RRJ INSIGHT™

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**"Insight: to see into and understand; an item of knowledge gained by this power."**

In this issue of *RRJ Insight* we review the structural restoration of the Delaware Building, a Chicago Landmark. During its 132 year life, numerous owner modifications including holes cut in bearing walls and installation of thick concrete floor toppings led to structural failure of main elements. The *Project Profile* article discusses some of the engineering challenges encountered and design solutions utilized. In the *Tech Tip* article, we look more closely at considerations of repairing building settlement from the initial assessment to the final solution.

*INSIDE*



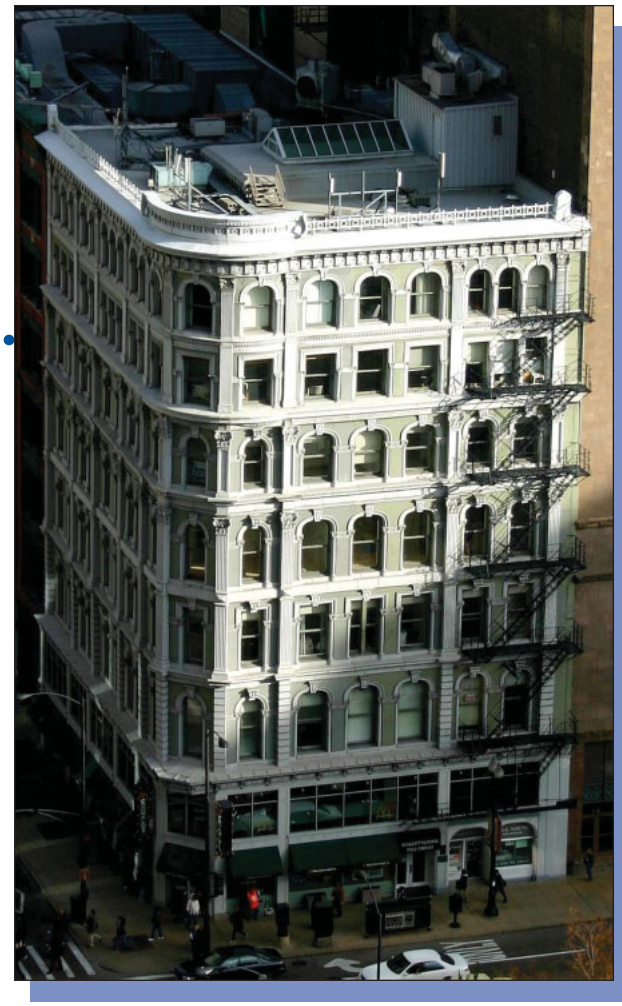

*Figure 1 — The Delaware Building in Chicago, Illinois.*

# Project Profile

## Structural Restoration of a Historic Chicago Landmark

The Delaware Building in Chicago, Illinois was constructed shortly after the Great Chicago Fire of 1872. It is currently one of the oldest buildings in the Chicago Loop. Designed in the *Italianate* style of Architecture by the firm of Wheelock and Thomas, the original building was constructed as a six-story structure clad with one of the earliest uses of precast concrete facade construction. The lowest two floors were clad with ornamental cast iron and glass. The building was structurally supported by brick masonry bearing walls and timber floor joists. Masonry walls divide the interior building space into isolated cells to improve fire-resistance as well as provide structural support.

In 1889, two additional floors were added along with a dramatic steel-framed atrium. The facades of the added floors were clad with sheet metal shaped to replicate the original precast construction. Existing masonry walls were removed at the fifth and sixth floors to allow the existing fourth floor walls to support a new metal column and beam skeletal framing system. The building was designated a Chicago Landmark on November 23, 1983.

Over time, various owners and tenants knocked large holes through the third and fourth floor masonry bearing walls to install doors and mechanical ductwork. Old, abandoned door openings were sometimes concealed by drywall such that their presence may have been undetected at the time new adjacent wall openings were made. The once solid bearing walls were weakened over time as they took on the appearance of "Swiss cheese." During earlier building restoration work, sagging timber floors were also leveled with a thick concrete topping, which added significant weight to the structure.

The building was recently purchased by an owner who retained RRJ to investigate the cause of bowing door jambs and sagging floors. At the time of our involvement, no original construction drawings existed, the means of structural support was unknown, and all structural elements were concealed by plaster and drywall finishes. As part of our investigation, we performed floor level surveys and made exploratory openings at locations of excessive deflection. We found that the lower masonry bearing walls supporting the metal column and beam structure above had failed, resulting in about 2 inches of downward, full-height building movement at one location. Level surveys at each floor were important in identifying the problem because the interior finish damage that would normally be expected to accompany this type of building movement was not present due to previous repairs by past owners/tenants. RRJ also found that sagging timber floor joists were split and cracked at certain locations due, in part, to the heavy concrete topping slab that was placed by past owners over the original hardwood floors.

