Chapter (4): Frame Analysis

4.1 Types of Frame Structures:

Frame structures are the structures having the combination of beam, column and slab to resist the lateral and gravity loads. These structures are usually used to overcome the large moments developing due to the applied loading. Frames structures can be differentiated into:

1- Rigid frame structure: which are further subdivided into:
   a. Pin ended
   b. Fixed ended
2- Braced frame structure: which is further subdivided into:
   a. Gabled frames
   b. Portal frames

4.1.1 Rigid Structural Frame

The word rigid means ability to resist the deformation. Rigid frame structures can be defined as the structures in which beams & columns are made monolithically and act collectively to resist the moments which are generating due to applied load. Rigid frame structure provides more stability. This type of frame structures resists the shear, moment and torsion more effectively than any other type of frame structures. That's why this frame system is used in world's most astonishing building Burj Al-Arab.

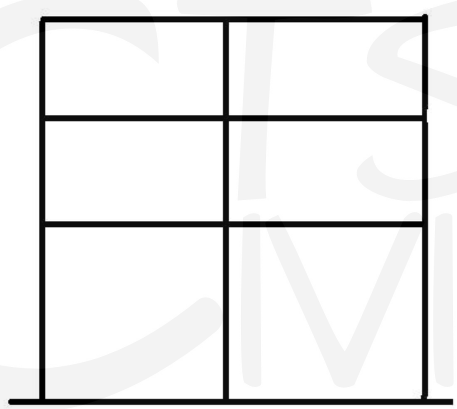


Figure 4-1: Braced Structural Frame

Pin Ended Rigid Structural Frames:

A pinned ended rigid frame system usually has pins as their support conditions. This frame system is considered to be non-rigid if its support conditions are removed.

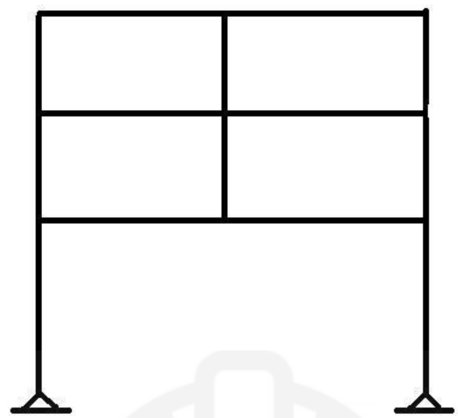


Figure 4-2: Pin Ended Rigid Structural Frame

Fix Ended Rigid Frame Structure:

In this type of rigid frame systems end conditions are usually fixed.

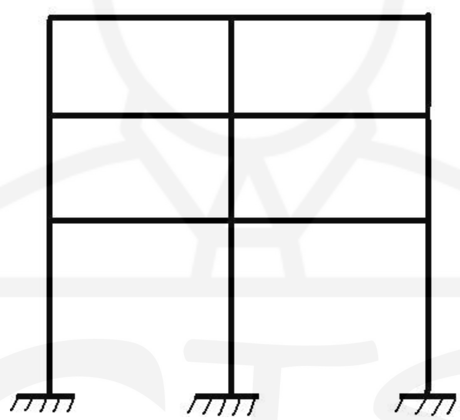


Figure 4-3: Fixed Ended Rigid Structural Frame

4.1.2 Braced Structural Frames

In this frame system (Figure 4-4), bracing is usually provided between beams and columns to increase their resistance against the lateral forces and side-ways forces due to applied load. Bracing is usually done by placing the diagonal members between the beams and columns. This frame system provides more efficient resistance against the earthquake and wind forces. This frame system is more effective than rigid frame system.

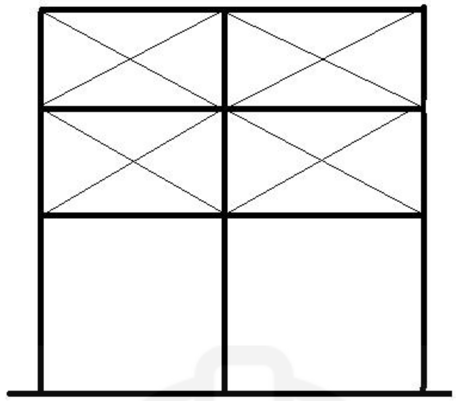


Figure 4-4: Braced Structural Frame

Gabled Structural Frame:

Gable frame steel structure building is a typical construction system. Its upper structure consists of steel of parapet, gutter, roof purlin, steel frame, and wall purlin, etc. This kind of building offers a series of advantages and features.

