

## Office Buildings of the Chicago School: The Restoration of the Reliance Building

The American Architectural Historian Carl Condit wrote of the Reliance Building, "If any work of the structural art in the nineteenth century anticipated the future, it is this one. The building is the triumph of the structuralist and functionalist approach of the Chicago School. In its grace and airiness, in the purity and exactitude of its proportions and details, in the brilliant perfection of its transparent elevations, it stands today as an exciting exhibition of the potential kinesthetic expressiveness of the structural art."<sup>1</sup> The Reliance Building remains today as the "swan song" of the Chicago School. This building, well known throughout the world and listed on the US National Register of Historic Places, is presently being restored. Phase I of this process which addresses the exterior building envelope was completed in November of 1995. The design/builder of the project was McClier/UBM, a joint venture of a Chicago based Architectural and General Contracting firms. Wiss, Janney, Elstner Associates, Inc. of Chicago acted as façade consultant and was responsible for the investigation and restoration of façade elements including the terra cotta and windows. Phase II, which will address the interior, is set to begin as early as 1997.

### The Reliance Building and the History of the Skyscraper

The main stream of Chicago's building history recommenced after 1871, when the Great Chicago fire devastated the City. Despite this catastrophe – and due to a strong local economy, the high cost of land, and rapidly evolving building technologies – Chicago quickly rose from the ashes and afforded an opportunity for the realization of innovations in architecture, engineering and construction which established it as the birthplace of the skyscraper. The German-American civil engineer Frederick Baumann, who had settled in Chicago, promulgated the first rational technique for foundation design for the new skyscraper. In describing the skyscraper, he wrote:

"The design is to erect on foundations a firm and rigid skeleton, or hull, of iron... The enclosure, whether of stone, terra cotta, or brick, or any combination of these materials, may be erected at the same time the iron structure is being put in place. But the latter might proceed much faster than the former; while the hull might be roofed within two months, the enclosure might not have proceeded further than the fourth story. Thus there need be no delay to a steady progress. Light, the great desideratum in all city buildings, is secured, even on the lowest – the most valuable – floors, whereas, otherwise, the necessarily broad piers would be a hindrance. The iron uprights are to be provided with a series of projecting brackets for the purpose of anchoring and supporting the parts forming the

exterior enclosure. These supporting brackets will be so arranged as to permit an independent removal of any part of the exterior lining, which may have been damaged by fire or otherwise."<sup>2</sup>

Chicago architect William LeBaron Jenney is widely recognized as the innovator of the application of the iron frame and masonry curtain wall for skyscraper construction. The Home Insurance Building, completed in 1885, exhibited the essentials of the fully-developed skyscraper on its main façades with a masonry curtain wall.<sup>3</sup> Spandrel beams supported the exterior walls at the fourth, sixth, ninth, and above the tenth levels. These loads were transferred to stone pier footings via the metal frame without load-bearing masonry walls.<sup>4</sup> The structure however had no system of lateral support and the masonry envelope alone was considered sufficient to stiffen the frame.

Jenney trained many of the architects who designed Chicago's early skyscrapers including Daniel Burnham, William Holabird, Martin Roche, and Louis Sullivan. The steel frame and masonry curtain wall technique was fully developed within a few years by these architects, and was utilized in a functional aesthetic that came to be known as the Chicago School of Architecture. The evolution of structural techniques used in skyscraper construction rapidly accelerated over the next decade. By 1890 steel had supplanted cast iron for skeletal framing and afforded the opportunity to develop rigid beam-column connections which could not be realized with the brittle cast iron. Skeletal frames were beginning to be designed to work independently of the masonry envelope and not rely on the exterior walls to achieve lateral stability.<sup>5</sup>

As skeletal framing came into common use, masonry bearing wall construction reached its practical limit. Burnham and Root's 16-story Monadnock Block (Chicago, 1891) utilized traditional load-bearing masonry walls which at ground-floor level were almost 2 meters thick. This building was also the first to utilize the rigid steel frame to achieve lateral stiffness. At the same time, Burnham and Root developed a complete steel frame for the Rand McNally Building (Chicago, 1890). They also developed a steel frame laterally stiffened with a diagonal bracing system in the 20-story Masonic Temple (Chicago, 1892).<sup>6</sup> These latter two structures allowed for smaller columns and larger windows at the street level for increased daylight and rentable retail space where the highest rent was demanded. Of these structures and dozens of others that were realized in the next few years only a handful, including the Monadnock Building, remain.

