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"Buildings Without Walls:" A Tectonic Case for Two "First" Skyscrapers

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Abstract

"A practical architect might not unnaturally conceive the idea of erecting a vast edifice whose frame should be entirely of iron, and clothing the frame--preserving it--by means of a casing of stone…that shell must be regarded only as an envelope, having no function other than supporting itself..." --Viollet-le-Duc, 1868. Viollet-le-Duc's recipe for an encased iron frame foresaw the separation of structural and enclosing functions into discrete systems. This separation is an essential characteristic of skyscrapers today, but at the time of his writing cast iron's brittle nature meant that iron frames could not, on their own, resist lateral forces in tall structures. Instead, tall buildings had to be braced with masonry shear walls, which often also served as environmental enclosure. The commercial availability of steel after the 1880s allowed for self-braced metal frames while parallel advances in glass and terra cotta allowed exterior walls to achieve vanishingly thin proportions. Two Chicago buildings by D.H. Burnham & Co. were the first to match a frame "entirely of iron" with an "envelope" supporting only itself. The Reliance Building (1895) was the first of these, but the Fisher Building (1896) more fully exploited this new constructive typology, eschewing brick entirely, to become the first "building without walls," a break with millennia of tall construction reliant upon masonry.

Keywords: Skyscraper, Steel, Glass, Curtain Wall, Chicago

1. Iron and Envelope: A Negative Definition from The Home Insurance Building

"In the evolution of the modern office building there is nothing more wonderful than that the fact should have been accomplished of erecting a building literally without walls."

--"The Fisher Building, Chicago." *Inland Architect*, May, 1896.

The Home Insurance Building in Chicago, designed by William Le Baron Jenney and completed in 1885, was demolished in 1931, bringing belated attention to a building that the city had long claimed as the "first skyscraper." (Figure 1) Two committees assessed the structure as it was being demolished. One, commissioned by the Marshall Field estate, which was developing the site, was composed of architectural historians led by Thomas Tallmadge. The other was an independent group of engineers and builders assembled by the *Journal of the Society of Western Engineers.* The groups came to different conclusions; Tallmadge and his colleagues ratified the building's mythology while the engineers cast doubt on its claims to be the "first" anything. (Figure 2)

The Home Insurance's reputation originated in the 1890s, when it was cited as early "steel-cage construction" by *The Engineering Record* in response to a query from a steamship company that wanted to name one of its vessels after the "architect or engineer" responsible for "discovering and practically working out the idea of lofty



Figure 1. Home Insurance Building, Chicago, IL. William Le Baron Jenney, 1885.(Library of Congress).

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Figure 2. The Tallamadge Committee investigating the Home Insurance Building during demolition, 1931. from Tallmadge, *The Origin of the Skyscraper*, 1939.

steel construction of buildings." (Gates, 1896) In reply, Jenney wrote to the journal to claim that "skeleton construction" was "exclusively my invention," and that "all the principal and essential features were found in the Home Insurance Building." (Jenney, 1896) Other Chicago figures, including Daniel Burnham, wrote in support, as a show of thanks to one of the city's pioneering engineers at the end of a career that had influenced every major design firm in the city. Jenney's claim was contradicted by his own writing, though. Describing the building in *The Sanitary Engineer*, Jenney titled the article "The Construction of a Heavy Fire Proof Building on a Compressible Soil," and mentioned the building's framing only as a method to make the building's brick piers smaller: "A square iron column was built into each of the piers in the street fronts," he wrote, suggesting that, at the time, he thought of these piers as hybrid elements of iron-strengthened brick. (Jenney, 1885) (Figure 3)

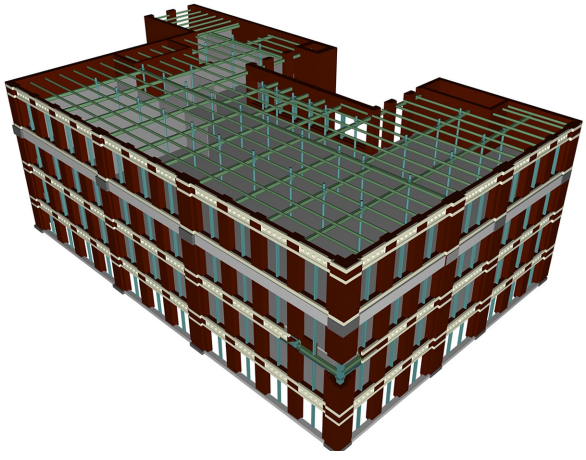


Figure 3. Home Insurance Building, Chicago, IL. William Le Baron Jenney, 1885. Digital reconstruction of structure showing iron frame and integral masonry walls.(Author, model by Ryan Risse.)