1- This product is lightweight and its steel volume of bearing structure is in the range of 20 kg to 50kg per square meter. Its dead weight ranges from 1/20 to 1/3 of reinforced concrete structure. Therefore, this structure greatly reduces damages from earthquake and lessens its foundation costs.
2- It comes with short construction period and high economic benefits.
3- The arrangement of columns is quite flexible.

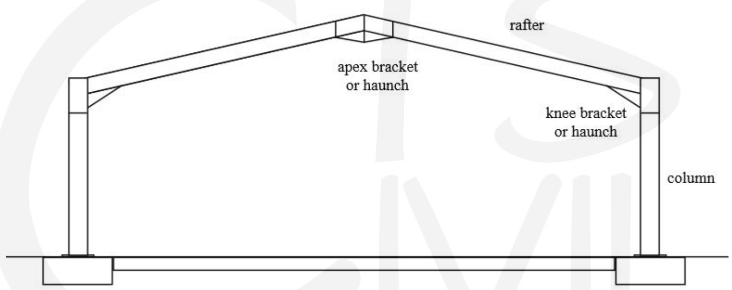


Figure 4-5: Gabled Structural Frame

Portal Structural Frame:

Portal structural frames usually look like a door. This frame system is very much in use for construction of industrial and commercial buildings

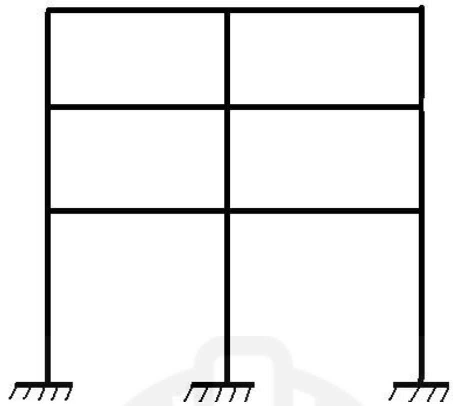


Figure 4-6: Portal Structural Frame

4.1.3 Load path in Frame Structure:

It is a path through which the load of a frame structure is transmitted to the foundations. In frame structures, usually load first transfers from slab to beams then to from beam to columns, then from columns it transfers to the foundation.

Advantages of Frame Structures

One of the best advantages of frame structures is their ease in construction. it is very east to teach the labor at the construction site.
Frame structures can be constructed rapidly.
Economy is also very important factor in the design of building systems. Frame structures have economical designs.

Disadvantages of Frames:

In frames structures, span lengths are usually restricted to 40 ft when normal reinforced concrete. Otherwise spans greater than that, can cause lateral deflections.

4.1.4 Comparison of Frame structures with Normal Load bearing Traditional High Rise Building:

Selection of frame structures for the high rise building is due to their versatility and advantages over the normal traditional load bearing structures. These include the following:

1- Actually the performance of load bearing structures is usually dependent on the mass of structures. To fulfill this requirement of load bearing structures, there is the need of increase in volume of structural elements (walls, slab).this increase in volume of the structural elements leads toward the construction of thick wall. Due to such a type of construction, labor and construction cost increases. in construction of thick wall there will be the need of great attention, which will further reduce the speed of construction.
2- If we make the contrast of load bearing structures with the framed structures, framed structures appear to be more flexible, economical and can carry the heavy

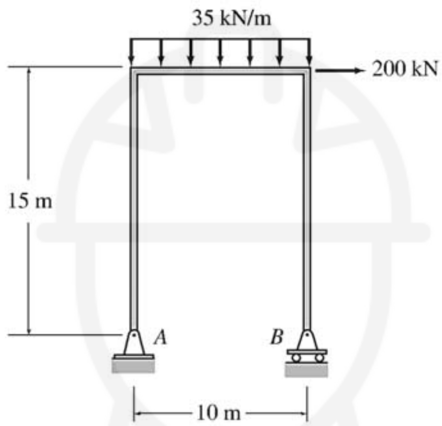
loads. Frame structures can be rehabilitated at any time. Different services can be provided in frame structures. Thus the frame structures are flexible in use.