An archetype of the Chicago School and example of the structural innovations of the period can be found in the Reliance Building. The Reliance Building curtain wall of terra cotta is a clear aesthetic expression of the underlying structure and provides a maximum of natural lighting. This

### III. 1

Chicago, view of the construction of the tower portion of the Reliance Building. The foot scaffolding at the foot of the tower was used as the roof of the Department Store that was open for business in the structure directly below. Visible in this photograph is the system of cast iron mullions and rails that would hold the fixed glass and onto which most of the terra cotta was attached.



1868 for the First National Bank of Chicago. Though largely destroyed by the Chicago fire, it was rehabilitated as a four-story office structure. Developer William E. Hale purchased the building in 1882 and by 1889 had entered into a contract with his friend, architect Daniel Burnham, to erect a 16-story structure on the site to be called the Reliance Building.<sup>8</sup> Construction was set to begin in 1890 and the design was prepared by Burnham's partner, John Wellborn Root. A stipulation of the construction as work began was that habitation by commercial tenants, who had a standing lease until 1894, was to continue during construction. This feat was accomplished by raising the existing masonry edifice on jack screws while the foundations, basement, ground floor, and mezzanine of the Reliance Building were constructed. The inhabitants above were left relatively undisturbed and accessed their office by temporary stairs constructed solely for this purpose. The new space below was leased by the Carson Pirie Scott Department Store which occupied the space in late 1891.<sup>9</sup> Due to the existing lease that did not expire until 1894 and the economic recession of 1893, the tower portion of the project could not proceed until 1895. By this time Root had died at the age of 41 due to an unfortunate illness and his design, of which no indications remain today, was changed. The new design was that of Charles Atwood, an associate of Burnham and Root who had been hired to oversee the Reliance Building project. Demolition of the raised edifice and construction on the upper floors proceeded with the new tenants left undisturbed below.<sup>10</sup>

### III. 2

Chicago, Reliance Building: The build-up of compressive stresses within the façade had caused mullions to fracture and hundreds of terra cotta units to crack and split. This was the single most prevalent cause of deterioration. (left)

façade treatment has been compared to the "Glass Skyscraper", a study project developed by Ludwig Mies van der Rohe in 1921 whereby a skeleton with cantilever slabs was sheathed totally in glass.<sup>7</sup> The predecessor building to the Reliance Building was a five-story masonry structure that had been constructed in

The construction of the Reliance Building illustrated all of the modern construction techniques which had come into widespread use at the end of the 19<sup>th</sup> century to facilitate rapid construction. The construction site was lit, so work could continue into the night. Work spaces were enclosed and heated, so the project could proceed during the win-



### III. 3

Chicago, Reliance Building: Corrosion of wrought iron clamps within the terra cotta and the consequent expansion of the corrosion product also caused large cracks and fissures to open up within the façade. These openings promoted further water infiltration and accelerated the corrosion process. (right)



ter months. The erection of the structural frame required only fifteen days, beginning in mid July and topping off on August 1, 1894.<sup>11</sup> The skeletal frame was realized as a rigid frame and utilized mild steel. The two-story 'Gray columns', named after their inventor, were erected with staggered joints and further increased the rigidity of the frame.<sup>12</sup> The exterior cladding enclosed the building by November 8<sup>th</sup> thereby securing the structure for winter work. The treatment of this cladding, using wide expanses of glass and delicate use of terra cotta that expressed the underlying structure, established the Reliance Building as the ultimate refinement of the nineteenth-century skyscraper that foretold the 20th century modern movement. The Reliance was the first such structure in the US to use highly ornamented terra cotta exclusively as a cladding. The use of terra cotta was considered a great innovation because it could be easily cleaned.<sup>13</sup> The gleaming white façade stood out from the surrounding structures composed of brick and grey, red, and brown colored sandstone. A unique feature of the exterior cladding of the building was the use of a cast-iron mullion and rail system which spans from floor-to-floor. The mullion and rail system forms a grid-work into which all the non-operating windows are placed and onto which the terra cotta was attached. The result was the minimalization of the terra cotta mullions and the appearance of no window frame. Due to this detailing and appearance, the Reliance Building façade is widely held as an early example of the modern curtain wall. The building was dedicated for occupancy on March 15<sup>th</sup>, 1895. Many of the original tenants of the building included doctors, lawyers, and dentists. It was customary to advertise one's services by placing advertising in the upper part of the window, and the tenant use of the wide expanses of glass at the Reliance Building was no exception. Due to the small floor plate, the building was not conducive to larger companies.



