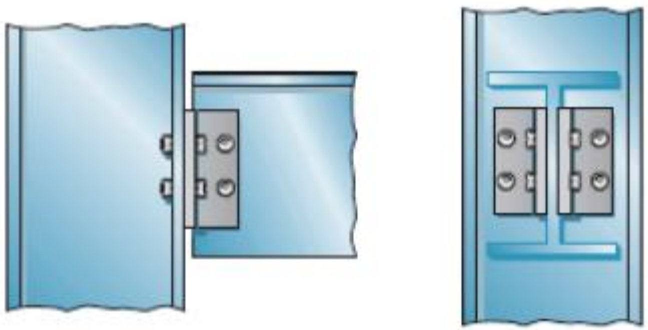
Theory of Structure

Lec.3 Analysis of Statically Determinate Structures

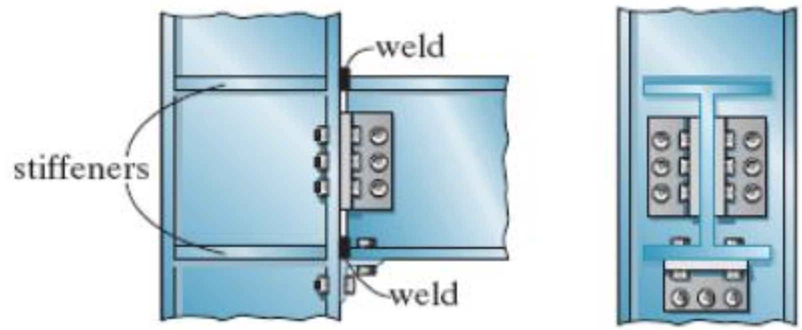
- Analysis of Statically Determinate Structures
- Idealized Structure To develop the ability to model or idealize a structure so that the structural engineer can perform a practical force analysis of the members

Support Connections

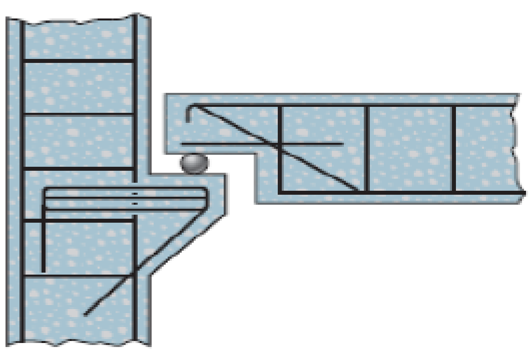
- Pin connection (allows some freedom for slight rotation)
- Roller support (allows some freedom for slight rotation)
- Fixed joint (allows no relative rotation)



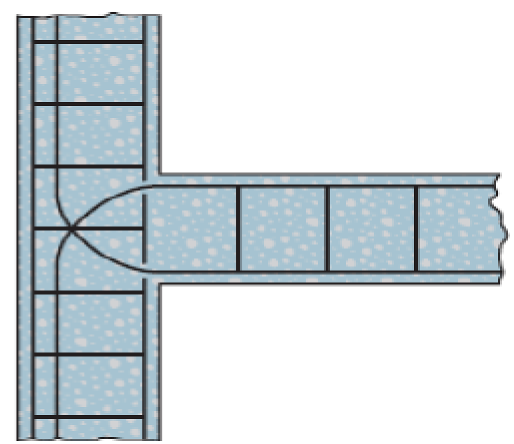
typical "pin-supported" connection (metal)
(a)



typical "fixed-supported" connection (metal)
(b)



