Making More of a Good Thing

BY JEANNETTE M. PFEIFFER, P.E., S.E., LEED AP

Expanding aquarium facilities the Chicago way—by going up.

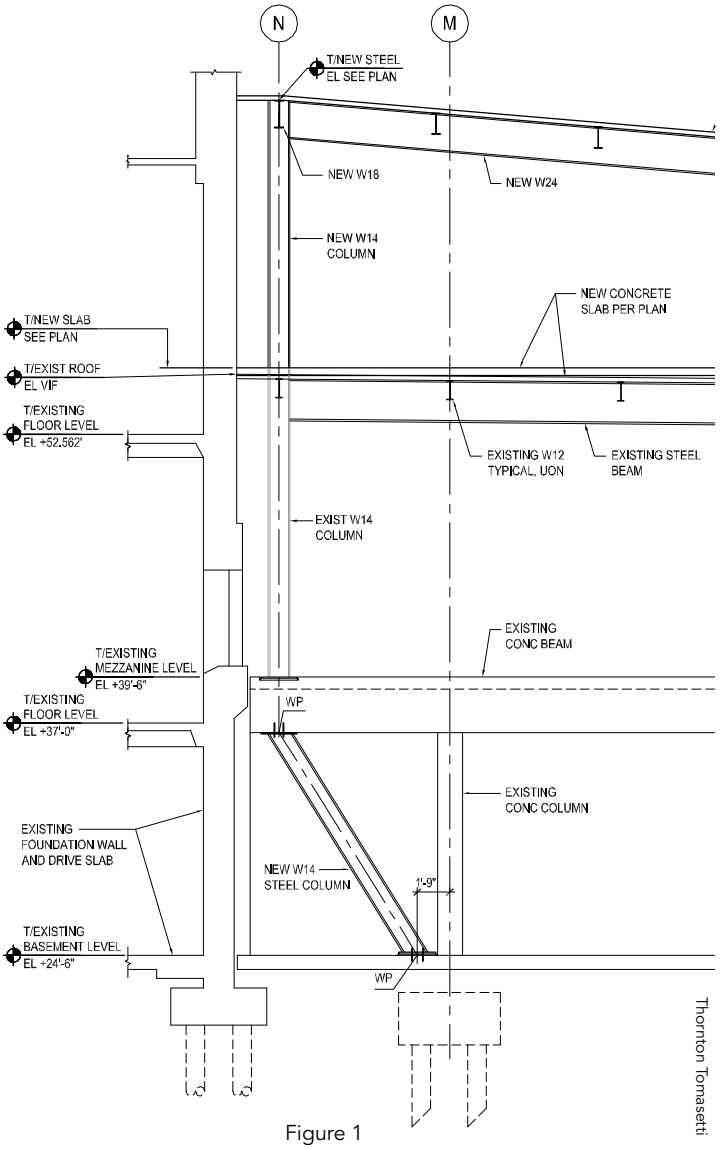


Figure 1

WHEN AN OWNER WANTS TO EXPAND ON A VERY limited site, without increasing the structure's footprint, the obvious choices are to either go down or go up. For the John G. Shedd Aquarium, located in Chicago on a spit of land jutting out into Lake Michigan, that meant adding usable space on the largest available area around—the expansive roof of the aquarium's salt-water habitat, the Oceanarium (see sidebar).

The design for the first phase of the aquarium's Oceanarium Renovation project kicked off in the fall of 2007. The first phase consisted of providing 24,000 sq. ft of new office space above the existing Oceanarium roof for the aquarium staff. The second phase of the project included major changes to the large animal habitat pools in the Oceanarium.

For years the staff had been crowded into the basement and sub-basement of the Oceanarium and aquarium. Adding new space above the existing roof would provide open offices and conference rooms.