III, 4  
Chicago, historic view of the Masonic Temple (Burnham and Root, 1892). This building, now demolished, utilized a steel frame that was laterally stiffened with a diagonal bracing system and did not rely on the masonry curtain wall for lateral support as had earlier skyscrapers.

The history of the Reliance Building into the 20th century, however, is the unfortunate story of lacking maintenance. By 1940, the cornice at the top of the building had been removed. This was not uncommon at the time when the cornices of 19th century skyscrapers were regularly removed to address safety concerns in a permanent and

III, 5  
Chicago, Reliance Building: During terra cotta replacement exposed metal elements such as columns, spandrel beams, and the cast iron mullion and rail system, were cleaned and painted. It was found that the mullion and rail system was in relatively good condition. If this system was found to be significantly deteriorated the restoration project would not have been feasible. (left)



III, 6  
Chicago, Reliance Building: Cast aluminum that was painted was used as a substitute material for replacement of the cornice because of its durability. The cornice was realized as a system of panels that were independently suspended from a steel frame above with joints to allow movement between adjacent panels and between panels and the terra cotta façade. (right)

Chicago turn-of-the-century view of the Reliance Building. Once constructed, the building stood prominently on the skyline because of its height and gleaming white appearance in contrast to the shorter and darker surrounding buildings. Advertisements in the windows of historic photographs together with annual city registries helped the architect date many of the alterations to the building façade.



Chicago, the view of the east elevation of the Reliance Building before restoration reveals the Chicago style windows made up of fixed glass flanked by double-hung windows. The largest panes of glass on the façade would not fit into the elevators. Consequently, when larger windows cracked, they were replaced with smaller panes of glass with vertical mullions which bisected the once magnificent windows (right side).

economical manner. By 1941, the base of the building including two of the three projecting bays were altered to accommodate signage. Many of the large windows had cracked and were replaced with smaller panes of glass with vertical mullions which bisected the once magnificent windows because full size window glass would not fit into the elevators. The building had become noticeably darkened by atmospheric pollutants. By the mid 1980s, the building posed a danger to pedestrians due to falling terra cotta and its future was in question. The Reliance Building was purchased by the City of Chicago in 1994 and funds were allocated for restoration.

### Understanding the Mechanisms of Decay

The first step in understanding the mechanisms of decay and deterioration and developing an appropriate restoration program was the preparation of an Historic Structures Report or HSR<sup>14</sup>. As part of the HSR a comprehensive investigation of the cladding and windows was performed. Only a handful of the original architectural documents were available for review. Details of the façade did exist in architectural drawings and in historic publications. The investigation of the façade of the Reliance Building included a close-up visual inspection of each of the 14,300 units of terra cotta from a suspended scaffolding. All distress was recorded onto façade elevations, and "crack maps" were used to delineate and categorize patterns of distress. Areas of obvious visible distress where the original fabric was badly damaged were selected for dis-



assembly. The openings that were created revealed hidden conditions within the façade and gave an indication of the causes of distress. Terra cotta and mortar samples that were removed during the inspection opening process were taken to the laboratory for petrographic and chemical analyses.

It was determined that the terra cotta portions of the curtain wall were under a tremendous build-up of compressive stresses due to foreshortening of the steel frame under the weight of the building, expansion of the terra cotta masonry caused by environmental forces, and a lack of means within the curtain wall to accommodate these contrary forces. This compression build up had caused fracture of a significant number of terra cotta units. Cracking promoted water infiltration which attacked the wrought iron clamps attaching the terra cotta to the cast iron mullion and rail system. The consequent corrosion of the clamps caused further cracking of the terra cotta and exacerbated the water leakage problem. Furthermore it was determined that, until the stresses within the wall were addressed, terra cotta units could not be removed from the wall for replacement or repair without damage to adjacent panels. Openings were also made at the top of the building to view and record those portions of the cornice structure which were still in existence. The original architectural documents that were available gave no record of the appearance of this element of the building. The new cornice was designed from the study of historic photographs.

