In its mid-19th-century heyday, Cincinnati was the sixth-largest city in America, a hub of the nation’s canal traffic and home to one of the country’s densest city districts. While the Civil War and the transition from canals to railroads cost the city its prominence, Cincinnati was—and still is—home to an array of significant architecture that belies its size. Among these structures, few have proved more important than the Ingalls Building, the world’s first reinforced-concrete high-rise.

According to John Clubbe’s book *Cincinnati Observed: Architecture and History* (Columbus: Ohio State University Press, 1992), railroad tycoon Melville Ezra Ingalls planned a 16-story office tower in downtown Cincinnati for the headquarters of the Cleveland, Cincinnati, Chicago and St. Louis Railway Co., better known as “the Big Four,” of which he was the president. He intended the building, which would begin construction in 1902, as “an everlasting monument to Cincinnati; her progress and enterprise.”

To achieve his vision, Ingalls hired Alfred Elzner, one of the more progressive architects in the city. Elzner trained in art and engineering in Cincinnati and later studied architecture at the Massachusetts Institute of Technology (MIT). According to *Architecture in Cincinnati: An Illustrated History of Designing and Building an American City* by Sue Ann Painter, Beth Sullebarger, and Jayne Merkel (Athens: Ohio University Press, 2006), Elzner had supervised construction of the city’s chamber of commerce building, designed by perhaps the top architect in America at the time, Boston-based H.H. Richardson. Elzner was later joined by George Anderson, the first Cincinnati native to earn a diploma from the École des Beaux-Arts in Paris. Henry N. Hooper, of the Ferro-Concrete Construction Co., of Cincinnati, would serve as the Ingalls Building’s structural engineer.

Though the efforts of Elzner, Anderson, and Hooper were cutting edge in 1902, the roots...
of reinforced-concrete construction date as far back as the 17th century, when iron tie rods and armatures were used to strengthen masonry, according to historian Carl W. Condit, in his journal article “The First Reinforced-Concrete Skyscraper: The Ingalls Building in Cincinnati and Its Place in Structural History” (Technology and Culture, Vol. 9, No. 1, January 1968, pp. 1–33).

But the contemporary use of reinforced concrete only accelerated in the middle of the 19th century, as engineers, builders, and inventors sought a way to reinforce concrete with metal to, Condit wrote, “secure a property thought to be lacking in the material itself.”

By the 1870s, many builders were exploring the use of reinforced concrete. William E. Ward built a home in New York state near the Connecticut border that “proved to be the first complete work of reinforced-concrete construction,” Condit wrote. Ward himself explained that the impetus of the idea struck him in 1867, when he noticed “the difficulties of some laborers on a quay trying to remove cement from their tools. The adhesion of the cement to the iron was so firm that the cleavage generally appeared in the cement rather than between the cement and the iron.”

While conducting experiments early in the home’s construction, Ward discovered that “the utility of both iron and béton [concrete] could be greatly increased for building purposes through a properly adjusted combination of their special physical properties.”

There were other innovations along the way, Condit wrote. American inventor Thaddeus Hyatt studied the behavior of reinforced concrete in 1877 and concluded that “the coefficients of thermal expansion of iron and concrete are nearly identical and that the elongation of the two under load is virtually the same for the two materials.”

But the key figure in the United States was Ernest Ransome, who came to America from England in the 1870s to represent his father’s cast stone manufacturing business. Over the years he began to experiment with iron reinforcing to improve the company’s products; he also started studying reinforced concrete. His innovations led to the first reinforced-concrete bridge in the United States, the Alvord Lake Bridge at Golden Gate Park in San Francisco, built in 1889. This was followed by a variety of other reinforced-concrete structures around the country.

In 1884 Ransome patented twisting rebar and described it thusly: “My invention consists in a means for strengthening the structure by the use of rods or strips of iron, steel, or other suitable metal, which extend through the material and are twisted, so that they are fixed within the material at every point from end to end, and a rigid bond is thus formed throughout the entire length, the tendency of the iron to stretch or draw being resisted at every point in its length.”