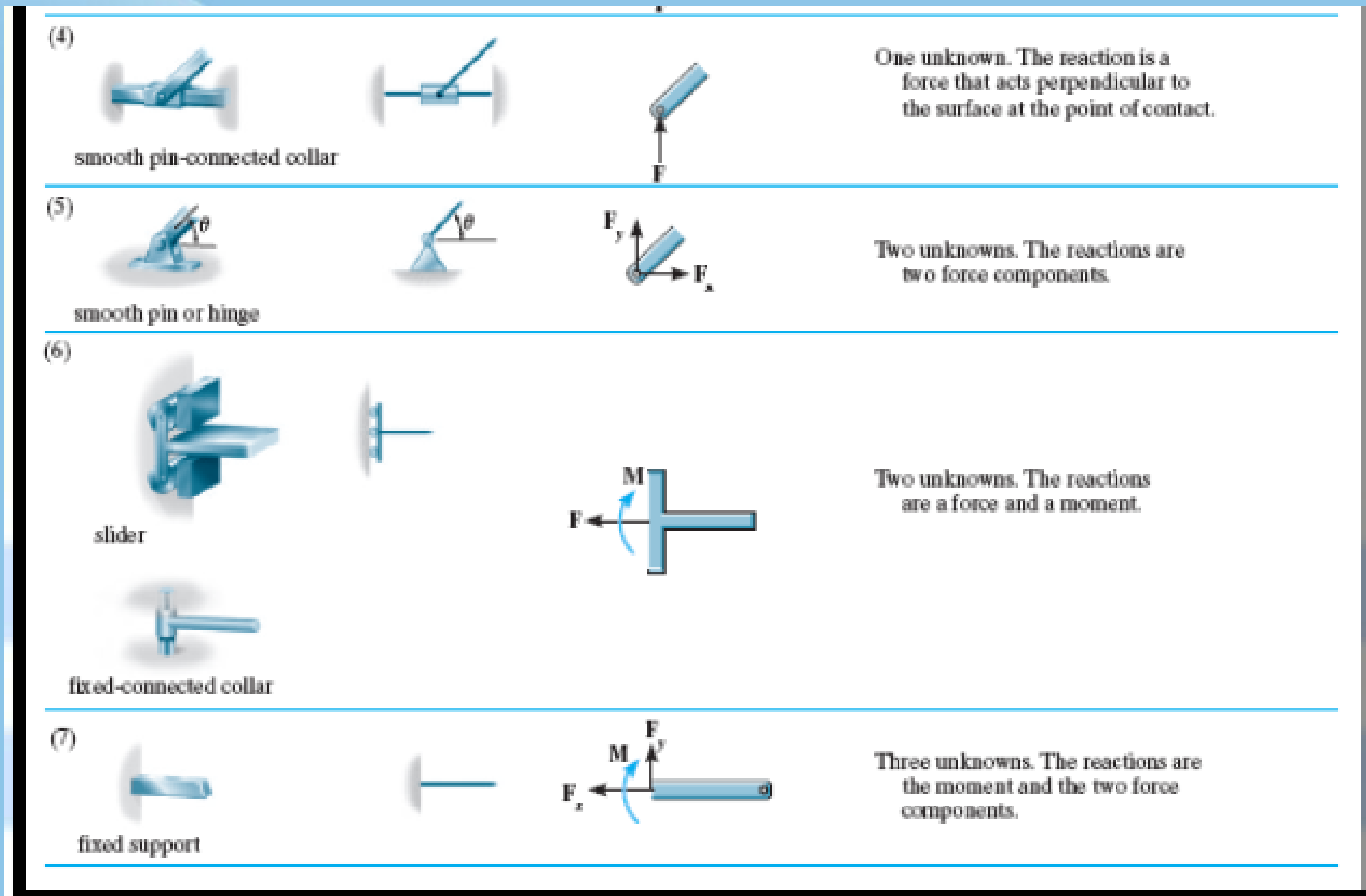
typical "roller-supported" connection (concrete)
(a)



typical "fixed-supported" connection (concrete)
(b)

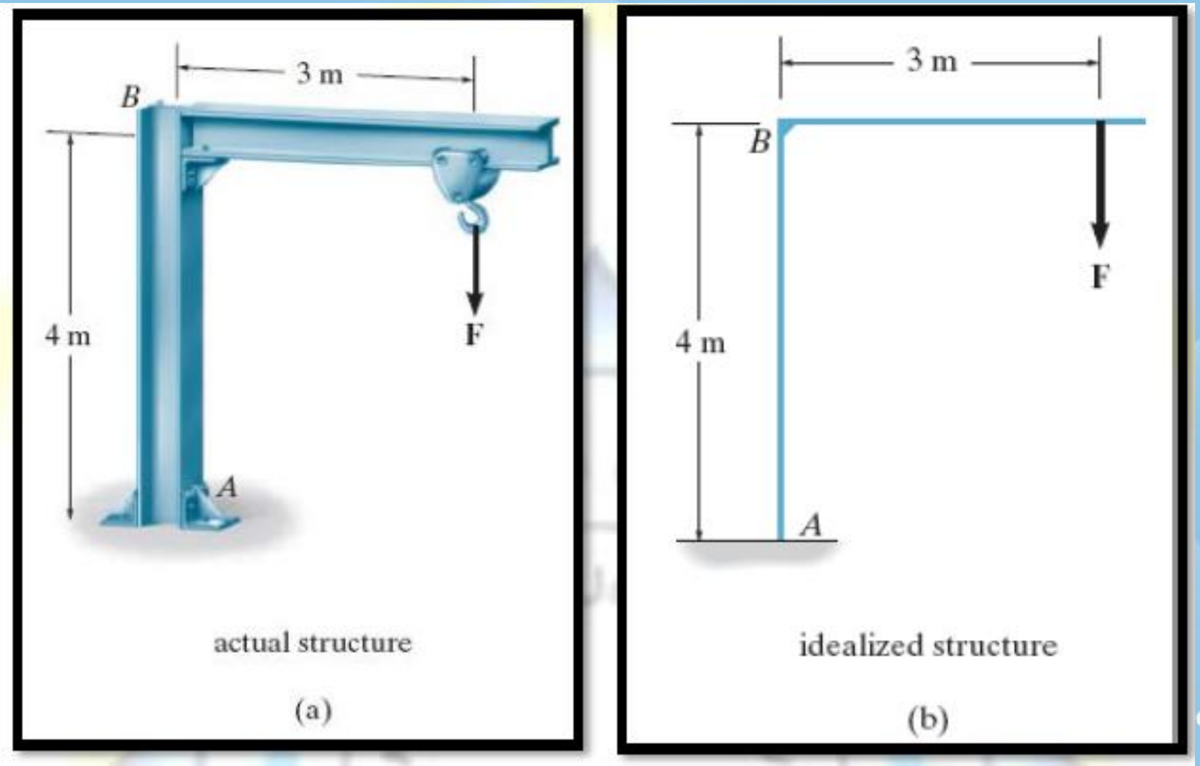
TABLE 2–1 • Supports for Coplanar Structures

Type of Connection	Idealized Symbol	Reaction	Number of Unknowns
(1)  light cable, weightless link			One unknown. The reaction is a force that acts in the direction of the cable or link.
(2)  rollers, rocker			One unknown. The reaction is a force that acts perpendicular to the surface at the point of contact.
(3)  smooth contacting surface			One unknown. The reaction is a force that acts perpendicular to the surface at the point of contact.