This description was echoed by the *Journal of the Society of Western Engineers'* report, which found that the building fell short of its reputation on several counts:

1. We find the steel [sic] skeleton was self-supporting.
2. Structural members were provided for supporting the masonry, but on account of the size of the piers it is probable the load was divided between the columns and the piers.
3. The wind load was carried by the masonry as the steelwork was not designed to take wind bending.
4. The masonry work could not be started at an upper floor without providing temporary support for the eight inches of masonry in front of the cast iron columns.
5. The walls were not of the curtain type but were, as previously described of the ordinary bearing type. It is apparent that the designer of this building was reluctant to give up the known strength and security of heavy masonry walls and piers for the untried curtain walls and steel wind bracing of the modern skeleton building." (Sanderson, 1932)

These 'divergences' from "the essentials of steel skeleton building" were intended as a critique, but they could also serve as a set of criteria. What elements, for the Society of Western Engineers' panel constituted a 'modern' skyscraper? Their answer, given the above 'divergences,' suggest two: an iron or steel framework that supports itself against gravity and wind loads, and that supports and is clad in a thin, lightweight, non-bearing enclosure. What, then, was the first high rise to meet these criteria?

2. Proto-Skyscrapers in Chicago: Toward the Split Between Structure and Enclosure

The Home Insurance's hybrid approach-an iron skeleton that carried the building's loads in conjunction with a hybrid system of masonry walls and piers-was superseded piecemeal over the next decade. In Chicago, Holabird and Roche's Tacoma Building (1889, Figure 4) addressed the committee's latter two points by turning the bearing and bracing masonry of the Home Insurance perpen-dicular to the exterior wall. The Tacoma's plan featured two pairs of thick, brick shear walls cutting across its narrow floor plates, which freed the exterior wall to become a true 'curtain' wall. This wall was entirely reliant upon the internal structure for its support and, in fact, begun above the first floor to allow movement of materials and labor in and out of the job site at street level. Freed from the bulky structural piers of the Home Insurance, the Tacoma's exterior wall was an open grid of large, double-hung windows and minimal terra cotta- "as now standing," the *Chicago Tribune* reported on its opening, "there is no masonry whatever on either front of the structure, where space is most valuable…take away their glass and steel beams and terra cotta, and nothing would be left except the iron columns." ("Chicago's Sky-Scrapers," 1889) (Figure 5) This article was the first in the *Tribune* to apply the

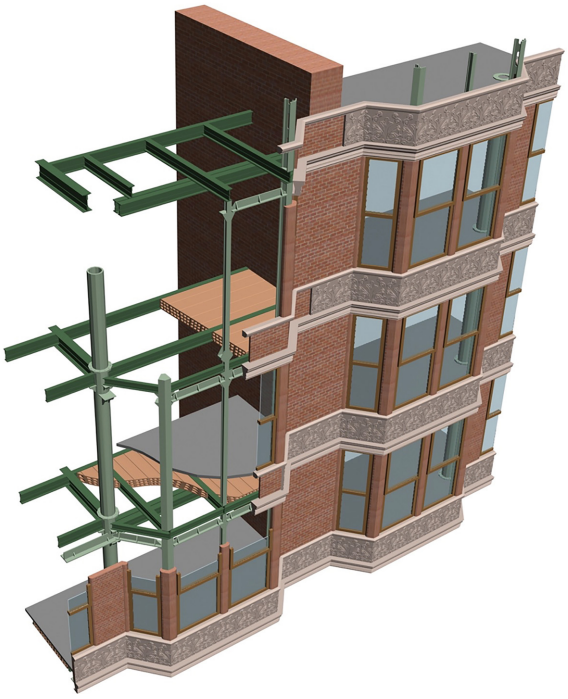


Figure 4. Tacoma Building, Chicago, IL. Holabird and Roche, 1889. Digital reconstruction of structure showing masonry and glass curtain wall with masonry shear walls and iron structure. (Author, model by Shagayegh Missaghi and Ryan Gauquie).



