2.5 ROOF FRAMES

Consider the roof frame shown in Figure 2.21. This is a plane frame. Three cases are shown corresponding to three different loadings typical for roof frames. In each case the global coordinate axes and the local coordinate axes for member AB are shown.

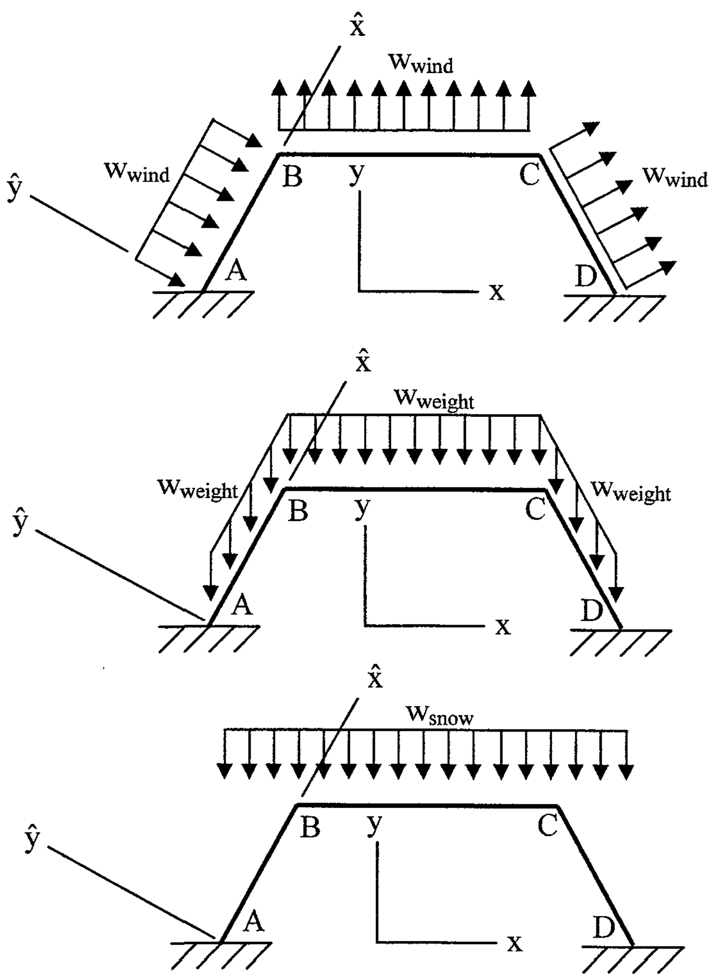


Figure 2.21: Wind, Weight, and Snow Loads on a Roof Frame

The first loading in Figure 2.21 is wind loading. The force of wind exerts pressure or suction normal to the members, and thus, is naturally specified in local directions. Local distributed loads are needed in Equation 2.26 to calculate the local member force vector. For member AB, the local distributed loads are:

$$\hat{\mathbf{w}} = \begin{Bmatrix} \hat{w}_x \\ \hat{w}_y \end{Bmatrix} = \begin{Bmatrix} 0 \\ -w_{wind} \end{Bmatrix} \tag{2.27}$$

The second loading in Figure 2.21 is weight loading. This loading represents the force of gravity acting on each member itself and on any roofing material that the member supports. In this case, gravity acts in the global y direction. Global distributed loads must be pre-multiplied by the rotation matrix **R** to get the local distributed loads needed in Equation 2.26. For member AB, the local distributed loads are:

$$\hat{\mathbf{w}} = \begin{Bmatrix} \hat{w}_x \\ \hat{w}_y \end{Bmatrix} = \mathbf{R} \begin{Bmatrix} 0 \\ -w_{weight} \end{Bmatrix} \qquad R = \begin{bmatrix} \cos\alpha & \sin\alpha \\ -\sin\alpha & \cos\alpha \end{bmatrix} \tag{2.28}$$

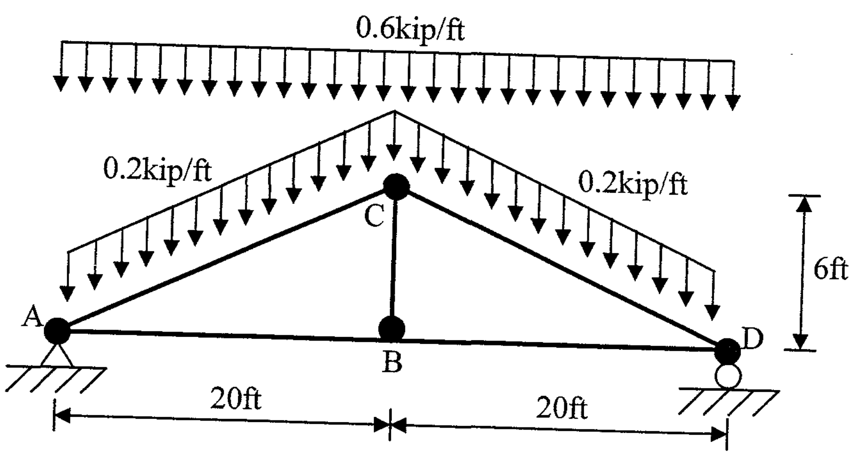
The third loading in Figure 2.21 is snow loading. This loading represents the force of gravity acting on the snow that falls on the roof. Like the weight loading, the snow loading acts in the global y direction. However, the snow loading differs from the weight and wind loadings in another way. The weight and wind loadings are uniform loads per unit length in the local $\hat{x}$ direction. The snow loading is a uniform load per unit length in the global x direction. This is because snowfall is assumed to be uniform in the horizontal plane. The uniform snow load per unit length in the local $\hat{x}$ direction will be less than the uniform snow load per unit length in the global x direction depending on the slope of the member. Specifically, the snow load must be multiplied by R_{11} = cosine of the counterclockwise angle α from the global x axis to the local $\hat{x}$ axis. For member AB:

$$R = \begin{bmatrix} \cos\alpha & \sin\alpha \\ -\sin\alpha & \cos\alpha \end{bmatrix}$$

$$\hat{\mathbf{w}} = \begin{Bmatrix} \hat{w}_x \\ \hat{w}_y \end{Bmatrix} = \mathbf{R} \begin{Bmatrix} 0 \\ -w_{snow} \end{Bmatrix} R_{11} \qquad \begin{bmatrix} \cos\alpha & \sin\alpha \\ -\sin\alpha & \cos\alpha \end{bmatrix} \begin{bmatrix} 0 \\ -W_{snow} \end{bmatrix} = \begin{bmatrix} -W_{snow} \sin\alpha \\ -W_{snow} \cos\alpha \end{bmatrix} \cos\alpha \qquad (2.29)$$

Example 2.8

Analyze the timber roof truss below by the matrix stiffness method. Take E = 1100ksi. Member BC is a 2x4 (rectangular cross-section 1.5 inches by 3.5 inches). Members AC, CD, AB, and BD are 2x8's (rectangular cross-section 1.5 inches by 7.25 inches). The truss is subjected to a 0.6kip/ft snow load and a 0.2kip/ft weight load due to roofing material.



Solution

This structure must be analyzed as a plane frame rather than as a plane truss because members AB and BD are rigidly connected, and members AC and CD are subject to distributed loads. Can we exploit symmetry? The loading is symmetrical. The structure is symmetrical except for the supports. This roof truss rests on top of walls at A and D which offer little resistance to horizontal translation. This suggests that the supports at A and D are both roller supports. However, such a structure would be unstable under horizontal loading. Since the structure is not horizontally loaded,