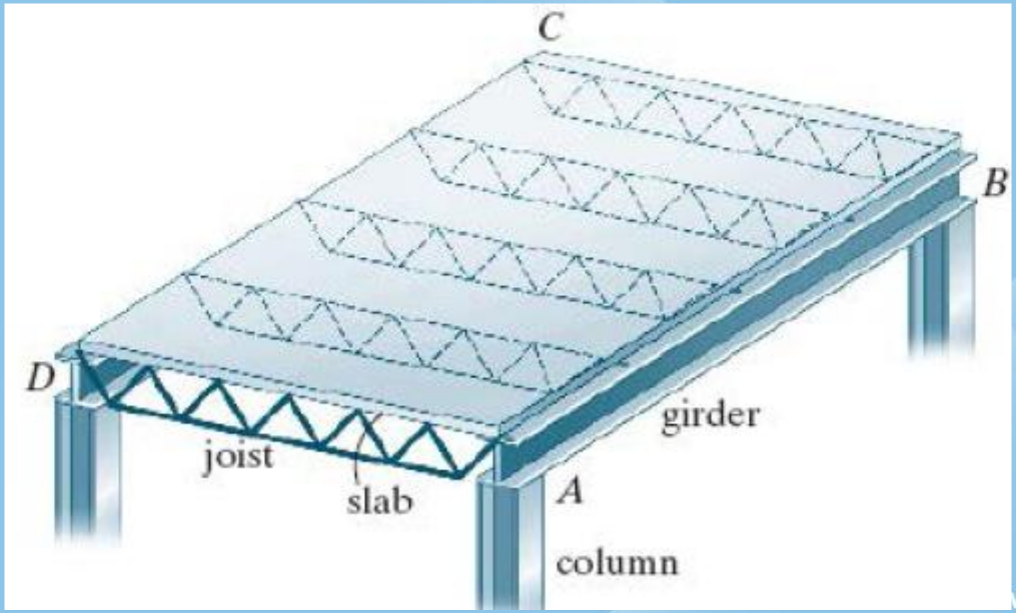


(4) smooth pin-connected collar		F	One unknown. The reaction is a force that acts perpendicular to the surface at the point of contact.
(5) smooth pin or hinge	θ	F_y, F_x	Two unknowns. The reactions are two force components.
(6) slider; fixed-connected collar		M, F	Two unknowns. The reactions are a force and a moment.
(7) fixed support		M, F_x, F_y	Three unknowns. The reactions are the moment and the two force components.

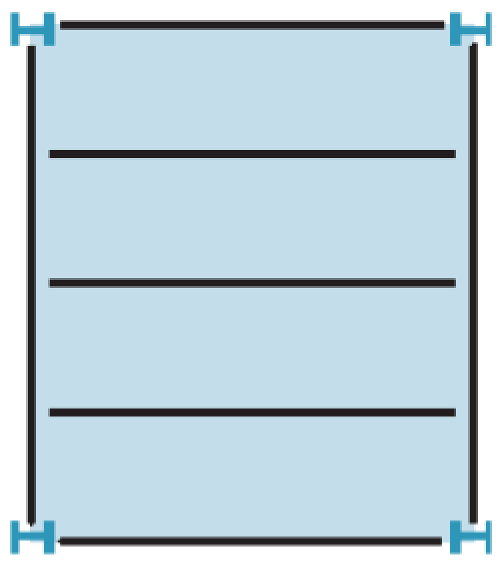
- Consider the jib crane & trolley shown in Figure below, we neglect the thickness of the 2 main members & will assume that the joint at B is fabricated to be rigid
- The support at A can be modeled as a fixed support



- Consider the framing used to support a typical floor slab in a building shown below.
- The slab is supported by floor joists located at even intervals
- These are in turn supported by 2 side girders AB & CD