4.1.5 Frame Reactions:

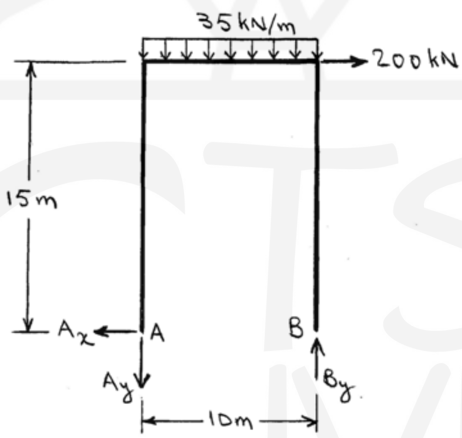
For the following examples, calculate the reactions at the frame supports.

4.1.6 Examples:

Example (1):



Solution:



$\overset{+}{\rightarrow} \sum F_x = 0$ $\qquad$ $\underline{A_x = 200\ kN \leftarrow}$

$+\circlearrowleft \sum M_B = 0$

$$A_y(10) + 35(10)(5) - 200(15) = 0$$

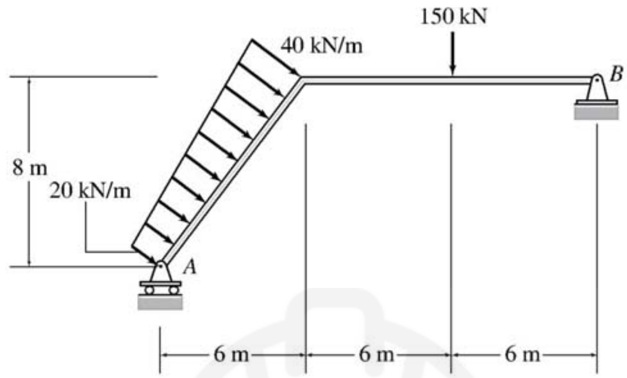
$\underline{A_y = 125\ kN \downarrow}$

$+\uparrow \sum F_y = 0$

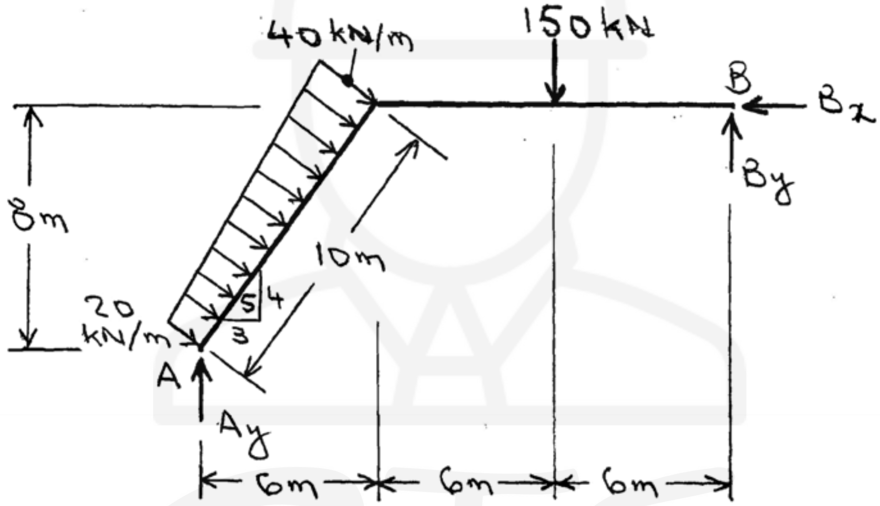
$$-125 - 35(10) + B_y = 0$$

$\underline{B_y = 475\ kN \uparrow}$

Example (2):



Solution:



$$\overset{+}{\rightarrow}\Sigma F_x = 0 \qquad \left(\frac{20+40}{2}\right)10\left(\frac{4}{5}\right) - B_x = 0$$

$$\underline{B_x = 240\ \text{kN} \leftarrow}$$

$$+\circlearrowleft \Sigma M_A = 0$$

$$-20(10)5 - \frac{1}{2}(20)10\left(\frac{20}{3}\right) - 150(12) + 240(8) + B_y(18) = 0$$