While Ransome was the leading American builder of reinforced-concrete structures at the turn of the century, others offered alternative techniques, wrote Condit. “Around 1893 William Orr, the superintendent of mills of the New Jersey Wire Cloth Company, a subsidiary of the John A. Roebling’s Sons Corporation, invented a system of floor construction in which the familiar arches springing between the floor beams were made of concrete reinforced with woven wire netting strengthened by being tightly bound to parallel iron rods.” Orr’s method, which came to be known as the Roebling system of reinforcing, could support loads of up to 1,200 lb/sq ft.

Other innovations were occurring in Europe around the same time.

In France, Alphonse de Man pioneered a “composite construction of steel columns and beams and concrete floor slabs reinforced with twisted steel strap.” A gardener, Josef Monier, was granted a patent for reinforcing “concrete columns and girders with a grid of iron rods.” German builder, G.A. Wayss, later bought Monier’s patents, and, Condit wrote, “began experiments to determine the capacity and behavior of reinforced concrete under load, the resistance of concrete to fire, and the corrosion resistance of the iron reinforcing.”

French builder François Hennebique was also developing reinforced concrete, in parallel with Ransome. Among other contributions, Hennebique, wrote Condit, “first introduced small vertical plates and later U-shaped stirrups set at intervals along the length of the beam to bind the reinforcing in the lower or tension zone to the upper or compression zone of the beam.” Hennebique was granted his first patents in 1892 for a system that featured tension bars
and stirrups, as well as “the bending up of the ends of tension bars to resist diagonal shear at the ends of the beams. Before the close of the century, several French engineers were proposing alternatives, chief among them Armand Considère, who was the leading exponent of helical reinforcing for the compression members of building frames and bridge trusses.”

Hennebique generally gets more credit than Ransome, says Jeff Tilman, an associate professor of architecture and the associate director of the School of Architecture and Interior Design at the University of Cincinnati. That, Tilman says, is because the Frenchman taught architect Auguste Perret, who later taught Charles-Édouard Jeanneret, a Swiss-French architect also known as Le Corbusier, thus establishing a clear lineage of the use of reinforced concrete in modern architecture. Ransome’s work tended to be used in buildings with more classical facades.

Nevertheless, Ransome’s ideas, says Tilman, were better “because the rebar is twisted. Twisted rebar adhered to the concrete and made a better bond between concrete and steel. Ransome came up with that innovation.”

Ultimately, the Ingalls Building reflected innovations from multiple sources, wrote Condit: “(1) Ransome’s heavy monolithic beam-and-slab construction with tension reinforcing; (2) the two-way reinforcing systems of Monier and Wayss; (3) the bent bars and stirrups of Hennebique; (4) the hoops and continuous helixes for compression members, the former originally proposed by Hyatt and the latter by Considère.”

The first skyscrapers of the 1880s and 1890s had been built of steel frames, Clubbe noted. And in 1902 no one had built a structure out of concrete that was more than half as tall as Ingalls’ was planned to rise. “Many persons thought that a tall building poured into concrete molds, even reinforced with metal bars, must soon topple of its own weight.”

Elzner and Anderson chose reinforced concrete in part because it would have better resistance to fire and would be cheaper to build than steel, according to the website concretecontractor.com, which is operated by the 72-year-old Arlington, Texas, contracting firm Bob Moore Construction to document the history of concrete construction. Still, it took Elzner two years of battle with the city’s building department to convince it the building would stand.

“It is said that the day the building was to be completed and they were going to pull the scaffolding down off the building, a reporter for one of the local papers decided that the building was certainly going to topple,” says Tilman. “So he stationed a photographer and himself across the street and stayed up all night waiting for the building to collapse. When it didn’t, he was greatly disappointed.”

The Ingalls Building’s overall dimensions in plan are about 50 by 100 ft; the 16 stories above the basement rise 210 ft above grade, or 235 ft above the undersurface of the foundations, according to Condit.