Figure 5. Tacoma Building, Chicago, IL. Holabird and Roche, 1889. View from Southwest.(New York Public Library/ Chicago Architectural Photographic Co.)

term "sky-scraper" to a building. But its authors went on to point out that, behind this innovative façade, the Tacoma relied on trusted techniques for its stability. "The structure is not without heavy masonry. In the centre is a strong buttress of solid brick, and from this heavy walls run to the four sides, giving the structure a solidity not suspected by those who examine only the shell-like exterior." ("Chicago's Sky-Scrapers," 1889) The Tacoma, like the Home Insurance, resisted wind loads with masonry, not iron.

By divorcing the structural and enclosure functions of the exterior wall, Holabird and Roche set the stage for further developments that would refine these two, now separate, systems. No longer needing to bear gravity or lateral loads for the frame, curtain walls became thinner, more transparent, easier to maintain, and less expensive. These were matched by structural advances that led to greater efficiencies in skyscrapers' internal frames. Most important was the switch from cast and wrought iron to steel. Cast iron had been the primary material for columns in tall buildings since the turn of the century. Its formidable compressive strength-up to 8000 kg/cm^2-made it an ideal replacement for bulky brick piers, as it could carry the same load in a smaller footprint, leaving more floor space for rental and functional purposes. But cast iron came with important drawbacks. In particular, the high carbon content that made it a good structural material also left it brittle and impossible to drill or cut once formed. The casting process led to shrinking and twisting, making such elements imprecise. Any connec-tions to the resulting columns had to be made with oversize holes and loose pins, making it impossible to achieve rigidity without resorting to bracing walls or jacketing piers of masonry. Wrought iron offered solutions to these issues, but at a cost. By removing carbon from a pool of molten iron through oxygenation or manual 'puddling,' ironmakers could produce a ductile material, one that could be rolled into thin, reliable shapes that could be cut or drilled. Wrought iron was weaker in compression than cast, and the time and labor involved in its production made it expensive. It was used, however, in the hundreds of bridges that extended the nation's railway network to the west in the 1860s and 1870s. Its ductility enabled prefabrication and reliable assembly at remote sites, making it worth the additional cost.

Iron frames in skyscrapers had split the difference between wrought and cast, using the cheaper, stronger cast iron for columns and more expensive, more versatile wrought iron in beams. Beginning in 1887, however, American manufacturers began producing structural shapes in steel, based on methods pioneered by Englishman Henry Bessemer. In 1856, he had patented a system for removing carbon from molten iron using forced air, adding back precise amounts to achieve an iron equally strong in tension and compression and ductile enough to be worked and rolled cold. With improvements to the

process, high-quality steel could, by the late 1880s, be produced for less than cast or wrought iron; its impact on railroads, shipbuilding and building was profound. ("Bessemer Steel," 1898) As important as the quality and cost of the material was its workability; for the first time, columns and girders could be connected to one another with tight connections instead of loose pins. Driving hot, malleable rivets into precisely drilled steel members, offered stiff, reliable connections that cast iron's bulk, hollow shapes, and brittleness had made impossible. Jenney himself noted the rapidity and importance of the change in 1891:

"The columns [in Chicago construction] were at first of cast iron with ingenious devices to tie the beams rigidly to the columns. As soon as riveted steel columns of a proper quality could be manufactured, their superior advantages at once brought them into use, which has not become general. All column connections are now made with hot rivets…." ("Chicago's Big Buildings," 1891)

At the time, Jenney was completing work on the Manhattan Building, one of many tall buildings on the narrow blocks formed when South Dearborn Street was carved through existing blocks in the south Loop to meet the new Dearborn Station. Rising land values from the new transportation hub and these blocks' thin dimensions demanded tall construction that was only feasible with wind bracing techniques borrowed from rail bridges. The Manhattan used two vertical trusses that acted as cantilevers from their foundations to resist bending loads from wind. Other techniques employed in steel included the portal frames that brace Holabird and Roche's Old Colony Building (1892), and steel trusses that work with masonry cross walls to stay the Monadnock Building (Burnham and Root, 1891). These techniques were effective but they imposed upon internal planning; vertical trusses limited door or window placement, while portal frames demanded curved ceilings.