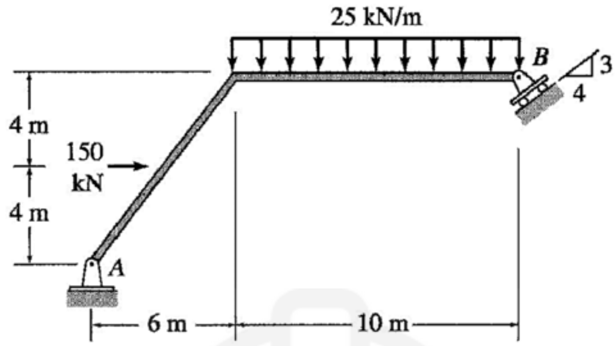
$$\underline{B_y = 85.93\ \text{kN} \uparrow}$$

$$+\uparrow \Sigma F_y = 0$$

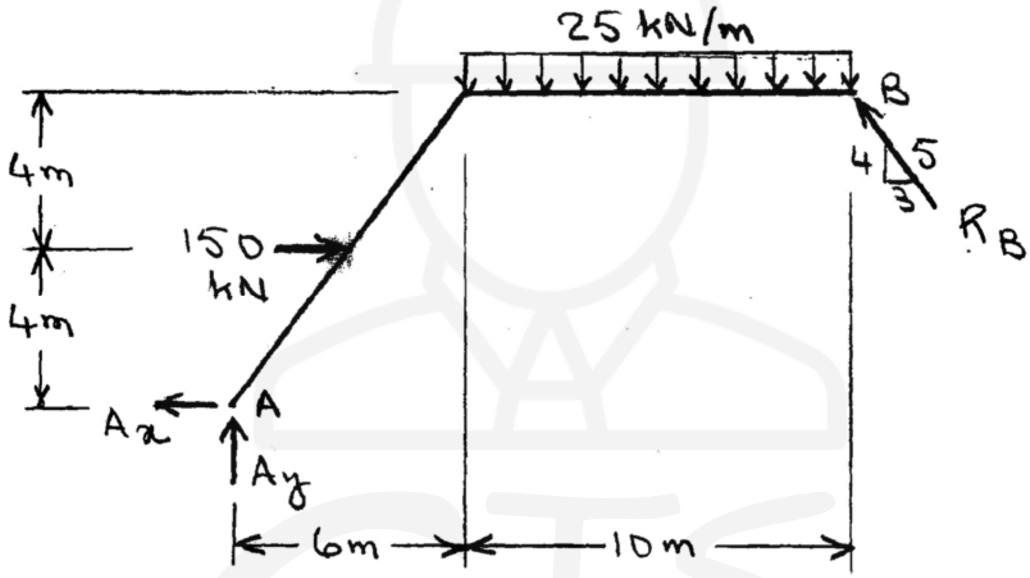
$$A_y - \left(\frac{20+40}{2}\right)10\left(\frac{3}{5}\right) - 150 + 85.93 = 0$$

$$\underline{A_y = 244.07\ \text{kN} \uparrow}$$

Example (3):



Solution:



$+\circlearrowright \Sigma M_A = 0$

$$-150(4) - 25(10)(11) + \frac{3}{5}R_B(8) + \frac{4}{5}R_B(16) = 0$$

$$\underline{R_B = 190.3 \text{ kN} \nwarrow}$$

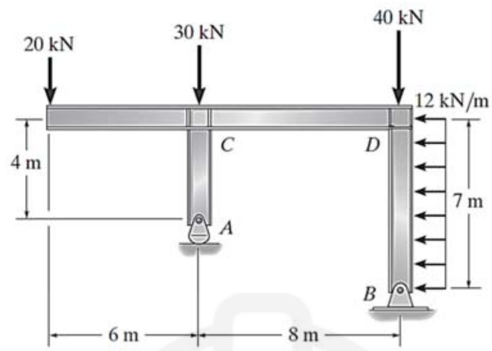
$\overset{+}{\rightarrow} \Sigma F_x = 0 \qquad -A_x + 150 - \frac{3}{5}(190.3) = 0$

$$\underline{A_x = 35.8 \text{ kN} \leftarrow}$$

$+\uparrow \Sigma F_y = 0 \qquad A_y - 25(10) + \frac{4}{5}(190.3) = 0$

$$\underline{A_y = 97.7 \text{ kN} \uparrow}$$

Example (4):