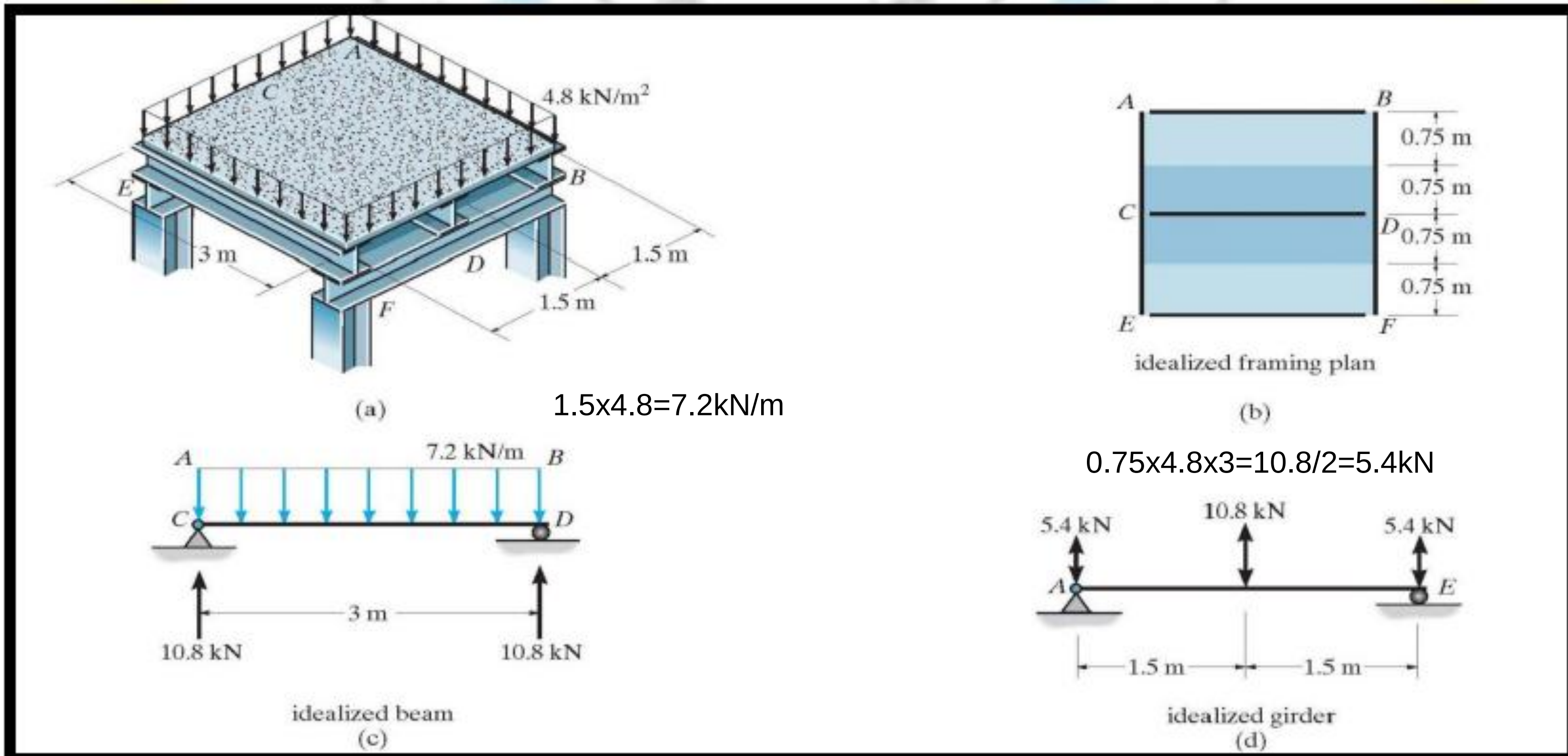


- For analysis, it is reasonable to assume that the joints are pin and/or roller connected to girders & the girders are pin and/or roller connected to columns


idealized framing plan

- Tributary Loadings
- There are two ways in which the load on surfaces can transmit to various structural elements
- one-way system
- two-way system

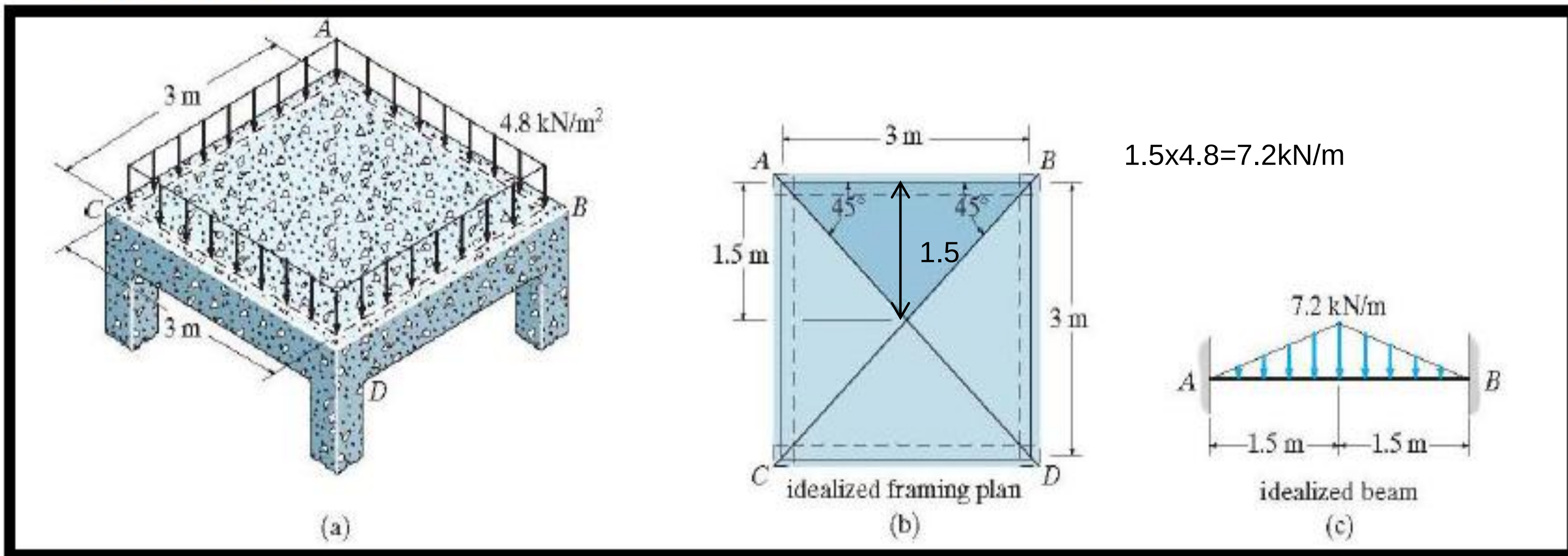
One-way system



1.5x4.8=7.2kN/m

0.75x4.8x3=10.8/2=5.4kN

Tow-way system



- ex1:-The floor of a classroom is supported by the bar joists. Each joist is 4.5m long and they are spaced 0.75m on centers. The floor is made from lightweight concrete that is 100mm thick. Neglect the weight of joists & the corrugated metal deck, determine the load that acts along each joist.