Soils on the building were analyzed and found to be composed of carbon deposits from the burning of oil and coal.



Ill. 9

Chicago, Reliance Building: The restoration of the exterior façade was completed in November of 1995. Remaining to be restored on the exterior are the storefronts which are now covered with a temporary aluminum curtain wall system. The storefronts will be restored along with the interior of the building in the phase-II-restoration set to begin in 1997.

A laboratory was established on site and various façade cleaning techniques were analyzed to determine the most gentle method of cleaning which would be effective. A cleaning process was selected which utilized the systematic use of mild basic and mild acidic washes that were separated by water rinsing. Once the cleaning process was selected, two large trial repair areas were performed on the façade and examined to verify expected results. The windows, of which there were two types, were inspected from the interior. The wood double hung windows were checked for functionality and areas of deterioration were recorded. An inventory was made of the fixed windows to determine the number of broken units and the relative condition of the cast iron mullion and rail system.

### Restoration of the Reliance Building

The first step in restoration was to clean the façades. Cleaning was performed during the night to protect pedestrian and vehicular traffic on the busy street below from exposure to the chemical cleaning compounds. After each drop was cleaned, it was inspected by the architect to assure the quality of the work. During the inspection, the alkalinity of the façade and run-off water was often measured using pH-paper to verify that the cleaned façade and surrounding site were left in a neutral state.

To address the stresses within the curtain wall, temporary horizontal expansion joints were saw-cut through the wall at each level. The joints were introduced continuously below floor line relief angles and at mortar joints starting

at the top level and working downward. The result was a graduated relaxation of stresses as the expansion joints were installed floor by floor. Once the expansion joints were completed and the stresses were relaxed, the joints were again filled with mortar to reinstate the original integrity of the curtain wall.<sup>15</sup> It was accepted that stresses will eventually reappear in the curtain wall, but it is believed that they will never reach the magnitude of the time before restoration.

Once the stresses were relaxed, restoration of the terra cotta curtain wall could proceed. Approximately 3,000 units were removed, 1,000 of these were conserved and reinstalled and 2,000 were replaced with newly fabricated terra cotta. With all replacements and re-installations, the wrought iron clamps were replaced with similar anchors of stainless steel. In addition, about 500 pieces were repaired in situ. Each unit of terra cotta was treated with extreme care and, when possible, terra cotta units were reused rather than replaced. Small chips and spalls in terra cotta that were unrelated to system pathologies were patched with mortar in the color of the terra cotta bisque and were molded to conform to the original shape of the unit. The patches were then coated with a breathable paint of the same color as the terra cotta glaze.

Due to the mortar joints that ranged from 1.5 to 3 mm in thickness, it was virtually impossible to fabricate new terra cotta units that would easily fit within the existing openings. The contractor was uncomfortable with altering any of the terra cotta prior to installation due to their unfamiliarity with this archaic building material and the high cost of each unit. Therefore, a shop was established at the build-

Ill. 10

Chicago, view of the east elevation of the Reliance Building after restoration. The planes in which the glass are located and the meeting rails of double-hung windows replicate the originals precisely. The aluminum frame introduced around the fixed glass is undetectable. The appearance of the glass itself, however, became the most important issue during the project. Though the flatness of the annealed glass matches the original cast glass rather closely, the new insulated glass units reflect a double image making the overall reflectance not as clear as the original (right side).

ing to cut terra cotta when this process was required. This shop was administered by the architect and the terra cotta fabricator. Mortar removal for repointing was first attempted using hand tools and hand techniques. It was determined that power cutting tools would cause much less damage than traditional hand techniques. This illustrates the need to consider machine techniques – those that would otherwise be considered undesirable – on heritage structures when these structures are themselves the result of the machine age. The building was repointed with a low strength mortar mix composed of one part portland cement, one part lime, and six parts sand.

