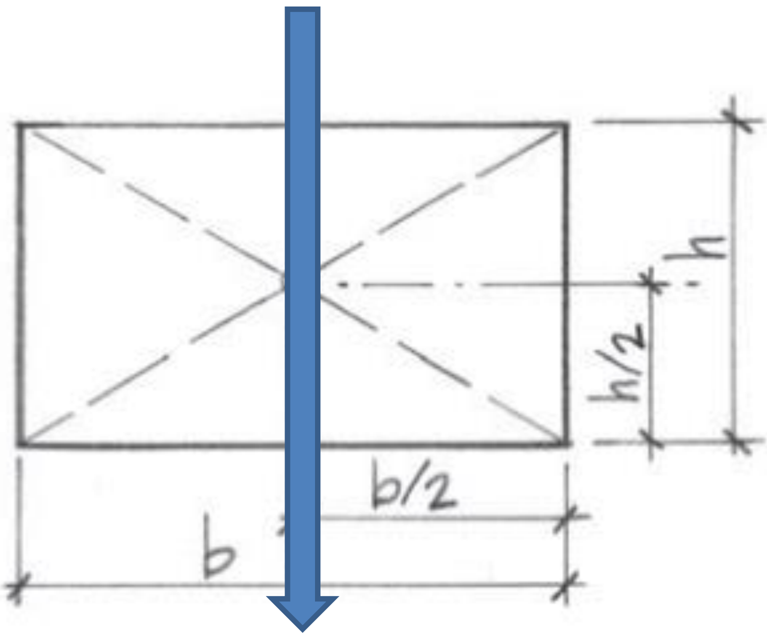


Figure 3.26 Centroid of a rectangle (Area = b × h).

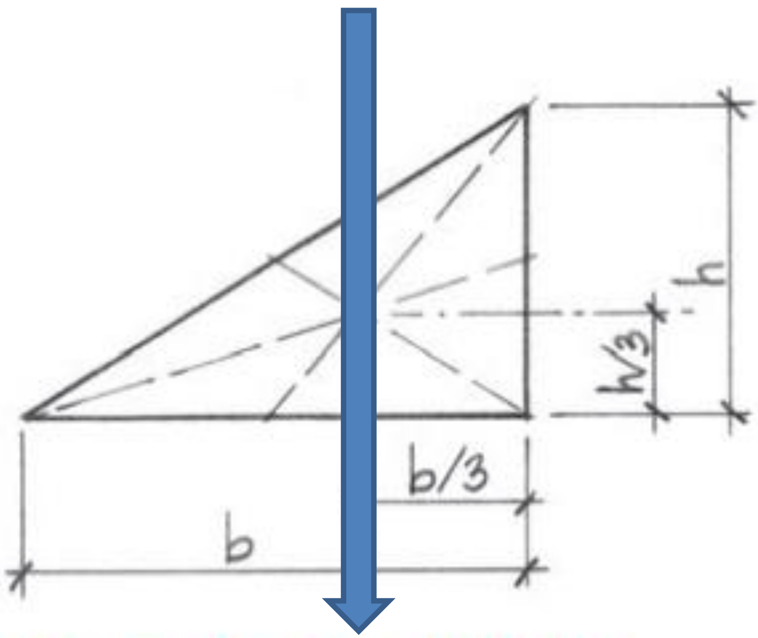


Figure 3.27 Centroid of a triangle (Area = 1/2 × b × h).

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