1.2 DECLINE

Renaissance architecture produced few significant innovations in structural building practices, since designs were based primarily on the classical forms of earlier eras. The forward thrust of structural achievements in masonry essentially died during this period of "enlightenment," and masonry structures remained at an arrested level of development.

With the onslaught of the Industrial Revolution, emphasis shifted to iron, steel, and concrete construction. The invention of portland cement in 1824, refinements in iron production in the early nineteenth century, and the development of the Bessemer furnace in 1854 turned the creative focus of architecture away from masonry.

By the early twentieth century, the demand was for high-rise construction, and the technology of stone and masonry building had not kept pace with the developments of other structural systems. The Chicago School had pioneered the use of iron and steel skeleton frames, and masonry was relegated to secondary usage as facings, in-fill, and fireproofing. The Monadnock Building in Chicago (1891) is generally cited as the last great building in the "ancient tradition" of masonry architecture (*see Fig. 1-2*). Its 16-story *unreinforced* loadbearing walls were required by code to be several feet thick at the base, making it seem unsuited to the demands of a modern industrialized society. Except for the revivalist periods following the 1893 World's Columbian Exposition and the "mercantile classicism" which prevailed for some time, a general shift in technological innovation took place, and skeleton frame construction began to replace loadbearing masonry.

During this period, only Antonio Gaudi's unique Spanish architecture showed innovation in masonry structural design (*see Fig. 1-3*). His "structural rationalism" was based on economy and efficiency of form, using ancient Catalan vaulting techniques, parabolic arches, and inclined piers to bring the supporting masonry under compression. His work also included vaulting with hyperbolic paraboloids and warped "helicoidal" surfaces for greater structural strength. Gaudi, however, was the exception in a world bent on developing lightweight, high-rise building techniques for the twentieth century.

At the time, most considered both concrete and masonry construction to be unsophisticated systems with no tensile strength. Very soon, however, the introduction of iron and steel reinforcement brought concrete a step forward. While concrete technology developed rapidly into complex steel-reinforced systems, masonry research was virtually non-existent, and the widespread application of this new reinforcing technique to masonry never occurred.

The first reinforced concrete building, the Eddystone Lighthouse (1774), was actually constructed of both concrete *and* stone, but the use of iron or steel as reinforcing was soon limited almost entirely to concrete. A few reinforced brick masonry structures were built in the early to mid-nineteenth century, but these experiments had been abandoned by about 1880. Reinforced masonry design was at that time intuitive or empirical rather than rationally determined, and rapid advances in concrete engineering quickly outpaced what was seen as an outmoded, inefficient, and uneconomical system. Even by the time the Monadnock Building was constructed, building codes still recognized lateral resistance of masonry walls only in terms of mass, and this did indeed make the system expensive and uneconomical.

1.3 REVIVAL

In the early 1920s, economic difficulties in India convinced officials that alternatives to concrete and steel structural systems had to be found. Extensive research began into the structural performance of reinforced

Figure 1-2 The Monadnock Building in Chicago (1891, Burnham and Root architects) was the last unreinforced high-rise masonry building. (*Photo courtesy of the School of Architecture Slide Library, the University of Texas at Austin.*)

masonry, which led not only to new systems of low-cost construction, but also to the first basic understanding of the structural behavior of masonry. It was not until the late 1940s, however, that European engineers and architects began serious studies of masonry bearing wall designs—almost 100 years after the same research had begun on concrete bearing walls.