Steel and concrete skeleton frames are generally classified as moment-resisting space frames in which the joints resist forces primarily by flexure. This flexibility, although effective in dissipating the energy of the seismic loads, can cause substantial secondary, non-structural damage to windows, partitions, piping, and mechanical equipment. Structural frame buildings "ride" through an earthquake because they can deflect in response to loads, but such deflection breaks glass and damages plaster, drywall partitions, stairs, mechanical piping, and other costly and potentially dangerous elements.

Loadbearing masonry buildings are classified as rigid box frames in which lateral forces are resisted by shear walls. A box frame structural system must provide a continuous and complete path for all of the assumed loads to follow from the roof to the foundation, and vice versa. This is achieved through the interaction of floors and walls securely connected along their planes of intersection. Lateral forces are carried by the floor diaphragms to vertical shear walls parallel to the direction of the load. The shear walls act as vertical cantilevered masonry beams subject to concentrated horizontal forces at floor level, and transfer these lateral forces to the foundation by shear and flexural resistance. The amount of horizontal load carried by a shear wall is proportional to its relative rigidity or stiffness. The rigidity of a shear wall is inversely proportional to its deflection under unit horizontal load, and resistance is a function of wall length. The load transfer induces shear stresses in the wall.

12.1.3 Diaphragms

A roof or floor diaphragm must have limited deflection in its own plane in order to transmit lateral forces without inducing excessive tensile stress or bending in the walls perpendicular to the direction of the force. The stiffness of the diaphragm also affects the distribution of lateral forces to the shear walls parallel to the direction of the force (*see Fig. 12-5*). No diaphragm is infinitely rigid, and no diaphragm capable of carrying loads is infinitely flexible. For the purposes of analysis, diaphragms are classified as *rigid, semirigid or semiflexible,* or *flexible.* Cast-in-place concrete and flat precast concrete slabs are considered rigid. Steel joists with structural concrete deck are considered semirigid or semiflexible, and steel or wood joists with wood decking are considered flexible. Rigid and semirigid diaphragms do not experience excessive deflection under load. They distribute lateral loads to the shear walls in proportion to their relative rigidity compared to that of the walls.

Diaphragms may be constructed of concrete, wood, metal, or combinations of materials. Design criteria for materials such as steel and reinforced concrete are well known and easily applied once the loading and reaction conditions are known. Where a diaphragm is made up of distinct units such as plywood panels, precast concrete planks, or steel deck sections, its characteristics are dependent largely on methods of attachment to one another and to supporting members. Such attachments must resist shearing stresses and provide proper anchorage to the supporting shear walls.

12.1.4 Masonry Shear Walls

The lateral load absorbed by a floor or roof diaphragm is transferred to shear walls. Shear walls are designed to resist lateral forces applied parallel to the plane of the wall (*see Fig. 12-6*). Shear walls perform best when they are also

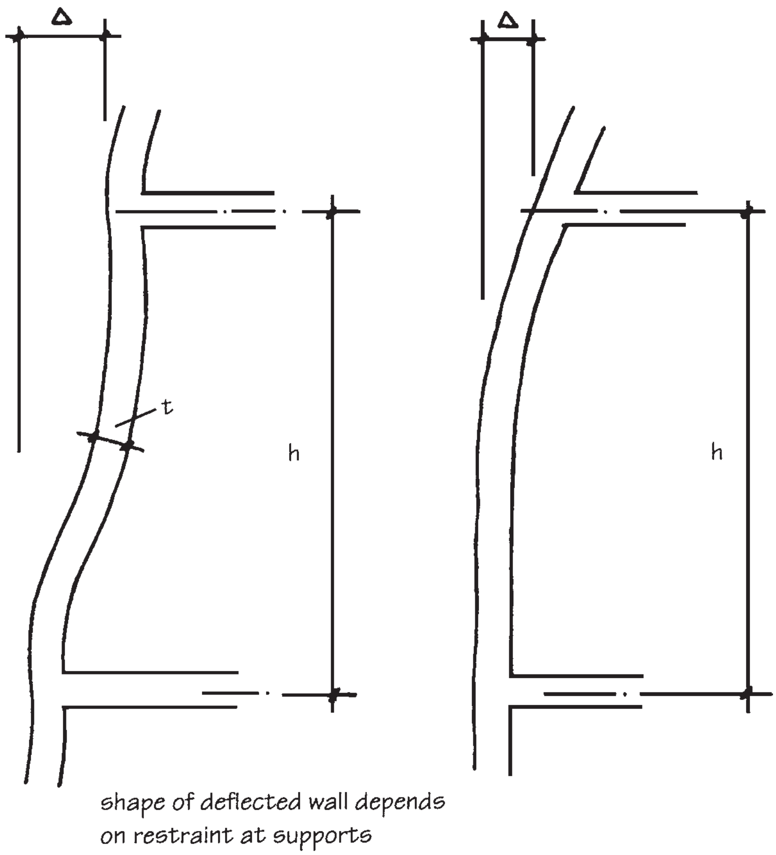

Figure 12-5 Diaphragm deflection limitations. (*From BIA* Technical Note 24C.)

loadbearing, because the added loading offers greater resistance to overturning moments. The orientation of the bearing walls in a building can minimize lateral load stresses and take advantage of the natural compressive and shear resistance of the masonry. If all of the bearing walls in a building are oriented in one direction, they will resist lateral loads only in that direction, and additional non-bearing shear walls may be needed in other orientations. Two-directional and multi-directional wall configurations can resist lateral loads and shear from more than one direction. Both loadbearing and non-loadbearing shear walls can be stiffened by adding flanges that have a positive connection to the intersecting shear walls.

If analysis indicates that tension will be developed in unreinforced masonry shear walls, the size, shape, or number of walls must be revised, or the walls must be designed as reinforced masonry.

The lateral load resistance of masonry structures is basically a function of the orientation, area, and strength of the shear walls. If the cumulative area of shear wall is sufficient, the building can elastically resist even strong earthquakes without reaching the yield point of the steel reinforcement.

Some of the most important aspects of shear wall and seismic design are qualitative elements regarding symmetry and location of resisting members, relative deflections, anchorage, and discontinuities. Shear walls resist horizontal forces acting parallel to the plane of the wall through resistance to