Raised in Manhattan

Using built-up girders to temporarily transfer column loads enabled conversion of an old low-rise warehouse into a swank high-rise hotel.

BY JOSH A. GREGG, P.E., AND FRANK DEJOSE

IN ORDER TO ACCOMMODATE a 16-story addition to an existing 12-story steel-framed warehouse and the conversion of the entire building into an upscale hotel, the designers needed to first upgrade the structure's foundation.

Further complicating the project was its Manhattan location, which resulted in severe site constraints.

The solution was to transfer the loads from four of the building's interior columns to four adjacent columns, temporarily jack up the interior columns, remove the existing foundation, and install a new foundation and core. But as can be expected, the details proved complex.

The antiquated 12-story brick clad steel-framed warehouse at 150 Lafayette Street, New York, rests between the cusp of the non-stop, hustle-bustle attitude of the historical Chinatown district and the trendy, eclectic epicenter of cool that is SoHo (named for its location South of Houston Street). The 150 Lafayette Street building, constructed in 1911, also happens to sit atop the city's oldest functioning subway line. The location is a developer's dream, the existing conditions and constraints a designer's labyrinth.

Most of the warehouse's original steel framing remained in place for the new, taller, repurposed structure. Some concrete floor slabs were removed before raising the superstructure to lighten the dead load and facilitate the foundation upgrade.

City zoning rules and regulations allow for an existing building to have its height increased, but to obtain this height increase an existing structure cannot be fully demolished and the original total floor area ratio must remain the same. Thus, to maximize the building height a resizing and reconfiguring of this warehouse's existing floor plate dimensions were required to transform the existing 12-story warehouse into a 28-story luxury boutique hotel. But that was only a small challenge.

With an architectural design scheme on paper, a New York City Department of Buildings zoning permit approval for the height increase, and the developer eagerly awaiting this transformation to begin, one major aspect was missing: a plan for how this architectural scheme could be brought from the design documents to the real life SoHo neighborhood.

The transformation of this warehouse into a new, twice as tall, hot spot hotel raised many challenges for the structural engineer. The existing warehouse layout was not designed to receive the increased load of the additional 16 stories. Increasing the height of the building required existing columns to be reinforced, the foundation system to be analyzed for the additional loads imposed, and the installation of a structural elevator core to serve and stabilize the transformed 28-story tower.

Increased lateral support for the original portion of the structure was provided by a new concrete elevator core. However, new steel framing elements provide the above lateral support for the original roof.

Adding 16 floors to convert a boxed-in old 12-story warehouse into a high-end hotel required a serious foundation upgrade, even though using steel for the vertical expansion kept the additional loads to a minimum.

Josh A. Gregg, P.E., is a project manager at DeSimone Consulting Engineers and an AISC Professional Member. He has more than 10 years experience in the design and construction field on a variety of both domestic and international projects. His experience has been focused around high-rise steel and concrete construction. Frank DeJose is currently pursuing his master of science in civil engineering at the University of South Florida. He previously was with DeSimone Consulting Engineers where he was the project engineer on this project.

▲ One of four 44-in.-deep, 50-ksi built-up steel plate girders with 3½-in.-thick flanges being lowered into the basement. The girders transferred column loads of as much as 900 kips and facilitated a foundation replacement under existing columns.

◄ Steel bearing pedestals ensured the redistributed and transferred loads were properly induced into the outer columns and footing system.

The new hotel design scheme posed other challenges as well, but the most demanding was the installation of the new structural elevator core, which would serve the hotel from the existing cellar floor level to the 28th floor penthouse suite. To set the structural core in place required the installation of a new 7-ft-thick foundation mat. For the foundation mat and structural core to be set, portions of the existing building's strip footing foundation system had to be severed, demolished, and removed to allow the new elevators to extend further below grade and through the existing footing supports. That required undermining the existing strip footings, but undermining the foundation system would create an unstable condition and allow for a possible building collapse. Needless to say, that would be the last thing a fully functioning neighborhood needed.

A plan was required that would keep the building stable and support the remaining structural elements while the foundations were undermined and reconstructed. Such a design scheme required that the column/footing loads be relieved to allow for the demolition, removal and exposure of the below grade soil. Once those processes were completed, the new foundation mat and elevator core could be prepared and placed.

With budget, schedule, and safety in mind, designers analyzed two viable design options. The first option called for an auger cast-in-place pile system that would surround the four problematic columns at the new elevator core location. That meant drilling 12-in.-diameter piles through the existing concrete strip footings to create a temporary pile group at the four elevator columns that would provide the needed temporary support during the foundation upgrade. However, lack of space, poor soil conditions and the existing heavily reinforced footings rendered this option unconstructible.