Solution

Dead load, weight of concrete slab

$=(100)(0.015)$

$=1.50 kN/m^2$

Live load $=1.92 kN/m^2$

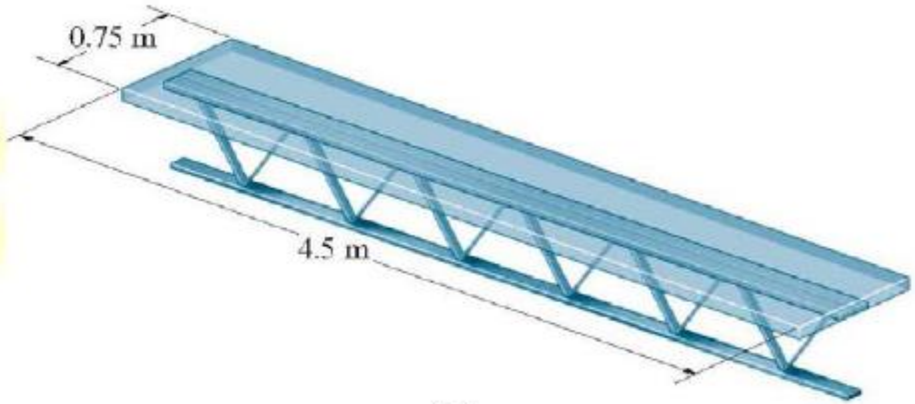
Total load $=1.50+1.92=3.42 kN/m^2$

$L_1=0.75m, L_2=4.5m$

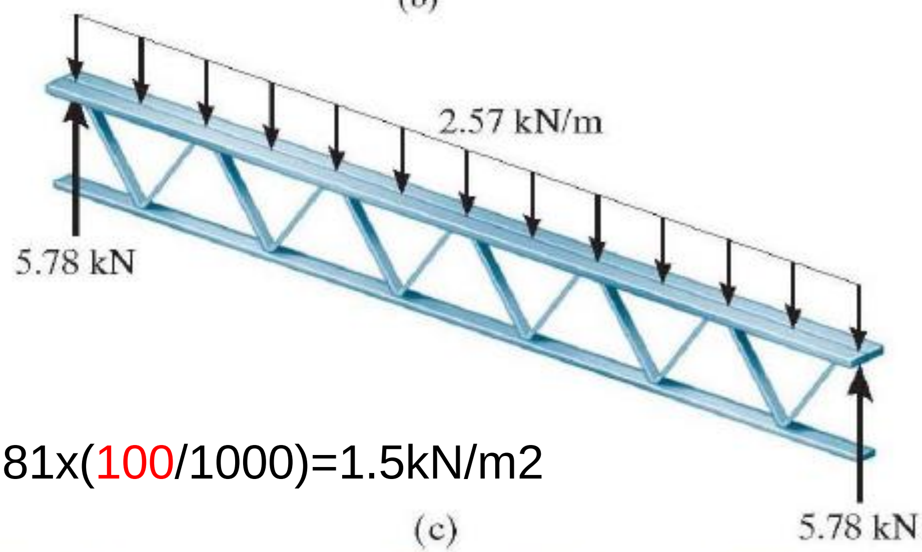
$L_1/L_2>2 \Rightarrow 1$ - way slab

Uniform load along its length, w

$=3.42 kN/m^2 (0.75m)=2.57 kN/m$



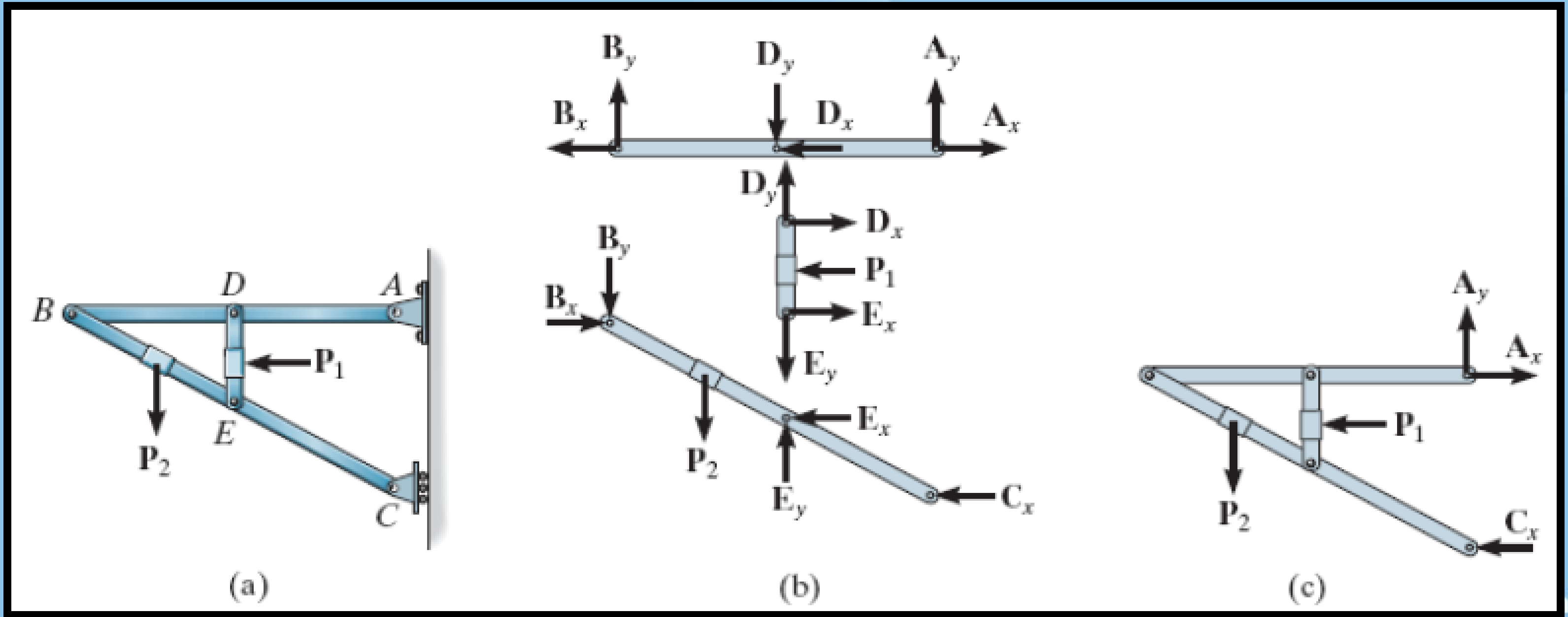
(b)