3. Frames and Skins: The Reliance and Fisher Buildings

In 1895, E. C. Shankland, the lead engineer in Daniel Burnham's office, developed a new bracing technique that exploited stiff connections in steel to produce a rigid metal frame without additional members. The Reliance Building, a tall, thin structure at the corner of State Street and Washington, was erected in 1894-95. (Figure 6) Because of its small floor plates-just 55 feet by 85 feet-Shankland had few options to install cross bracing or portal frames. Instead, he relied on what he called the "table leg" principle, designing each floor plate with stiff, 24-inch deep steel girders around its perimeter, tightly riveted to the building's exterior columns. At every floor these stiff connections maintained the 90° angle between the table 'top' (the floor plate) and its 'legs' (the columns below). To deflect the structure, a lateral force would have to deflect the columns and girders *themselves*, 'recruiting' every one of



Figure 6. Reliance Building, Chicago, IL. Burnham & Root/D.H. Burnham & Co., 1895. View from Northeast. (HABS/HAER).

these elements throughout the frame into resisting a lateral wind force. (Shankland, 1896) This took advantage of the thin sections and flat surfaces achievable in rolled steel, properties that enabled easy access, workability, and robust, riveted connections. It uses Gray columns, fabricated by connecting four pairs of steel angles to one another by intermittent, lattice-like diagonals. These columns and girders work as a monolithic frame, a more spatially efficient system than the towering vertical trusses or portal frames of a few years prior.

The Reliance's exterior matched this innovative structural thinking, taking advantage of two material developments. Polished plate glass saw improvements in manufacturing that brought its astronomical price down during the late 1880s, but a particular regional development made it "cheaper than bricks" in Chicago by the mid-1890s. (Williamson, 1896) Encouraged by a newly-discovered reservoir of natural gas under central Indiana in the late 1880s, glass entrepreneurs from Pittsburgh constructed the two largest glass factories in the world in Kokomo and Elwood, Indiana, with the intent of cornering the Chicago market. But these began production just as the country fell into the Depression of 1893, leaving huge stocks in warehouses with little demand. Burnham and Atwood took advantage of this, making the Reliance's street facades more than two-thirds glass, spanning between panels and mullions of enameled terra cotta. (Figure 7) Pioneered by Chicago's Northwestern Terra Cotta Company,

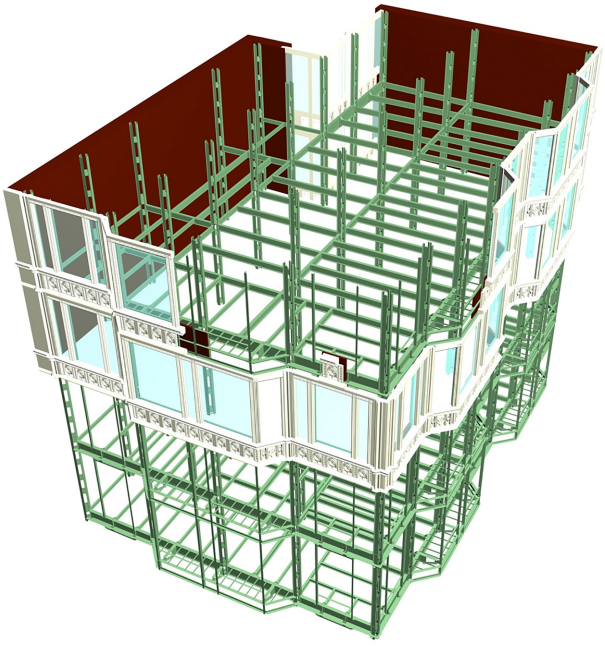


Figure 7. Reliance Building, Chicago, IL. Burnham & Root/ D.H. Burnham & Co., 1895. Cutaway View of Typical Floor: (Author, model by Ryan Risse.)

this new material matched lightweight, malleable clay with a baked, glazed surface that protected the porous surface of terra cotta. The result, Northwestern claimed, resisted dirt, smoke, and rain. The result-a "crockery finish" that would "glint and blaze in the sunlight"-was shaped by designer Charles Atwood into vertical, Gothic-inspired ornament to make the Reliance appear light, transparent and, in the words of one local reporter, "more modern than any of the large office buildings of the city." ("Springs Up," 1894)