The second option consisted of redistributing and transferring the four problematic elevator column loads to their respective adjacent columns. For this scheme to be successfully implemented, the existing structure would be "stripped" of approximately 50% of its original superimposed dead load and 95% of its live load, allowing the redistribution and transfer of loads to the outer adjacent columns without the existing structural system being overstressed.

With a concept in place, it was time to determine how to make it work. The first step in configuring the column transfer process was to establish the current loads being supported by the four problematic inner columns at the new elevator core location. Analysis showed that they were supporting approximately 350,000 lb (350 kips or 175 tons) of structural dead and live load.

The idea was to transfer each column load to a girder which by jacking would redistribute that load to adjacent outer columns and their respective undisturbed strip foot-

◄ The jacking process required four 150-ton hydraulic jacks for each steel collar and raised each of the four inner columns approximately 3⁄16 in.

After the jacking process relieved the load on the interior columns, the existing foundation in that area was demolished and replaced with a larger, deeper mat foundation.

ings below. In total, eight columns were needed for this redistribution and load transfer process.

Two design challenges remained: the transfer girders and their bearings at the outer existing columns. Due to the load, the support point locations and the overall member length required, steel wide-flange girders were the most feasible and economical to design. A standard wide-flange member able to sustain the desired loading did not exist, so four 44-in.-deep 50 ksi built-up steel plate girders with 3½-in.-thick flanges were designed. The built-up girders were 65 ft long, weighing approximately 17-tons (34,000 lb or 34 kips) each. An intricately detailed built-up steel collar assembly at each of the four inner columns connected them to the new built-up steel transfer girders.

The jacking would transfer as much as 800 to 900 kips to the outer supports. Steel bearing pedestals were designed to ensure the redistributed and transferred loads were properly induced into the outer columns and footing system. A 12-ton assembly of steel beams, posts, braces and a roller assembly for the transfer beams to bear on was designed and fabricated for each outer column.

The jacking process required four 150-ton hydraulic jacks for each steel collar; for a total of 16 jacks. During the process, each of the four inner columns was raised approximately 3⁄16 in. upward and the transfer girders each deflected ¾ in. downward.

Having the four inner elevator core columns jacked and the load redistributed to the four outer columns and footings, the required demolition and removal process was able to commence below the elevated built-up members. That consisted of removing the existing strip footings and the below-grade soil. Upon completion of the demolition and removal process, the area had a new concrete foundation installed. After a suitable time, the existing four inner columns at the elevator core were lowered and the loads transferred back to the desired foundation elements.

After completion of the substructure foundation system, a new lateral system needed to be established that would perform adequately under significantly increased seismic and wind loads. This lateral system consists of a new concrete shear wall surrounding the elevator core and steel outriggers, both of which extend up to the original roof elevation at the 13th floor level.

Numerous standard steel shapes were installed throughout the existing lower levels to establish new façade edges and infill existing slab openings. A structural system consisting of standard wide-flange beams and girders supporting lightweight concrete over metal deck floor system was chosen to limit the overall dead load of the new construction above the previous roof level.

To create the most direct load path, all new columns were aligned with the existing column grid below. Elements of the new lateral system, which consists of steel braced frames and

Installing large transfer girders allowed portions of the existing building's strip footing foundation system to be severed, demolished, and removed to allow the new elevators to extend further below grade and through the existing footing supports.

moment frames, were embedded within the new concrete core below.

The 150 Lafayette Street building, an early 20th century 12-story steel framed warehouse, has been transformed into an early 21st century 28-story steel-framed boutique hotel, another example of the challenges architects, engineers, and developers face in New York City. However, it also shows the lengths to which a design team must sometimes go to when introducing new building designs into fully functioning neighborhoods. The project will be completed in early 2011. MSC

Owner
Cape Advisors, Inc. New York

Architect
H. Thomas O'Hara Architects, PLLC, New York

Structural Engineer
DeSimone Consulting Engineers, New York

General Contractor
Gotham Construction Corporation, New York

Fabricator
Sure Iron Works, Brooklyn, N.Y. (AISC Member)

The new 7-ft-thick mat foundation for the elevator core, constructed under the transfer beams, prior to infill placement. Once complete the column loads were transferred to the new foundation.

Transition from the existing columns to where new columns for the upward expansion would be connected, above the original structure's roof.