Case Study
Skyscrapers and Building Booms

You and your directors were well advised in the choice of your symbol. For a tower, with its light and its belfry, has always been a source of inspiration. ... Thus your Tower partakes of the character of the ancient towers of refuge and defense ... Your high tower should, therefore, be a symbol of God to you and others, standing out boldly and erect as a plea for righteousness and purity in business corporations, and as a monumental protest against the exploitation of the poor.[1]

The technologies necessary to construct buildings of almost unlimited height became available in the mid- to late-19th century. In locations where land values were high, the potential benefits of building a skyscraper were immediately obvious. While the visceral appeal of towers may have appealed to certain visionaries, overly powerful executives and politicians, the ability to replace a 5-story building with a 25-story building excited the financial instincts of developers and real estate agents. Whether buildings were designed for office space or for apartments, the ability to rent far more building space on the same site was a prospect too enticing to resist.
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Table 1 Technological Innovations Required for the Construction of Skyscrapers

Steel frames	1848	James Bogardus demonstrates how to use cast-iron posts and beams to support a building without relying upon the walls, but height is limited to 7 or 8 stories.
	1880	Using steel rather cast-iron allows framing much higher buildings because steel is more flexible, stronger, and can be joined with rivets rather than nuts and bolts. Leroy Buffington shows how tall steel-framed buildings could be built.
	1883	William Le Baron Jenny uses Buffington's method in design for the first skyscraper, the Home Insurance Company Building in Chicago, which was built using a steel frame rather than using steel to reinforce thick masonry walls.
Elevator	1853	Graves Otis demonstrates an elevator at the Crystal Palace in London.
	1870	Equitable Building in NYC is first building to install an elevator.
	1889	Otis installs the first electric elevator.
Utilities		Water for fire protection and sanitation.
		Electricity for elevators and lighting.
Fire protection		Building codes call for fire-retardant materials, fire escapes, sprinkler systems, inspections and fire drills.
Zoning		Zoning is required to deal with effect of buildings on wind currents and sunlight.

Source of information: John Tauranac, **The Empire State Building**, St. Martin's Griffin, NY, 1995

The pace at which skyscrapers were erected in New York City was astonishing (Tauranac, pp. 41-42). In the 1890s, several 20-30 story buildings were constructed in the city. By 1929, there were 188 that were more than 20 stories tall and nearly 2,500 that were more than 10 stories tall. In 1899, the 29-story Park Row Building was the tallest in the world; the world record was broken three more times in the next fourteen years in Manhattan, capped in 1913 by the 55-story, 787-foot high Woolworth building. During the 1920s, the Chrysler Building, at 1,048 feet held the record for a while until it was surpassed by the Empire State Building, which had 102 stories and was more than 1,250 feet tall.

This incredible construction boom in Manhattan was fueled by the fact that skyscrapers allowed many more people and businesses to crowd into an area with some of the highest property values in the world. The new technology made it possible to house an order of magnitude more people than could previously be housed on a site. Once developers realized the profits that could be made by rebuilding the city to a taller standard, the proposals and construction efforts

[1] This bit of hyperbole was addressed to Met Life stockholders in 1915 according to John Tauranac, **The Empire State Building**, St. Martin's Griffin, NY, 1995 p. 38. The president of Met Life was apparently more concerned with his pocketbook than with his view, as he is reported to have responded by saying "the tenants will foot the bill."

multiplied – even after vacancy rates started to increase in 1926 and a report to President Coolidge concluded that the country was overbuilt. According to Tauranac:

> *Developers had been desperate to develop, but by 1927 they were desperate to rent, to fill their vacancies, especially in apartment houses where the problem was critical. ... Realtors recognized that the profession could not view the extremely heavy construction program without apprehension of a glut on the market. (p. 83)*

Despite the slump and the dire warning, in both 1928 and 1929, developers filed plans for more than 700 new buildings in New York City. And some of these were quite spectacular plans. The planning for the Empire State Building and for Rockefeller Center were both initiated in this ambiguous period, still at the height of the construction boom, but just before the bottom was about to fall out of not just the New York City real estate market, but out of the worldwide economy.

The pace of construction seen in New York City in the 1920s was later replicated in many other locations around the world, notably Hong Kong, Tokyo, Shanghai and Dubai. Unfortunately, the instincts that cause developers to begin bigger and better projects are also perhaps too powerful to resist, even in the face of contrary economic evidence. The real estate bubble that burst in 2008 was linked to the same kinds of "irrational exuberance" and shaky financial dealings that led to the burst of the bubble in New York City in 1929.

Once a real estate bubble bursts, it may be years before development resumes. In the United States and elsewhere, construction of skyscrapers stalled because of the depression and World War II. Only after the war was it possible to resume construction of skyscrapers. As in the earlier period, technological and economic forces shaped what was built (see text box).

I began my career in structural engineering in 1947 and was in responsible charge of structural design of many notable high rise buildings including two of the world's highest over the next 40 years. I can attest to this period as one of great technological change in building design. Allowable stresses were increased by about a third and new high strength steel was developed and more precise methods of computation with computers were used to solve structural problems with speed and accuracy. Architects were anxious to express new concepts of modern design and postmodern design. The light aluminum and glass exterior curtain wall was developed and the "glass box" building was born. "Less is more" was a popular theme. Thus we had as the state of the art light-weight steel frames with glass and metal curtain walls. The new designs provided for large column free space around the central core of the buildings. The tube design was developed providing long span truss floor systems between closely spaced exterior wall columns and a grid of columns in the building core which housed elevators, stairways, mechanical shafts and wash rooms. Horizontal mechanical systems ran parallel and through the open spaces in the trusses and the structural steel was fireproofed with sprayed on asbestos cement material. After asbestos became a dirty word, other cementatious spray-on material was developed. ...

Money was the primary mechanism which drove these changes. We had to build economically to offset the increasing costs of both labor and materials. Cost saving was the name of the game and engineers were notable by their ability to carry out the ever-changing design concepts of the architects with as little tonnage of structural steel as possible. For example, in the pre-World War II era, buildings in the 25 to 50 story range had steel in the order of 20 to 40 pounds per square foot. The post War buildings in the 40 to 100 story ranges had steel weights in the order of 30 pounds per square foot. There were no catastrophic failures of these structures from fire, impact or explosions until 9/11.

What we do next involves the answers to many questions and numerous decisions by participants in the design and construction process, government and concerned public. Certainly examination of fireproofing systems and structural details is a high priority, including where possible the retrofitting of existing structures. Modification of zoning ordinances limiting height and location of high buildings and changes in building codes relative to fire, explosion, and impact safety should be considered. All this involves not only technical but also political and cultural considerations. 9/11, while a terrible tragedy, should serve as a wake-up signal for a more secure building environment in this new era of terrorist war.

Perhaps the day of megastructures in the United States is and should be over for many reasons other than safety. Concentration of thousands of people in a single structure has serious infrastructure effects on transportation systems and the environment. Time is wasted and people suffer from over-stress as they rush like ants each working day into their workplace often from homes hours away. I, having been there, seen it and done it, think there are better answers to housing the core operations of commerce than trying to make megastructures safe, efficient and healthy workplaces.

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