According to a 1904 article in Architectural Record magazine (“The First Concrete Skyscraper,” Vol. XV, No. 6), the building consisted of “a concrete box of 8-inch walls, with concrete floors and roof, concrete beams, concrete columns, concrete stairs; the whole entirely devoid of the usual I-beams, Z-bars, angle irons, plates, rivets and bolts.”

Vermont marble was used for the facade of the first three floors, according to Clubbe, while the rest, wrote Painter et al., was “wrapped in a conventional, Beaux-Arts Classical, buff-brick exterior to make it stylistically more acceptable to the public.”

Condit described the building’s structural frame as a “virtual monolith of solid columns, footings, foundation walls, girders, beams, floor and roof slabs, and spandrel panels, the last of which functioned as part of the load-
bearing system above the level of the third floor. Monolithic action was secured as nearly as possible by carefully bonding freshly poured concrete to partly set concrete at the joints left from successive daily operations.” The framing members were reinforced with Ransome’s twisting steel bars, “so located as to take all tensile and shearing stresses, thus allowing the concrete to develop its full compressive stress. In the case of the columns, however, the compressive action of the concrete is supplemented by groups of heavy round rods, four to a column.”

In all, the building took eight months to build and opened in 1903. According to concretecontractor.com, the Ingalls Building accounted for about one-half of one percent of all the cement used in the United States in 1902 to 1903. Tilman notes that workers found it difficult to produce all the concrete needed for the Ingalls Building. There were no concrete mixers, so the work had to be done by hand. “They were only able to place 100 cubic yards a day, maybe a quarter of a story,” says Tilman. “The building had to be built very slowly; rebar for floor slabs and columns had to be wired in story by story.”

The 1904 Architectural Record article noted that concrete being considered for projects in the era in which Ingalls was built was made with “high-grade Portland cement, clean sand, containing, if possible, grains of variable size, and crushed stone or gravel. In the superstructure, limestone should not be used, as it would too readily be injured in a fire. Such concrete should be dense, that is to say, the voids should be well filled, and all thoroughly tamped.” Enough water was needed, the article went on, to “make a soft concrete, so as to insure perfect contact with the steel bars; for concrete-steel, it must be remembered, depends for its strength chiefly upon the adhesion between the concrete and the steel.”

Beyond its structural properties, the use of reinforced concrete also had implications for practical aspects of the construction itself. According to Condit, the Ingalls Building revealed “one great advantage” of using concrete instead of steel: “the absence of heavy structural steel members freed the site from the traffic of large vehicles and from the associated problems of unloading, storing, and placing the awkward lengths of column girders.” Contractors, he added, didn’t need to provide derricks or other heavy-duty hoisting machinery, saving construction costs and limiting construction impacts on neighboring streets. However, he wrote, “These savings were (and continue to be) partly offset by the high labor costs of constructing the wooden formwork necessary for the pouring of concrete frames and slabs.”

When it opened, the Ingalls Building was the tallest building in Cincinnati. While the building was soon eclipsed in height, it has always remained open. This summer the building was purchased by Charlotte, North Carolina-based SREE Hotels, which plans to renovate the building and convert it into a hotel.

The Ingalls Building, Clubbe explained, “revolutionized the construction industry. In the late twentieth century at least half the new high-rises built use reinforced concrete.” Condit put it this way in his 1968 article: “All the techniques of construction used in erecting the Ingalls—building formwork, installing reinforcing bars, pouring concrete, preparing concrete surfaces, and applying veneer materials—have remained standard since the Cincinnati project was undertaken.” Other than “some increase in mechanization,” he added, little had changed.

The building was approved as a national historic civil engineering landmark in ASCE’s Historic Civil Engineering Landmark Program (HCELP) in late 1973 and dedicated in 1974. It was listed on the National Register of Historic Places in 1975. (Ransome’s Alvord Lake Bridge is also a national landmark in ASCE’s HCELP.)

While the Ingalls Building might not be the signature Cincinnati building in the eyes of locals, “It’s always been important to civil engineers,” says Tilman. “This building proved that almost any structure in any form could be built of reinforced concrete.” —T.R. WITCHER

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