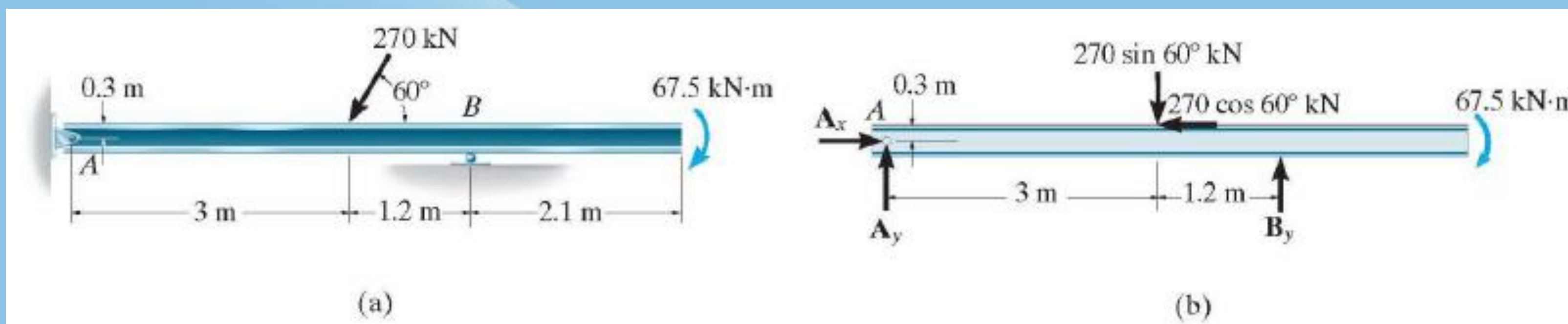
(c)

Dead load =0.75x1x2t/m3 x9.81x(100/1000)=1.5kN/m2

- Application of the Equations of Equilibrium
- The structure below subjecting to loads P1 & P2 , there are 9 unknowns in total 9 eqns. of equilibrium can be written, 3 for each member.
- It is statically determinate



- ex2:-Determine the reactions on the beam as shown**.**



<u>Solution</u>

$\underrightarrow{+}\sum F_x = 0;\; A_x - 270\cos 60^0 = 0$

$A_x = 135kN$

With anti - clockwise in the + direction,

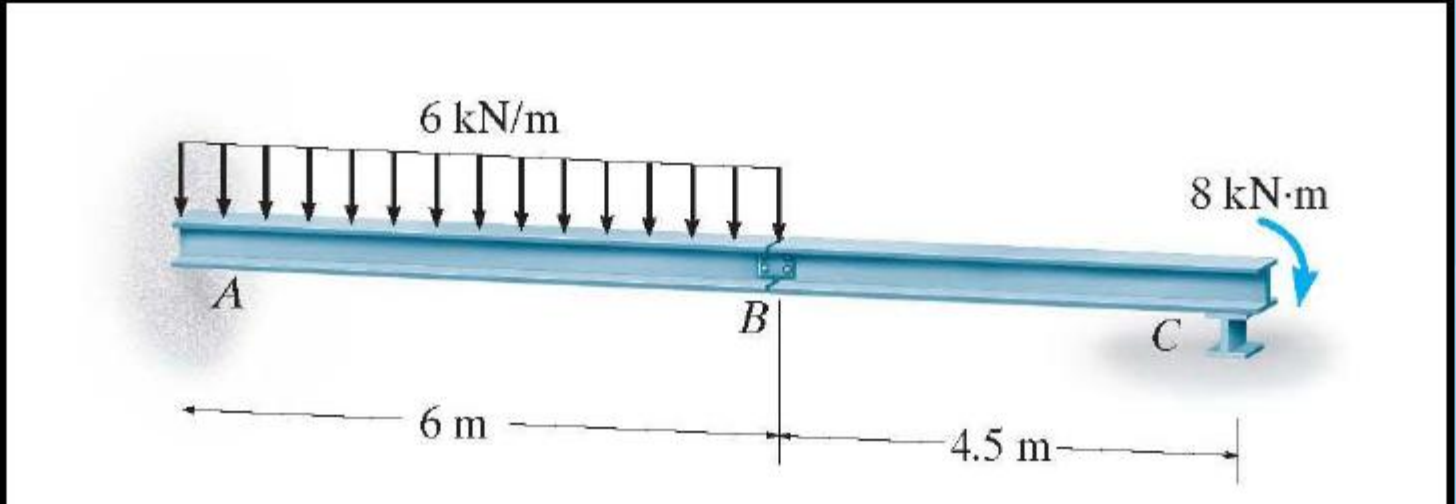
$\sum M_A = 0;\; -270\sin 60^0(3) + 270\cos 60^0(0.3) + B_y(4.2) - 6.8 = 0$

$B_y = 159kN$

$+\uparrow \sum F_y = 0;\; -270\sin 60^0 + 159 + A_y = 0$

$A_y = 74.8kN$

- ex3:-The compound beam in Figure (a) below is fixed at A. Determine the reactions at A, B & C. Assume the connections at B is a pin & C a roller.