The window systems are laid out with fixed panes of glass flanked by wood double-hung operating windows – a configuration known as “Chicago Style” windows. It was decided that all windows, fixed and double-hung, would be replaced with replica windows, but their replacement posed several challenges. The fixed panes of glass were set on a continuous wood setting block and were captured in the cast iron mullion and rail system with wood stops. This system, though avant-garde for the late nineteenth century, did not meet minimum glazing standards for such large panes of glass on a tall building. All the original glass that had become aged and brittle was cast, ground, and polished – a process that had been completely supplanted at the beginning of the twentieth century by the float glass process. Consequently, glaziers were not willing to place any guarantee on the use of the original cast iron gridwork or existing glass. In addition, a source for the replacement of broken or missing original glass replacement with exact replicas was no longer available. The wood double-hung windows had exceedingly thin meeting rails that no window manufacturer was willing to replicate.

To simulate the appearance of the original glass, a glass fabricator was located who was willing to provide insulated glass units of the size required constructed with annealed but untempered glass. The tempering process, though making the glass much stronger, would also introduce unacceptable warping into the glass. A special aluminum frame was designed to sit within the cast iron frame while being separated from the dissimilar metal with plastic shims. The aluminum frame provided the “bite” required by the glazing industry to hold the glass in place and the frame protrudes beyond the cast iron mullion by 3 to 5 mm making it invisible to the naked eye. The wood double hung windows were replaced by exact wood replicas which were not operable, and thus the meeting rail of the upper and lower sashes were fused to form a meeting rail of the specified size.

No portions of the original cornice remained and it was decided to consider substitute materials other than terra cotta for the cornice replacement. Cast aluminum that was painted was chosen as the best substitute material because of its durability. The new cornice was detailed so that it was separate from the façade so differing movement of dissimilar materials would not cause future distress on the building. The cornice was realized as a system of panels that were independently suspended from the frame support with joints to allow movement between adjacent panels and between panels and the terra cotta façade.

There is increased interest in the US in buildings of the Modern Movement that are now or will soon be considered for Landmark status. A re-evaluation of these examples of twentieth-century built heritage make us pause and reconsider their aesthetic and technical antecedents of the nineteenth century and what they mean in terms of preservation. As our newer buildings come to be defined in terms of heritage, the challenges faced with their preservation will become more complex and we must be willing to revise or question established approaches to meet these challenges.

- 1 Carl Condit, *The Chicago School of Architecture*, p. 111.
- 2 Frederick Baumann, p. 123.
- 3 New York, Chicago, and Minneapolis have all claimed to be the birthplace of the skyscraper. The question of whether the skyscraper originated in New York or Chicago remains a matter of controversy to this day. Comparative characteristics include the development of the curtain wall as well as the first use of the iron frame, appearance of the beam-column moment connection, height limits, and the theory of frame stiffness.
- 4 Upjohn, p. 53.
- 5 Stephen J. Kelley, *Assessment Techniques Utilized with Historic American Highrises*, in: “Structural Repair and Maintenance of Historic Buildings”, p. 63.
- 6 *Ibid.*, p. 63.
- 7 Schulze, p. 96-97.
- 8 “Reliance Building,” p. 2.
- 9 *Ibid.*, p. 3-4.
- 10 *Ibid.*, p. 4.
- 11 Carl Condit, *American Building Art. The Nineteenth Century*, p. 61.
- 12 *Ibid.*, p. 60.
- 13 Stephen Kelley and T. Gunny Harboe, p. V-80.
- 14 An HSR is a document commonly prepared for a building structure or group of buildings of recognized significance in the US to record and analyze the property’s initial construction, and subsequent alterations through historical physical and pictorial evidence. It documents the performance and condition of the buildings architectural materials and overall structural stability, identifies the appropriate course of treatment and documents the alterations made through that treatment. The HSR for the Reliance Building was authored by T. Gunny Harboe of McClier.
- 15 A contemporary curtain wall features a means at the floor levels to transfer the wall loads into the structure. The Reliance Building curtain wall, however, was a transitional curtain wall. That is, the means of transfer was located in most, but not all areas. It was decided that, as a philosophical approach, the façade would not be altered to make it behave as a contemporary curtain wall, thereby respecting the original technical features of the curtain wall as defined by its period in history.

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