CHAPTER

9

Lateral-Force Effects

This chapter deals generally with the topic of horizontal-force effects in buildings. The term used for these effects is *lateral*, meaning sideways, which identifies them in relation to the major orientation of the effect of gravity as a vertical force. Conceptually, then, designing for lateral forces is typically viewed in terms of bracing a building against sideways collapse (see Figure 9.1). In truth, most load sources that produce lateral forces also generate some vertical effects and so it is of limited use to treat the horizontal-force effects in isolation. Even where this may be valid as an investigative technique, it should always be borne in mind that lateral effects always occur in some combination with some vertical effects, including those due to gravity. In the end it is the full combined effects that must be understood and dealt with.

In many situations, the elements of the building construction that work to achieve lateral bracing are not visible in the finished building. However, architects may choose to feature the lateral bracing in a major way, as shown in Figure 9.2. Visible or not, the bracing is there, and its planning and design are the topic of this chapter.

While the issues of lateral forces are generally treated in this chapter, lateral forces are included in the work in several other sections in this book. The problem of horizontal forces on foundations and sites is developed in Chapter 8. Some design examples of lateral resistive structures are treated in this chapter, but the building design examples in Chapter 10 present lateral-force design in the broader context of the whole building structure.

9.1 GENERAL CONSIDERATIONS FOR LATERAL EFFECTS

Sources of Lateral Loads

The principal sources for lateral-load effects in buildings are the following:

Wind. Wind is moving air. Air is a fluid, and some general knowledge of fluid mechanics is helpful for the understanding of the various effects of wind on buildings. Our primary concern here is for the effects of wind on the lateral bracing system for the building. As a net effect, this force is an aggregate of the various effects of the fluid flow of the air around the stationary object (the building) on the ground surface.

Earthquakes. Earthquakes—or *seismic activity* as it is called—produce various disastrous effects, including tidal waves, massive ruptures along earth faults, and violent vibratory motions. It is the last effect for which we design the lateral bracing systems for buildings, dealing mostly with the horizontal aspect of the ground motion. The force applied to the building is actually generated by the momentum of the building mass as it is impelled and rapidly reversed in direction. This activity cannot be fully understood in terms of static force alone, however, as dynamic aspects of both the ground motion and the building's response must be considered.

Soil Pressure. The problems of soil-restraining structures and the general action of soils under stress are discussed in Chapter 8. Wind and earthquake forces on the building must eventually be resolved by the building foundations and supporting soils. Some of these issues are discussed in this chapter, but also in Chapter 8.

Structural Actions. The natural action of various structures in resisting gravity loads may result in some horizontal forces on the supports of the structure even though the direction of the gravity load is vertical. Common examples of such structures are arches, gable roofs, cable structures, rigid frames, and pneumatic structures sustained by internal pressure.