(a)

Solution

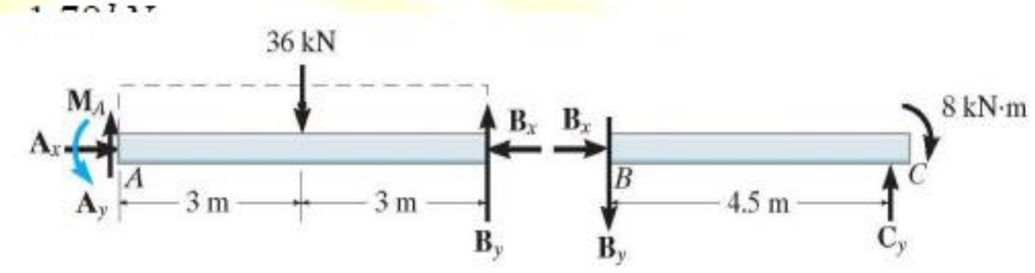
Segment BC :

With anti - clockwise in the + direction,

$\Sigma M_c = 0;\ -8 + B_y(4.5) = 0 \quad \Rightarrow B_y = 1.78kN$

$+\uparrow \Sigma F_y = 0;\ -1.78 + C_y = 0 \quad \Rightarrow C_y$

$\underset{\rightarrow}{+}\Sigma F_x = 0;\ B_x = 0$



Segment AB :