Solution:

$$\circlearrowleft + \sum M_B = 0; \quad 20(14) + 30(8) + 84(3.5) - A_y(8) = 0$$

$$A_y = 101.75 \text{ kN} = 102 \text{ kN}$$

$$\overset{+}{\rightarrow} \sum F_x = 0; \quad B_x - 84 = 0$$

$$B_x = 84.0 \text{ kN}$$

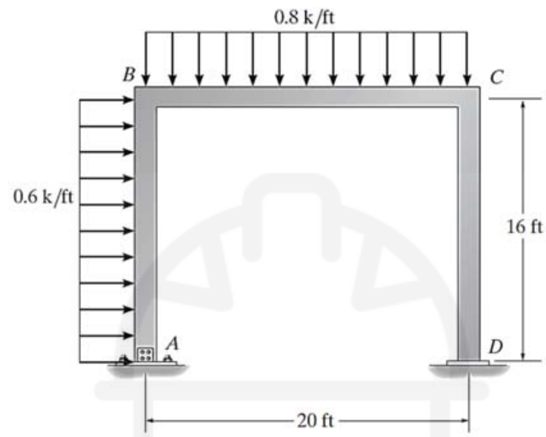
$$+\uparrow \sum F_y = 0; \quad 101.75 - 20 - 30 - 40 - B_y = 0$$

$$B_y = 11.8 \text{ kN}$$

4.2 Internal Forces in Frames:

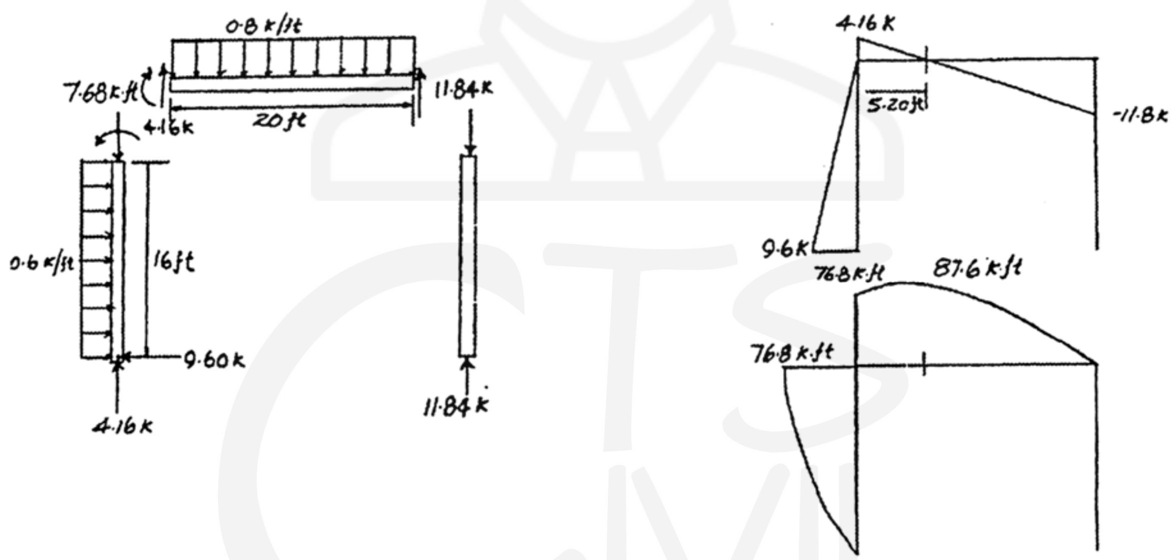
4.2.1 Examples:

Example (1):

