Find

1. The maximum design unit shear force in the diaphragm (assuming simple beam action) and the required diaphragm construction.
2. The maximum design moment in the diaphragm (assuming simple beam action) and the associated chord forces.

Solution

1. The maximum shear force in the diaphragm occurs at the center shear wall support. Using the beam equations in Appendix A for a 2-span beam, the maximum shear force is determined as follows:

$$V_{max} = \frac{5}{8} w\left(\frac{l}{2}\right) = \frac{5}{8}(200 \text{ plf})\left(\frac{48 \text{ ft}}{2}\right) = 3{,}000 \text{ lb}$$

The maximum design unit shear in the diaphragm is determined as follows:

$$v_{max} = \frac{V_{max}}{d} = \frac{3{,}000 \text{ lb}}{24 \text{ ft}} = 125 \text{ plf}$$

From Table 6.8, the lightest unblocked diaphragm provides adequate resistance. Unblocked means that the panel edges perpendicular to the framing (i.e., joists or rafters) are not attached to blocking. The perimeter, however, is attached to a continuous member to resist chord forces. For typical residential floor construction a 3/4-inch-thick subfloor may be used which would provide at least 240 plf of design shear capacity. In typical roof construction, a minimum 7/16-inch-thick sheathing is used which would provide about 230 plf of design shear capacity. However, residential roof construction does not usually provide the edge conditions (i.e., continuous band joist of 2x lumber) associated with the diaphragm values in Table 6.8. Regardless, roof diaphragm performance has rarely (if ever) been a problem in light-frame residential construction and these values are often used to approximate roof diaphragm design values.

Note: The shear forces at other regions of the diaphragm and at the locations of the end shear wall supports can be determined in a similar manner using the beam equations in Appendix A. These shear forces are equivalent to the connection forces that must transfer shear between the diaphragm and the shear walls at the ends of the diaphragm. However, for the center shear wall, the reaction (connection) force is twice the unit shear force in the diaphragm at that location (see beam equations in Appendix A). Therefore, the connection between the center shear wall and the diaphragm in this example must resist a design shear load of 2 x 125 plf = 250 plf. However, this load is very dependent on the assumption of a "flexible" diaphragm and "rigid" shear walls.

2. The maximum moment in the diaphragm also occurs at the center shear wall support. Using the beam equations in Appendix A, it is determined as follows:

$$M_{max} = \frac{1}{8}w\left(\frac{l}{2}\right)^2 = \frac{1}{8}(200plf)\left(\frac{48ft}{2}\right)^2 = 14{,}400ft - lb$$

The maximum chord tension and compression forces are at the same location and are determined as follows based on the principle of a force couple that is equivalent to the moment:

$$T = C = \frac{M_{max}}{d} = \frac{14{,}400ft - lb}{24ft} = 600lb$$

Therefore, the chord members (i.e., band joist and associated wall or foundation framing that is attached to the chord) and splices must be able to resist 600 lb of tension or compression force. Generally, these forces are adequately resisted by the framing systems bounding the diaphragm. However, the adequacy of the chords should be verified by the designer based on experience and analysis as above.

Conclusion

In this example, the basic procedure and principles for horizontal diaphragm design were presented. Assumptions required to conduct a diaphragm analysis based on conventional beam theory were also discussed.