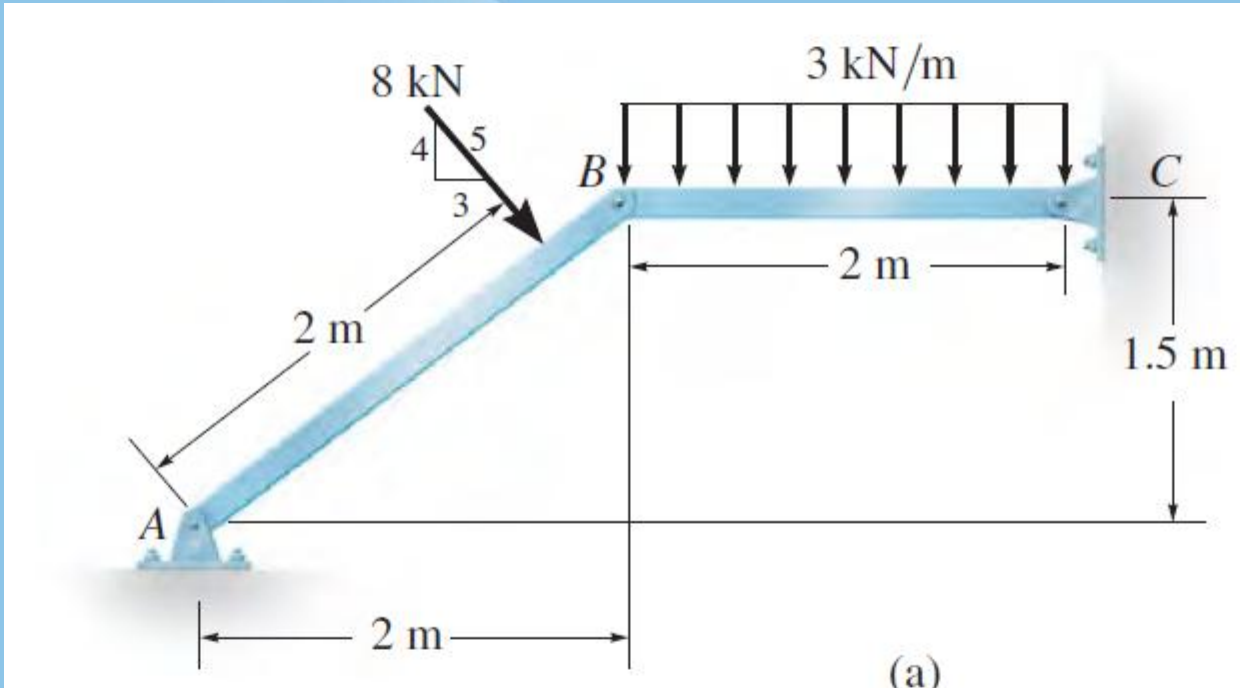
With anti - clockwise in the + direc

$\Sigma M_A = 0;\ M_A - 36(3) + (1.78)(6) = 0 \Rightarrow M_A = 97.3kN.m$

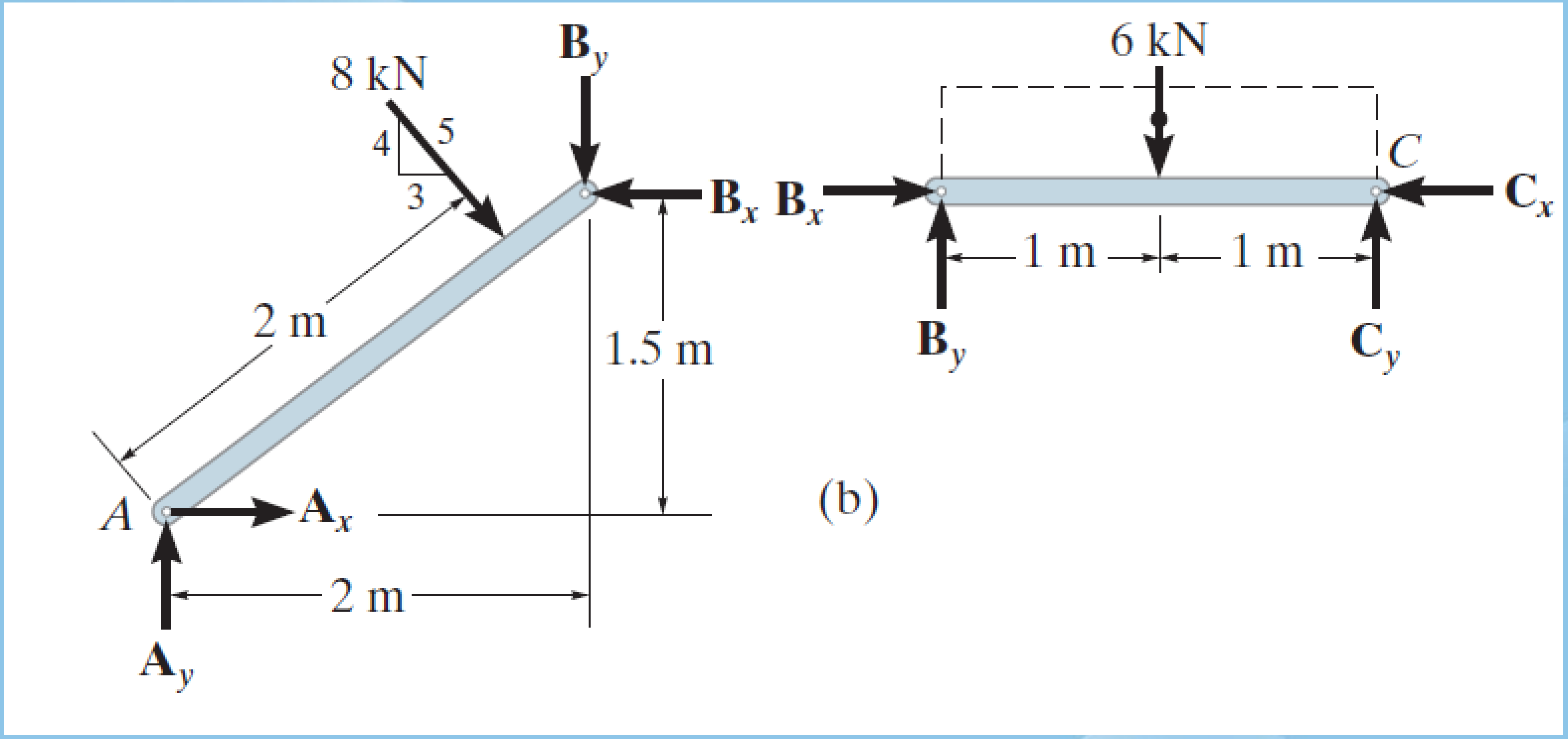
$+\uparrow \Sigma F_y = 0;\ A_y - 36 + 1.78 = 0 \Rightarrow A_y = 34.2kN$

$\underset{\rightarrow}{+}\Sigma F_x = 0;\ A_x = 0$

- ex4:Determine the horizontal and vertical components of reaction at the pins A, B, and C of the two-member frame shown in Fig.



(a)


8 kN
4
5
3
B_y
B_x
2 m
1.5 m
A
A_x
A_y
2 m
6 kN
C
B_x
C_x
1 m
1 m
B_y
C_y
(b)

- Equations of Equilibrium: Applying the six equations of equilibrium in the following sequence allows a direct solution for each of the six unknowns.
- Member BC:

$$\circlearrowleft + \Sigma M_C = 0; \quad -B_y(2) + 6(1) = 0 \qquad B_y = 3\text{ kN} \qquad \textit{Ans.}$$

Member AB:

$$\circlearrowleft + \Sigma M_A = 0; \quad -8(2) - 3(2) + B_x(1.5) = 0 \qquad B_x = 14.7\text{ kN} \qquad \textit{Ans.}$$

$$\overset{+}{\rightarrow} \Sigma F_x = 0; \quad A_x + \tfrac{3}{5}(8) - 14.7 = 0 \qquad A_x = 9.87\text{ kN} \qquad \textit{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \quad A_y - \tfrac{4}{5}(8) - 3 = 0 \qquad A_y = 9.40 \text{ kN} \qquad \textit{Ans.}$$

Member BC:

$$\xrightarrow{+} \Sigma F_x = 0; \quad 14.7 - C_x = 0 \qquad C_x = 14.7 \text{ kN} \qquad \textit{Ans.}$$

$$+\uparrow \Sigma F_y = 0; \quad 3 - 6 + C_y = 0 \qquad C_y = 3 \text{ kN} \qquad \textit{Ans.}$$

H.W: solve the problems
F2-7, F2-10, 2-19, 2-20, 2-35