Atwood took full advantage of the terra cotta and glass' light weight, designing massive bay windows that expanded a traditional Chicago element into dramatic double bays. 'Oriel' windows, originally a residential type, had served Chicago's commercial architecture for more than a decade. Cantilevered from the main building frame, bay windows were said to bring in more light and air, but they also effectively exploited a loophole in the city's building code to gain lettable square footage outside lot lines. The Tacoma's façade had been Chicago's most blatant application of this principle, using wrought iron beams to support its brick, glass, and terra cotta façade about three feet beyond the building's legal limit. But bay windows featured throughout the era; John Root's design for the Monadnock featured brick-clad bays that were detailed to appear as undulations in that building's exterior wall, but this stylistic choice concealed an early use of steel cantilever beams, which supported the building's bays from cross-beams anchored into its bearing brick structure. At the Reliance, Atwood expressed the tenacity of steel and the lightness of terra cotta, emphasizing the delicacy of the building's skin and the thin proportions of its skeleton-precisely the opposite of Root's monolithic approach at the Monadnock. The results were seen, a generation later, as a prescient vision of the modern curtain wall, but at the time the Reliance drew heavy criticism for its visual fragility. New York critic Barr Ferree was especially scathing, calling it "scarcely more than a huge house of glass." This hardly seems a critique in hindsight, but for Ferree the revolutionary nature of the Reliance's curtain wall violated long-held standards of aesthetics-and tectonics. "It is a good principle in architecture," he argued, "that a building should not only be firm and strong, but that it should seem so." (Ferree, 1896)

For all the advances of its structure and its street facades, however, the Reliance's corner lot meant that it's *other* two facades, adjoining existing structures along State and Washington streets, had to provide a code-required fire separation, and while the Reliance's south and west facades are curtain walls, they are made of brick, meaning that half of the building's skin is actually masonry. The next tall building designed by Burnham and Atwood, the Fisher Building on Dearborn, a block north of the Manhattan, had just one party wall because of its narrow lot, and here the firm relied on terra cotta instead of brick to provide a fire separation. ("Realty News," 1905) (Figure 8) Shankland again relied on the 'table leg' principle to support and steady the Fisher, using Gray columns in two-story lengths

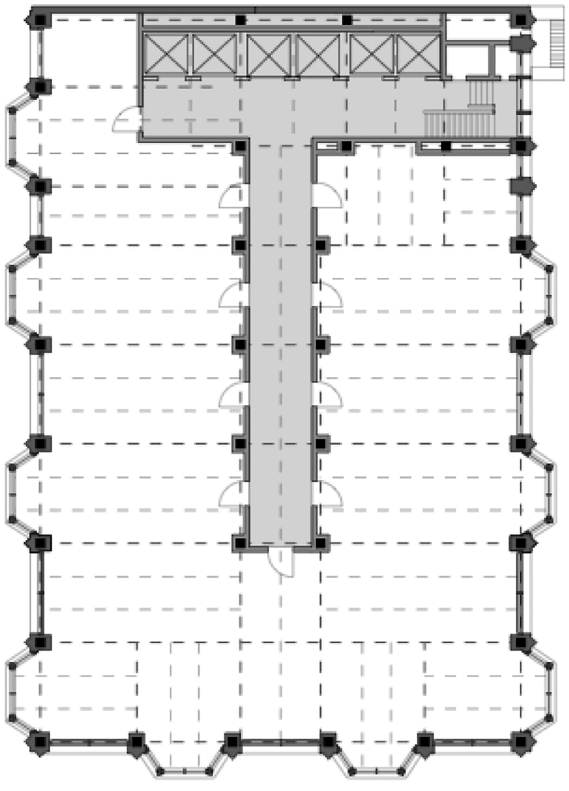


Figure 8. Fisher Building, Chicago, IL. D.H. Burnham & Co., 1896. Plan.(Author.)

connected around the building perimeter by deep edge girders. The Fisher's exterior was rendered in a bright orange enameled terra cotta, detailed, like the Reliance, with vertically-piped neo-Gothic ornament "rich as the tower of St. Jacques itself," according to the *Inter-Ocean*, while its interior was laid out in a more rigorously ordered structural grid than the Reliance. ("Newest Skyscrapers," 1896)

The Fisher also featured high-speed elevators, 'automatic temperature control' for its advanced steam heating, pneumatic clocks, and chilled drinking water in each office. Its agents claimed it to be the "finest finished building in America." But it was the Fisher's curtain wall that brought remarkable insight from *Inland Architect*'s editors, who noted that Atwood's choice of Gothic style matched that era's dissolution of mass into spare, light-filled skeletal structures:

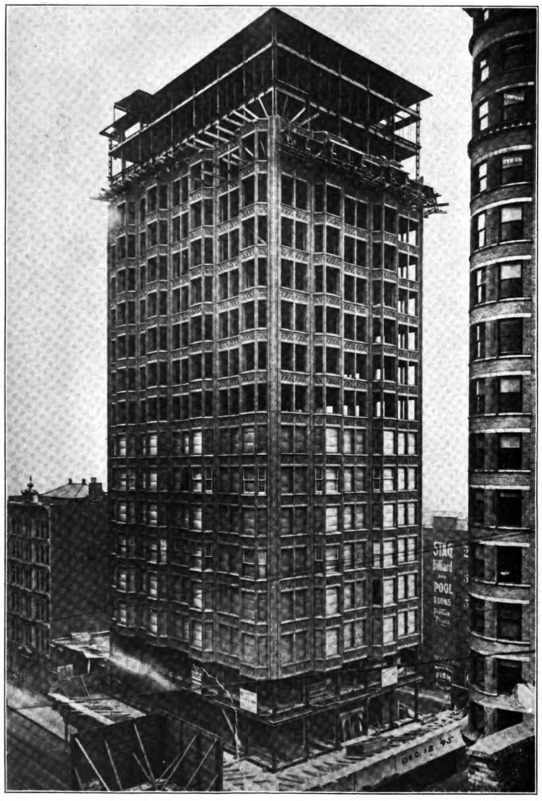
"The fronts are covered with cellular terra cotta on the outside, not in imitation of a wall, but following upward the steel supporting members, and closing in the transoms between the windows, leaving two-thirds of the exterior to be inclosed with glass." ("Technical Review," 1896)

The skeletal appearance of the Fisher impressed *Inland* as the culmination of advances that had appeared over the previous generation: steel framing, wind bracing, and curtain walls. (Figure 9) With its self-braced, skeletal steel structure and its transparent cladding, the Fisher represented the first *comprehensive* collection of modern skyscraper techniques that had been deployed *piecemeal* in earlier buildings. "If they have dispensed with front walls, they have retained often rear walls and those adjacent to other property," *Inland* noted of previous skyscrapers, a direct reference to the Reliance. "They have had division walls [the Tacoma, e.g.] or stacks of vaults rising like towers within [the Rookery, Burnham & Root, 1885], and even in the fronts have had encasements of heavy bricks, outside of the frames, and stone basements set as if for ballast at the lower stories." ("Technical Review," 1896) This last description was a particularly neat summary of the Home Insurance's hybrid conception.

For *Inland's* editors, however, what separated the Fisher from its predecessors was that Shankland, Burnham, and Atwood had eliminated masonry almost entirely in its structure and cladding. (Figure 10)

"In the evolution of the modern office building there is nothing more wonderful than that the fact should have been accomplished of erecting a building literally without walls….here, for what we believe to be the first time in human experience, one of the highest commercial buildings in the world has been erected almost without any bricks." ("Technical Review," 1896.)

Just two bricklayers had been employed during construction, to build stub walls to back up terra cotta sills. The Fisher thus marked a fundamental break. Eliminating brick in a tall building had distinct advantages: it reduced the building's weight, easing pressure on the supporting structure and foundations; it made for more efficient floor plans by replacing walls and piers with thinner columns; and it saved time and reduced reliance on expensive and strike-prone bricklayers. The Fisher was *assembled* rather



FISHER BUILDING, CHICAGO.
Nearing Completion, of Steel and Tile Fireproof Construction, with Exterior Terra Cotta Facing Close to the Roof. Sixty days from Street Level.

Figure 9. Fisher Building, Chicago, IL. D.H. Burnham & Co., 1896. Construction View from Southwest, December, 1895. (*Fireproof Magazine*, July, 1903.)

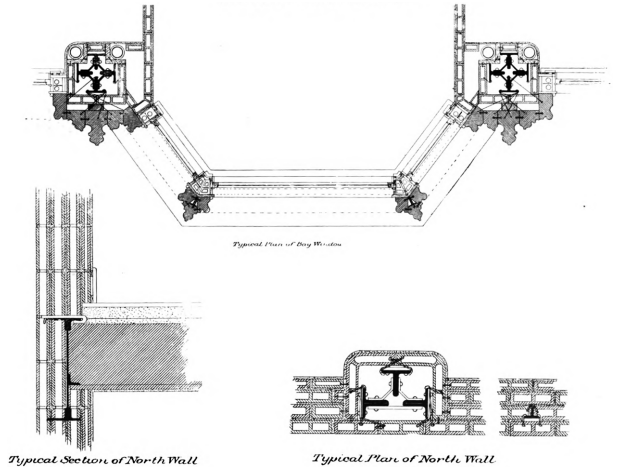


Figure 10. Fisher Building, Chicago, IL. D.H. Burnham & Co., 1896. Terra Cotta Curtain Wall Details.(*Inland Architect and News-Record*, May, 1896).

than *laid*. Its steel, terra cotta, and glass were all factory produced rather than crafted by hand. It took advantage of machine production and assembly at every scale, allowing the structure to be erected and clad in just three months, from October to December, 1895. ("Newest Skyscrapers, 1896)

4. Conclusions: The Difficulty of 'Firsts' in Evolutionary Processes

The Fisher was, therefore, the first structure to meet the criteria imposed by the Western Society of Engineers in their critique of the Home Insurance. (Figure 11) It has a self-supporting skeleton that carries both gravity and wind loads. Its exterior 'walls' are *cladding* carried entirely by the building frame. These are thin, lightweight, and they were assembled 'in the air,' leaving the ground floor to be enclosed last. Unlike the Home Insurance, the Fisher's 'walls' do not assist in any aspect of the building's structure. Unlike the Reliance, they do not rely on brick for structure or enclosure. Combined, these present us with a departure from buildings of just a year or two prior; the Fisher is more like the self-supported steel frames and thin curtain walls of the twentieth century than the iron and masonry hybrids and thick piers and masonry walls of the nineteenth. Modern skyscraper construction is distinct from that of previous eras' tall buildings in that it is skeletal rather than massive, that it divorces the structural frame from the cladding, and that it relies on assemblies of specialized components for its skins, rather than on the skill of masons in laying identical units into various forms. The Fisher Building was the first to realize these criteria together-to be wholly composed of an enclosed frame rather than of 'walls.' (Figure 12.)



Figure 11. Fisher Building, Chicago, IL. D.H. Burnham & Co., 1896. View from Southwest.(Library of Congress.)



Figure 12. Fisher Building, Chicago, IL. D.H. Burnham & Co., 1896. Advertisement from the *Chicago Tribune*, April 12, 1896. 34.

Legitimate arguments can, of course, be made against the Fisher as a true 'first.' Its foundations represented a failed experiment in short friction piles by Shankland. The building settled unevenly-it leans toward the east-and a 1907 extension was built in part to install stabilizing caissons under its northern end. Shankland's was one of several efforts to improve on the imprecise grillage foundations that underlay most of the city's skyscrapers, but Dankmar Adler' successful use of caissons under the Stock Exchange in 1895 meant that these, and not friction piles, became the preferred method of supporting tall buildings in the city. It is also true that enameled terra cotta was short-lived as a cladding material, replaced by metals such as bronze, stainless steel, and aluminum, all of which proved to be more exacting and durable. Finally, brick did see a re-emergence as a cladding material in tall buildings. The Chrysler in New York (1929) used white enameled brick to achieve its Reliance-like reflectivity, as did any number of apartment and commercial towers by postwar architects such as Emery Roth in New York and Al Shaw in Chicago. These suggest the complexity of the evolutionary process, which in architecture as in nature is full of false starts, reversions, accidental discoveries and missed opportunities. We recognize complex types such as the "skyscraper" only in hindsight, after enough examples have come into being with similar enough qualities that,

on reflection, they seem a single, nameable species. Working backwards to determine the 'first' of these applies narrative logic to processes that, in the skyscraper, are far more diffuse and complex. While the Fisher's claim to being a "first" is debatable, the criteria that it *does* meet are informative, showing how quickly advances in materials and techniques were marshalled toward meeting the functional and economic impulses of light weight, transparent skins, efficient planning, and rapid construction.

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