*Figure 2 – Timber floor joist repair.*

RRJ designed a substantial emergency shoring system consisting of needle beams and high-capacity shoring posts to temporarily reestablish load paths for supporting the building self-weight. After the bearing walls were temporarily stabilized, RRJ designed repairs consisting of structural steel frames and brick masonry that were installed in a specific construction sequence to restore the bearing wall load-carrying capacity, while accommodating the existing door and mechanical ductwork openings. RRJ further recommended that all concrete topping slabs be removed to minimize floor overload conditions. Upward jacking of the structure was not considered feasible due to the potential for significant damage to the masonry and plaster walls. Through each step of the repair process, RRJ worked closely with the repair contractor to ensure that the building was adequately supported.

One of the difficulties encountered when designing the repairs was a restriction on the lengths of building materials that could be brought into the building. This restriction became challenging in repairing certain long-span timber joists that were damaged as a consequence of excessive floor loads. In designing the repairs, RRJ took advantage of a high ceiling plenum space between a newer acoustic tile ceiling and the original plaster ceiling soffit fastened to the underside of the timber joists. Sagging floor areas were strengthened by supplementing existing joists with new plywood web and sawn lumber bottom chord members designed to act compositely with the existing floor joists as top chord members. (Figure 2) The strengthened timber joists were enclosed with fire-rated sheathing to meet building code requirements.

*– David Tigue, P.E., S.E.*

# Tech Tip

## Building Settlement Repair Considerations

Settlement-induced movement due to loss of vertical structural support elements such as bearing walls, columns, or foundations is a serious concern that often requires experienced engineering judgement and evaluations pertaining to building occupancy, emergency stabilization, monitoring, and repair techniques. RRJ is often involved in the structural evaluation and repair of buildings where existing vertical load-carrying elements are unknowingly compromised by renovation work, or by settlement resulting from neighboring property construction involving excavations in close proximity to the foundations of existing buildings.

An initial, expedient assessment must be made when first arriving to investigate settlement damage to determine the seriousness of the problem, the suitability of the structure for occupancy, and the need for emergency stabilization. An assessment should include not only a review of the obvious damaged vertical load-carrying components, but additionally, an assessment of possible alternate load paths at other parts of the building that may now be providing unintended structural support as a consequence of the damage.

*Figure 3 — Needle beams supporting five-story structure during foundation repairs.*

When specifying temporary shoring and bracing stabilization techniques, consideration should be given to future repair requirements. Once shoring is installed, it must generally remain in place until repairs are complete. Consequently, the shoring must not interfere with the demolition and reconstruction of damaged elements. Past repair experience is beneficial in determining suitable shoring methods. Common techniques include the use of proprietary shoring systems, needle beams, (Figure 3) or cribbing. Shoring may be required not only at locations of damaged vertical support components, but also at other building elements, such as floor joists, where movement may have resulted in the loss of bearing support. All shoring must be adequately braced to prevent lateral buckling and resist incidental contact or possible wind, earth, and other forces to which the shoring may be subjected.

Level surveys are typically performed as part of an evaluation, not only to determine the location and extent of existing building movement, but also to determine whether the building is continuing to move during the repair process. Follow-up surveys are performed at suitable time intervals such that corrective actions can be taken in a timely manner if continued movement is detected. Generally, closer time intervals are required at the beginning of the stabilization process, and at less-frequent time intervals once stabilization techniques are judged effective.

As part of a repair program, an assessment is made to determine the need for restoring the building structure to its original elevation. On certain projects, RRJ has specified hydraulic jacking as a means for raising the building to its original position. (Figure 4) The suitability of jacking as an effective repair technique depends on the type of construction and the nature of damage. Structures that have formed hinged planes of deformation during settlement, such as with steel construction, can generally be repaired with jacking techniques. Structures clad with masonry must be assessed to determine whether the cracked and open brick joints will close without impediment from damaged mortar and foreign material within the joints.

*Figure 4 — Hydraulic jacking of structure from newly-placed concrete foundation.*

Brickwork that is crushed and extensively cracked cannot be jacked upward without risking further damage. When utilized, jacking should be performed in defined increments with an assessment of the structure's response at each step.

When the settlement is not significant or discernable from the exterior, it may be economical to level interior floors by using sleepers or leveling mortars. Consideration should be given to the weight of these materials and to transition areas at doors and interfaces with undamaged building components.

After permanent repairs of vertical structural support members or foundations are complete, repairs of other structural components are generally straightforward. Repairs should ensure that all structural components affected by building movement are properly re-supported or reconstructed to serve their intended function. Finally, repairs to interior and exterior finishes may require re-hanging doors and re-setting windows to plumb and square conditions in addition to repair of ceiling, floor, and wall finishes.

*– David B. Tigue, P.E., S.E.*