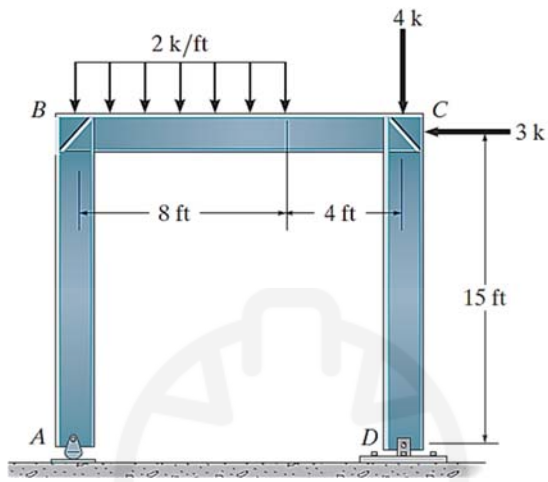


A → Pin, D → Roller

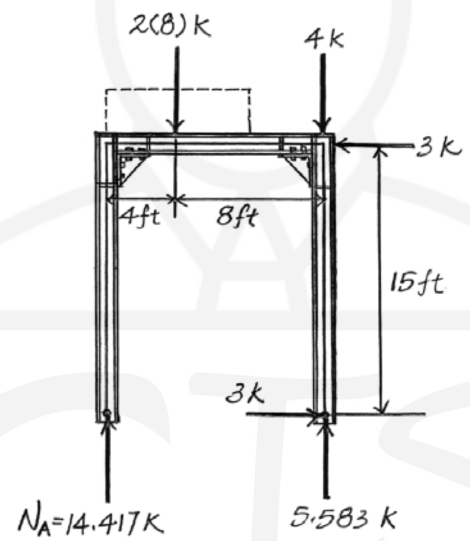
Solution:

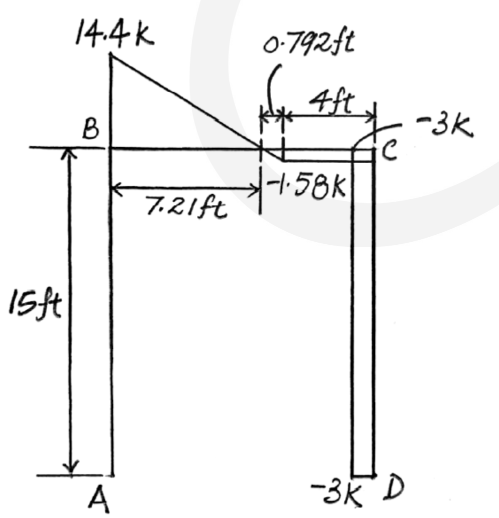


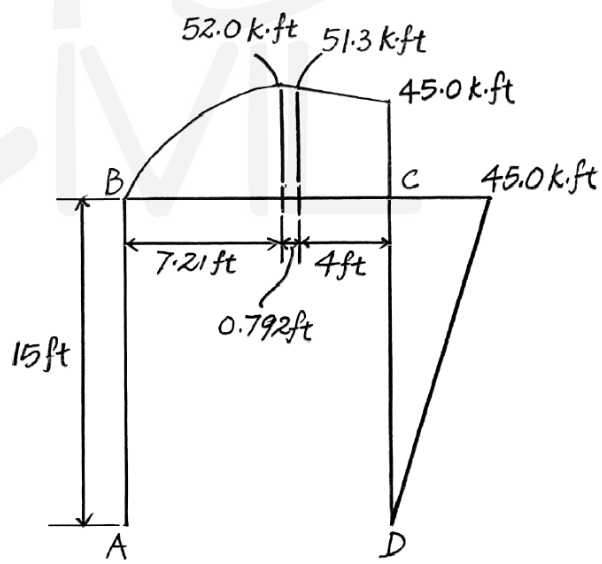
Example (2):



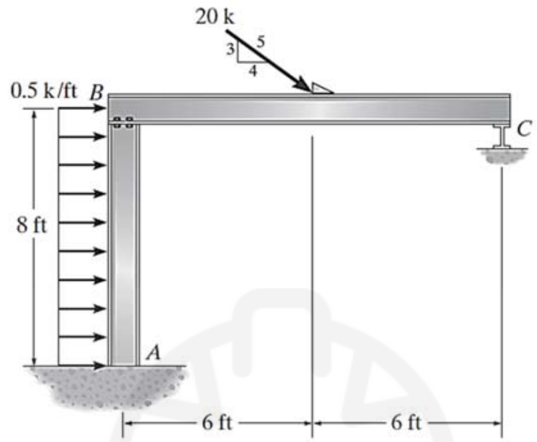
Solution:







Example (3):



A → Fixed, C → Roller

Solution: