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Author: Thomas Leslie, Professor, Iowa State University

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Thomas Leslie

Author

Thomas Leslie,
Pickard Chilton Professor in Architecture
Iowa State University
146 College of Design
Ames IA 50011
United States
t: +1 515 294 8460
f: +1 515 294 1440
e: tleslie @iastate.edu
http://www.design.iastate.edu/

Thomas Leslie
Thomas Leslie, AIA, is the Pickard Chilton Professor in Architecture at Iowa State University, where he teaches building design, history, and technology. He is the author of *Chicago Skyscrapers, 1871–1934* (University of Illinois Press, 2013), and *Louis I. Kahn: Building Art, Building Science* (Rizzoli, 2005). His research, which focuses on the influence of engineering, design, and construction on one another, has been supported by grants from the National Endowment for the Humanities, the Graham Foundation, and the American Philosophical Society, and he is the 2013–2014 recipient of the Booth Family Rome Prize in Historic Preservation.

Figure 1. Monadnock Building, Chicago.
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Far from being the world's last and largest "masonry skyscraper," the Monadnock was a profoundly transitional structural achievement, making important advances in steel construction while still relying in part on the well-proven strength and reliability of masonry. Historically celebrated as the "last masonry skyscraper," the real story behind the Monadnock is more complex, and more revolutionary than commonly assumed.

Introduction – The Monadnock in Chicago's Skyscraper History

Burnham and Root's 1892 Monadnock Building at 53 W. Jackson Boulevard (see Figure 1), occupying half a block on Chicago's Dearborn Street between Jackson and Van Buren streets, has come to symbolize the "apotheosis of the brick wall in American urban architecture" (Hoffman 1973: 165).[1] At 16 stories (plus a penthouse) and 65.5 meters, it was not the tallest building in Chicago, but its thick masonry walls and restrained ornament made it one of the city's most remarkable. Surrounded by structures that adhered to the tenuous proportions of lighter-weight steel framing, the Monadnock's relentless brick elevations have also stood as a counterpoint to the more open, glass-filled frames of the era, and as an endpoint to the long tradition of masonry skyscraper construction throughout North America. "It is," noted Carl Condit in his 1964 book *The Chicago School of Architecture,* "the ultimate logical step in strictly functional construction with masonry bearing walls; it remains today the last great building in the ancient tradition of masonry architecture." Siegfried Giedion, among others, used its brick elevations to point out the functional shortcomings that came with heavy masonry construction – particularly the resulting deep, narrow windows in a building type that demanded maximum daylight. "Heavy masonry walls," wrote Giedion, "were not the solution to the problem of the many-storied building."

Yet historians have also noted – often parenthetically – major technical advances contained within the Monadnock. Condit, for example, noted that the building's walls are braced, in part, by steel portal framing, a remarkable distinction for a construction type that usually relied on sheer mass to resist wind forces (Condit 1974). Donald Hoffman also pointed out in his interpretation of the block that the building's undulating bay windows also relied on advanced cantilevered steel to support their weight (Hoffman 1973: 137). Further pioneering technology at work in the Monadnock included electric lighting. It was the most extensively wired skyscraper in Chicago at the time, in part to overcome the shadows of its deeply recessed windows.

The paradox of the Monadnock – that it was a conservatively expressed yet technically advanced structure – has been noted but never adequately explained. The choice of bearing masonry as a structural system has generally been assigned to the buildings' clients, the Brooks brothers from Boston, and this has allowed critics and historians to credit John Wellborn Root for finding an expressive language with which to refine and dress the bulky form that was handed to him. This is certainly not undeserved, as the consistency with which the Monadnock was detailed remains a remarkable example of brick's expressive potential. In particular, the gently curved brick that makes up transitions from the base and cornice to the subtly battered street wall, and from that wall into gracefully undulating bay windows are detailing tours de force that "succeed in making the bays appear to have grown from the wall" (Hoffman 1973: 166). For Hoffman, this organic metaphor extended to the entire elevation, which seemed to reflect the proportions and shapes of an Egyptian papyrus reed.

By pointing out the organic appearance of this detailing palette, Hoffman made a case for Root as a forebear to Sullivan and Wright's claim to the organic. Yet this family of details is

problematic, in that it presents the Monadnock's street wall as a monolithic surface, emphasizing the reading of its brick skin as a single structural element that is molded to accommodate bay windows along its elevation. In fact, this obscures the Monadnock's actual structural system, which was more of a hybrid between steel and masonry than has typically been acknowledged. A close reading of the building's construction drawings from sets in the Centre Canadien d'Architecture and newly executed digital reconstructions by a team of graduate students at Iowa State University show that the Monadnock was largely a steel frame that worked in tandem with a system of much larger brick piers. The bay windows that both Hoffman and Condit referred to were structured in a way that was virtually identical to those of Holabird and Roche's Tacoma (1887) or the Pontiac (1891) – two skyscrapers that are often cited as technically more advanced than the Monadnock – and the combination of iron and brick structural elements that supported the Monadnock was nearly identical to those which held up these two buildings. The Monadnock was, in fact, a building that marked the beginning of the metal framing era more than it did the end of masonry, and it is precisely the details so praised by Hoffman – the gently-curved brick interfaces between bay windows and masonry "wall" – that conceal its reading as a frame structure. Far from being the world's last and largest "masonry skyscraper," the Monadnock was a profoundly transitional structural achievement, making important advances in steel construction while still relying in part on the well-proven strength and reliability of masonry.

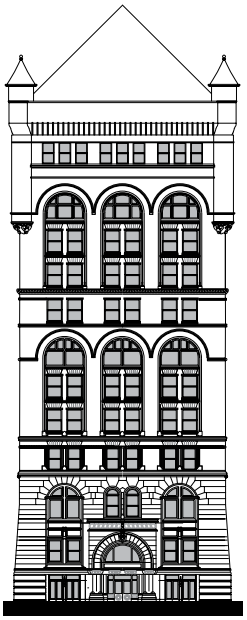


Figure 2. The 1885 scheme originally drawn by John Wellborn Root (Drawing by the author, based on Centre Canadien d'Architecture drawing DR1986:0767:063).

"Root labored to "solve" the tall office building with the Monadnock commission, and the resulting elevations show him struggling to resolve the mass of a heavy, brick-pier skyscraper with the proportions and textures of the modified Richardsonian Romanesque that had become his *métier*."

Burnham and Root designed the Monadnock in two phases. The Brooks family had planned to develop their lot at the corner of Dearborn and Van Buren since 1881, but only after the city planned to open Dearborn south to Dearborn Station in 1885 did they commission Burnham and Root. Rumors of restrictive building codes forced the hands of developers throughout the city that year, and this scheme seems to have been rushed through to ensure they could build under older, more permissive codes. This original Monadnock commission in 1885 was put on hold as economic uncertainty slowed construction, but the project was revived and executed rapidly in 1890–1892 when excitement over the Columbian Exposition began to drive real-estate prices back up.[2]

These two schemes by Root are similar in mass but different in appearance and structure. The 1885 scheme recalls contemporary projects in Burnham and Root's office, in particular the Rialto, the Phoenix (1886), and the Rookery (1888), which relied on brick piers for their structures and elevational motifs. Hoffman notes that Root labored to "solve" the tall office building with the Monadnock commission, and the resulting elevations show him struggling to resolve the mass of a heavy, brick-pier skyscraper with the proportions and textures of the modified Richardsonian Romanesque that had become his *métier.* One sketch shows arches in the lower stories that are clear allusions to Richardson's Field Warehouse (see Figure 2), then being constructed nearby, while the Dearborn Street elevation was developed as a plain grid of double-hung windows and wide brick piers – the Brooks brothers were known for their aversion to excess ornament, since projections attracted dirt and pigeons.[3] "As yet," noted Hoffman of the early scheme, "there are none of the wonderful projecting bays" (Hoffman 1967: 271).

The lack of bay windows, however, should not be surprising for a scheme developed in 1885. Bay windows, or oriels, had only just appeared in Chicago skyscraper elevations. John J. Flanders used them in the Mallers Building (1884), but their deployment as a non-bearing curtain wall came only with Holabird & Roche's Tacoma Building, completed in 1889. Root's elevations for the Monadnock at this early stage came before the full exploration of the bay window as a lighting and space-grabbing device in Holabird and Roche's Caxton (1890) or Pontiac (1891) buildings. Instead, his use of brick piers and double-hung windows related more to buildings of this scheme's era – W. W. Boyington's Royal Insurance, for example (1885), or Cobb and Frost's Opera House (1885). All of these buildings struggled to bring in enough daylight, since neither the steel to make these piers narrower, nor the plate glass to fill larger openings, was economical enough to

[1] In fact, Root's Women's Temple, completed in 1892, was the last bearing masonry skyscraper constructed in Chicago.
[2] Among other sources, "Chicago's Great Buildings." ***Chicago Daily Tribune.*** Jan. 1, 1893: 28, gives evidence that the real estate boom of 1890–93 was largely speculative, and based on assumptions that Chicago's economy would benefit from the Columbian Exposition – predictions that proved to be wildly optimistic.
[3] Burnham & Root Drawing, Centre Canadien d'Architecture, Acquisition DR1986:0767:001. n.d.

displace masonry as a structural or cladding material. Instead, the structural functions of brick walls were organized into systems of piers and openings that balanced the need for light with the structural bulk of masonry (see Figure 3).

The 1890 Monadnock scheme distilled the 1885 scheme's piers into a visually cohesive masonry surface, reversing the local tendency toward articulated frames in brick construction and replacing it with a smooth plane (Condit 1972). Root used nearly one hundred custom-made brick molds to achieve the building's subtle curves and billowing bay windows, marshaling the elements of a commercial skyscraper façade – structure, cladding, and daylighting – into one streamlined block. For Giedion in particular the Monadnock represented the Chicago School's aim to "…break through to pure forms…which would unite construction and architecture in an identical expression" (Giedion 1997). It is this stylistic argument that has typically been put forth by historians and critics eager to see in the visually striking Monadnock something of the city's technically progressive spirit. While acknowledging that bearing masonry was "technically outmoded" by 1892, for instance, Donald Miller nonetheless considered the building's appearance "audaciously modern" (Miller 1997). Root's ability to coax a coherent appearance out of an outmoded structural system is a testament to his considerable compositional skill. But the 1890 scheme's construction was not a pure bearing wall system; it incorporated steel framing for its gravity and lateral systems, and to support much of its masonry exterior.[4]

> "…the Monadnock's bay windows are a direct product of developments in steel and iron, despite being clad in a brick skin that visually blends with the surrounding piers."

Figure 3. View from northeast showing masonry bearing walls and cantilevered bay windows. Source: Contemporary post card, author's collection

The 1891 Scheme Technically Reinterpreted

Along with other developers, the Brooks brothers raced to finance, design, and erect the Monadnock in time to profit from the boom surrounding the 1893 Columbian Exposition. The building's mythology has it that Burnham stripped a preliminary scheme of Root's down to its masonry essentials while the latter was on vacation, but Hoffman notes that the image of Root trying to reconcile the Brooks' pragmatic loathing of projecting surfaces into a coherent architectural language rings somewhat truer (Hoffman 1967: 269–270). Plans for Holabird & Roche's Pontiac Building, two blocks to the south, appeared in parallel with the development of the Monadnock, with massive bay windows extending over two column bays clad in a brick veneer, which was blended into the structural piers and walls that actually gave the Pontiac much of its support.[5] Whether directly inspired by the Pontiac or not, this dual nature of masonry – its malleability into piers of great compressive strength or into lightweight veneers of environmental enclosure – informed Root's approach to the Monadnock. He organized new bay windows into regular ranks along Dearborn Street and Federal Place, extending out from the masonry piers that remained from the earlier scheme, in effect dressing the 1885 design with the newly popular device of bay windows.

Burnham and Root's drawings of 1890–1891 show this hybrid of regular brick piers alternating with cantilevered bay windows throughout. But another set of drawings, done to commission and price the building's steelwork, shows that this masonry support and cladding was supplemented – and in parts, supported – by a hidden steel skeleton. It is apparent from this set, copies of which are preserved at the Centre Canadien d'Architecture and in the possession of Bill Donnell, owner of the Monadnock, that the project was documented in considerable haste to ensure its completion before the onslaught of visitors to the city in 1892–1893. These drawings reveal the extent to which the bay windows, the interior floors, and the masonry piers themselves were assisted by one of the most extensive steelwork packages in the city to date. In three areas – the building's interior structure, its wind bracing, and its cantilevered bay windows – steelwork details and plans show that the Monadnock's structure was similar to that of the Tacoma and Pontiac, in that its interior floors and a portion of its exterior walls were supported by a skeletal metal framework. It was also similar to William Le Baron Jenney's Manhattan Building (1891) or Holabird and Roche's Old Colony Building (1892), in that it used a network of steel portal frames and tie rods to brace its short direction against wind (see Figure 4) (Freitag 1904).

Interior Structure

The Monadnock's gravity system was an example of "cage" construction, in which an interior grid of iron columns and girders supplemented an envelope of structural masonry (Friedman 2011). This was a common technique through the 1880s, and while buildings such as the Tacoma had made advances in efficiency by replacing exterior masonry with lighter envelopes, hybrids of brick and steel were familiar and well-tested

by 1890.[6] Burnham and Root deployed this combination in the Rookery (1888), and bearing masonry and interior iron had been used together by H. H. Richardson in the Marshall Field Warehouse (1887) and by Adler and Sullivan at the Auditorium (1889) (O'Gorman 1978). The Field Warehouse and the Auditorium suffered notable foundation failures, however, that were commonly ascribed to their cage construction. The Auditorium's tower settled further than initially planned due to additional stories that were included after the foundations had been laid, while the Field Warehouse suffered differential settlement that resulted from its combination of light iron and heavy masonry on Chicago's compressible soil (Monroe 1896). Masonry walls required larger footing pads than iron columns, since they weighed so much more, and improperly sized foundations under the Field meant that its exterior wall settled further than the interior structure ("Industrial Chicago" 1891, Peck 1948).

The Rookery, however, proved that cage construction in Chicago was feasible if foundations were carefully designed, and Burnham and Root replicated that structure's formula in the Monadnock. In both buildings, a masonry carapace surrounds a lighter internal network of iron; the masonry supports loads at the buildings' perimeters and, crucially, stiffens them against lateral forces. In fact, the buildings' plans show remarkable similarities; the exterior brick walls are in both cases composed of thick vertical piers that are elongated in the direction of required wind resistance, and connected to one another with brick spandrels and occasional iron hoops or beams. At the Rookery, Root chose to articulate the distinction between pier and spandrel through a grammar of planes and detail, but this was a stylistic choice – there was no structural reason that spandrels could not be set flush with piers as in the Monadnock, giving the appearance of a pierced wall rather than a system of skeletal members.

While it is common to think of the Monadnock as monolithic in both style and substance, it is clear from digital reconstructions that its massive appearance is largely just that; Root sculpted a visually solid block of masonry from a skeletal system of bearing piers and bridging spandrels. There is no reason that the Monadnock's spandrels – which each support only the sill and window immediately above – had to be as deep as the piers to either side. In Sullivan's hands, and even in Root's, it was common to set spandrels back, bringing piers to the front plane of the building façade, visually emphasizing the skyscraper's "proud and soaring" essence, in Sullivan's words. But the Monadnock's spandrels were blended into the neighboring piers in a conscientious denial of what was, in other contexts, a natural expression of a skyscraper's structural and visual hierarchy.

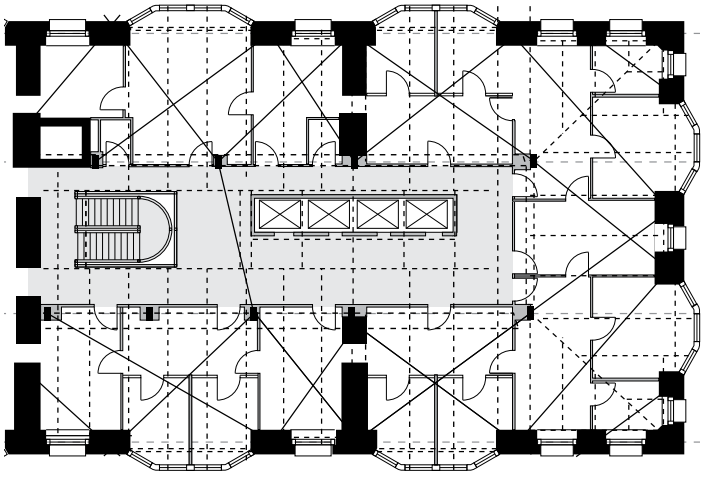


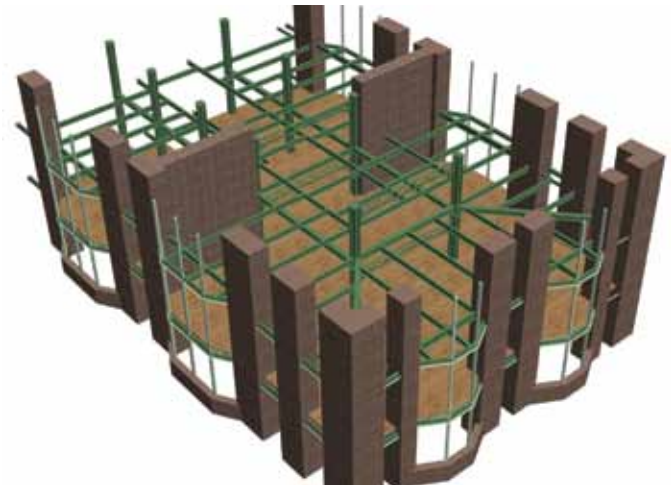
Figure 4. Structural plan of the 8th floor showing tie-rod layout for wind bracing, steel framing for floor structure (Drawing by the author based on Centre Canadien d'Architecture drawing DR1986:0767:052).

This misleading compositional program continued through what is perhaps the Monadnock's most noted detail. Though the Monadnock was considerably taller than the Rookery, the famed outward spread of its exterior walls toward their base occurs only beneath the vertical piers. Beneath the projecting bays, Root included large windows; this is the one moment on the exterior that contradicts the reading of the block as a massive, undulating wall. Indeed, when Holabird and Roche extended the building to the south in 1892, the first phase of the extension was also constructed with exterior piers entirely of masonry. But Roche saw no need to include the famed outward bulge at the lower levels, suggesting that the entire curve was a visual trope on Root's part rather than a strict structural necessity.[7]

Wind Bracing

The Monadnock was well braced in its north-south direction by the relative length of its footprint compared to its height, but it faced problems in its shorter, east-west dimension. Because of a quirk in Chicago's street layouts, the lots on either side of Dearborn Street are only 19.8 meters deep. Technical articles of the day show that engineers were concerned that the weight of a tall building multiplied by relatively short moment arm might not adequately resist the force of wind-multiplied by the much longer moment arm created by these newly-reached heights. No Chicago skyscraper was ever blown over, but minor racking deflections could easily crack plaster walls, stop elevators, and bind doors (Quimby 1892a & 1892b, Leslie 2010). Elsewhere on Dearborn, an encyclopedic array of wind-bracing techniques stayed William Le Baron Jenney's 1890 Manhattan building (diagonal cross-bracing), Holabird and Roche's Pontiac (masonry cross

[4] The following analysis is based upon drawings in the Canadian Center for Architecture, acquisition numbers DR1986:0767:001-473.
[5] See, for example, Burnham and Root, Monadnock Building, Chicago: Fourth Avenue elevation printed 1890–1892. CCA DR1986:0767:259.
[6] The Tacoma accomplished its remarkably open and glassy façades by essentially turning exterior shear walls of masonry perpendicular to its elevations, embedding them in the mass of the lettable floor plates themselves.
[7] This applies only to the first phase – the north half – of Holabird & Roche's extension. I am grateful to Bill Donnell for enlightening me to this fact, which productively challenges the traditional comparison of the building's two "halves" as brick versus steel construction.



Figures 5 & 6. Digital reconstructions showing the hybrid of masonry piers and cross-walls with steel columns, girders, and portal frames. © Shaghayegh Missaghi and Ryan Gauquie

walls), and 1894 Old Colony (portal frames). In 1896 Burnham's Fisher Building, across Dearborn from the Monadnock, employed one of the first moment frames against the same problem ("The Fisher Building," 1896).

Five years before this critical advance, however, Burnham and Root's engineer, E.C. Shankland, opted for the predictability of masonry cross walls and the convenience of steel's tensile capacity to brace the Monadnock (see Figure 5). Root's plan incorporated two thick, heavy masonry cross walls in the northern half of the project, and a third at the southern edge of the site that was later subsumed into the Holabird and Roche addition. These provided lateral resistance in the east-west direction, but Shankland added further reinforcing in the form of portal frame girders and tie rods in the building's floors (see Figures 4 and 5). This last set of elements appears to have been a late addition, given their ad hoc arrangement. Because of the building's functional layout – two ranks of offices with a wide circulation space between – the building's cross-walls were confined to the depth of the office zones themselves, leaving the central corridor open. This gap reduced the effectiveness of the walls, which Shankland addressed by tying each pair of cross walls across the corridors with steel trusses. The connections between truss and wall were made especially deep; the result was effectively a cross wall with three times the depth as the two individual brick planes. This provided a robust footprint that more efficiently stood against wind, but it left the northern end of the building vulnerable to torsion, since there could be no cross-wall on the northern elevation where views up Dearborn Street – and daylight – were at a premium. To avoid unequal movement of this weaker end, Shankland added further portal trusses that tied the iron columns to one another in this bay. As with its skeletal framing, the Monadnock was thus more like its steel-braced contemporaries than the masonry forebears to which it is often compared (Condit 1964: 123–124, 1974).

Cantilevered Bay Windows

While the Monadnock's cage construction and its hybrid wind bracing have been parenthetically acknowledged, the fact that the Monadnock's exterior wall itself is a mix of supporting and hung masonry is rarely noted; only in its solid piers is the "wall" of the building truly bearing, while the undulating window bays that make up much of its elevation are hung from cantilevered steel beams (Condit 1964: 91). It is these elements that most seriously question the traditional reception of the Monadnock as a monolithic structure, and suggest that instead we understand it as a transitional moment in the full development of the steel frame and lightweight skin.

The Tacoma Building's bay windows showed the potential for cantilevered glass bays that could bring air and daylight into offices while surreptitiously gaining additional floor space outside a building's lot line. For these reasons, bay windows appeared with increasing frequency through the early 1890s. These bays, however, needed better and more reliable bending capacity than cast or wrought iron could provide. Steel became the structural material of choice for girders by 1890, and its increased strength and relative ease of fabrication made it an efficient choice for cantilevered elements. The Tacoma was only the most extreme deployment of steel-framed cantilevered bays whose skins – relieved of their burden to support anything but their own weight – could be light and transparent. The 1891 Pontiac was also a promising example of brick-and-glass bay windows that offered affordable opportunities to bring in more daylight and outside air while gaining floor area outside the building's structural lines.

Again, Root's bay windows at the Monadnock

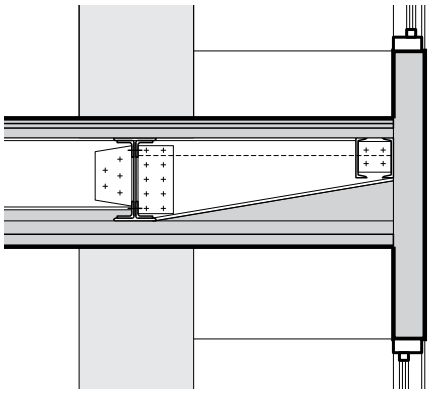


Figure 7. Cantilevered bay window bracket showing steel detailing. (Drawing by author, based on Centre Canadien d'Architecture drawings DR1986:0767:315 and DR1986:0767:234).

mimicked Roche's blend of masonry's cladding and structural functions at the Pontiac. The Monadnock's bays are hung from steel beams that cantilever from the building's internal structure and run between the building's masonry piers. The piers support cross-beams, on which the cantilevered beams rest, but the arrangement of the windows' structure suggests that Shankland saw them as extensions of the building's metal skeleton, rather than as integral to the masonry piers themselves (see Figure 7).[8] This is clear from a close reading of the elevations; the bays begin only at the third floor, showing that the brickwork in these vertical elements is non-load-bearing. Cross-beams between masonry piers act as fulcrums, and the considerable leverage imparted by the cantilevered bays is resisted by long steel beams that run deep into the building's center. Neither masonry nor cast iron could have efficiently carried these cantilevered loads; the Monadnock's bay windows are a direct product of developments in steel and iron, despite being clad in a brick skin that visually blends with the surrounding piers.

Conclusion – Structural Articulation vs. Root's Material Rhetoric

The most provocative element of the Monadnock's structure may not be its conservative use of bearing masonry, but rather the extent to which steel was used, and to which this choice enabled the building's primary functional and visual motifs while being entirely concealed. The ranks of undulating bay windows across the Monadnock's elevations, while suggestive of monolithic brickwork, play down the very real differences between its two structural systems: the regular march of heavy brick piers around its perimeter, and the lightweight network of steel within and between these piers (see Figures 5 and 6). That this network emerges in the bay windows – that it escapes its brick cage in an effort to push the cladding function of the exterior wall to greater functional dimensions – suggests that the Monadnock was very much a transitional building. Caught between the desire for a well-proven structural technique and the benefits of a more radical approach of masonry "veneers" on bay window buildings nearby, the Monadnock's design adopted elements of both traditional and new construction, and Root skillfully integrated these into a coherent, if less than fully expressive, set of elevations. The supposed "purity" of the Monadnock – Montgomery Schuyler's claim that its unapologetic brick façades represented "the thing itself" – might therefore be questioned. The reality of the Monadnock is that it was conceived at a time when technical advances were so rapid, and so untested, that its mélange of techniques represents precisely the uncertainty, experimentation, and inevitable concern that came with new developments in structural design and materials.

Beyond the building's history itself, however, this assessment points out the very real shortcomings of adopting a predominantly stylistic approach to analyzing complex buildings. It is not the case that Root sought consciously to make a singular statement about the visual appeal of "old" or new structural techniques. Rather, he seems to have quietly taken on board the functional realities of cage construction and the occasionally conflicting opportunities that came with cantilevered bay windows, and to have found a language that synthesized them into a visually coherent expression. This expression, however, gained its cogency from its suppression – rather than expression – of the underlying structure. While critics have largely seen the Monadnock as a *tour de force* of masonry, such an interpretation ignores Root's decision to adopt one element of a hybrid construction at the expense of visibly expressing the other. This does not, in the end, diminish either the technical or the aesthetic achievement of the Monadnock. Rather, it points out that these two realms are not always as tightly linked as critics seeking grand narratives might prefer, and that at transitional moments even exceptionally talented designers such as John Root sought comparatively easy stylistic solutions that glossed over complicated structural realities. ■

[8] Centre Canadien d'Architecture drawings CCA DR1986:0767:062 and 064.

References

CONDIT, C. 1964. ***The Chicago School of Architecture.*** Chicago: University of Chicago Press: 66, 91, 123–124.

CONDIT, C. 1972. "The Chicago School of Architecture: A Symposium – Part II. Structural Development." ***The Prairie School Review,*** IX(2): 11–12.

CONDIT, C. 1974. "The Wind Bracing of Buildings." ***Scientific American,*** 230(2): 98.

FREITAG, J. K. 1904. Architectural Engineering. ***With Especial Reference to High Building Construction, Including Many Examples of Prominent Office Buildings*** (2nd Edition). New York: Wiley & Sons: 271–272.

FRIEDMAN, D. 2010. ***Historical Building Construction: Design, Materials, and Technology*** (2nd Edition). New York: W. W. Norton & Company.

GIEDION, S. 1997. ***Space, Time, and Architecture: The Growth of a New Tradition*** (5th Edition). Cambridge: Harvard University Press: 382.

HOFFMAN, D. 1967. "John Root's Monadnock Building." ***The Journal of the Society of Architectural Historians,*** 26(4): 269–271.

HOFFMAN, D. 1973. ***The Architecture of John Wellborn Root.*** Chicago: University of Chicago Press: 137, 165–166.

Industrial Chicago: The Building Interests. 1891. Chicago: The Goodspeed Publishing Co.: 466–479.

LESLIE, T. 2010. "Built Like Bridges: Iron, Steel, and the Importance of Riveted Steel to the Nineteenth Century Skyscraper." ***Journal of the Society of Architectural Historians,*** 69: 2.

MILLER, D. 1997. ***City of the Century: The Epic of Chicago and the Making of America***. New York: Simon and Schuster.

MONROE, H. 1896. ***John Wellborn Root: A Study of His Life and Work.*** Cambridge: Riverside Press: 119–120.

O'GORMAN, J. 1978. "The Marshall Field Wholesale Store: Materials Toward a Monograph." ***The Journal of the Society of Architectural Historians,*** 37(3): 175–194.

PECK, R. B. 1948. "History of Building Foundations in Chicago." ***University of Illinois Bulletin,*** 45(29).

QUIMBY, H. H. 1892. "Wind Bracing in High Buildings." ***The Engineering Record,*** November 19: 394–395.

QUIMBY, H. H. 1892. "Wind Bracing in High Buildings." ***The Engineering Record,*** December 31: 99.

SCHUYLER, M. 1892. ***American Architecture.*** New York: Harper and Brothers.

"Technical Review: The Fisher Building, Chicago – A Building Without Walls." 1896. ***The Inland Architect and News-Record,*** Special Supplement, XXVII(4).