The first phase also included renovations to all levels at the north end of the Oceanarium, consisting of the existing food service areas. The updates to this space included making accommodations for the use of the aquarium for events and adding an outdoor terrace on the lakefront with an exceptional view of the Chicago skyline. To accommodate the fast-paced design and construction schedule, a steel package was issued early in the design phase, just after the contractor was selected.

The primary design consideration for the renovation was coordination with the existing structure. Because the new office space sits on the existing roof, the change in loading requirements required careful review. Where it was possible, new columns were located directly above the existing columns; however due to field issues some columns had to be eccentrically located with respect to the existing columns. Those columns required an analysis of the existing concrete and steel columns.

The radial grid with more than 100 unique columns, multiple partial levels, and column sizes changing from level to level made the column load takedown a challenge. Several concrete columns were reinforced with steel channels to support the new loads. The existing steel columns on N line were supported on beams at the mezzanine level. When analyzing these existing beams with the additional office loading, they were found to be insufficient. Therefore new sloping columns were added from the mezzanine level to the basement level to transfer the load from the columns on N line to the existing foundation at M line (see Fig. 1).

A New Aquarium on the Third Coast

The John G. Shedd Aquarium in Chicago, Ill., was originally built in 1927 with Mr. Shedd's idea of, "build it and they will come." The only other similar exhibit in Chicago at that time was the freshwater fish collection at the Lincoln Park Zoo. Graham, Anderson, Probst & White, the architectural firm that designed Shedd Aquarium, also designed many notable Chicago structures including the Field Museum, Union Station, Museum of Science and Industry, the Civic Opera Building, Wrigley Building, Strauss Building (topped by the blue beehive), and the Merchandise Mart.

During the aquarium's construction, 20 railroad tank cars made eight round trips between Key West, Fla., and Chicago to deliver one million gallons of seawater for Shedd's marine exhibits. The aquarium is enjoyed by two million people annually and is one of Chicago's greatest attractions.

The Oceanarium was constructed in 1987 on an additional 1.8 acres of lakefill and became home to beluga whales, sea otters, Pacific white-sided dolphins and penguins. When the Oceanarium opened in 1991, it nearly doubled the size of the original aquarium, and is one of the world's largest indoor marine mammal habitats.

photos by John G. Shedd Aquarium

When the Shedd Aquarium officially opened in 1930, it was the first inland aquarium to have a permanent saltwater collection and housed the greatest variety of sea life under one roof. The 1987-1991 addition of the Oceanarium along the aquarium's lake side nearly doubled its size.

Thornton Tomasetti

Photo 1: Adding steel grillage under the existing concrete roof structure provided additional capacity for the new floor above.

Thornton Tomasetti

Photo 2: The low-rise addition atop the Oceanarium nonetheless adds a significant new wind load to the structure.

The existing Oceanarium roof has two distinct structural systems. At the north and south end of the building the structure is concrete beams and columns. The center area, shown in Figure 1, consists of concrete beams and columns below the mezzanine level between grids N and F; above the mezzanine the framing structure is steel beams and columns. To the right of grid F the roof system is steel trusses spanning the Oceanarium amphitheater.

At the existing concrete roof on the north end of the building, a grillage of steel beams was added below the roof structure to provide additional capacity for the new floor (see photo 1). The grillage works in combination with the existing framing and helps to support the heavier loading requirements. In addition, the grillage is located to take advantage of the stronger existing members and supplement the weaker members.

In the center area, where the existing roof is steel beams and steel deck, steel headed studs were welded to the beam through the existing deck and along with a concrete topping created a composite steel system. Analyzing and detailing the existing steel for composite beam design achieved the required capacity for office loading. The option of reinforcing from below was reviewed, but was not possible due to mechanical constraints. It was important that the existing roof remained in place to allow operation of the facility below while this new level was being constructed.

Jeannette M. Pfeiffer, P.E., S.E., LEED AP is a senior project engineer in the Chicago office of Thornton Tomasetti, Inc. She has been with the firm for four years.

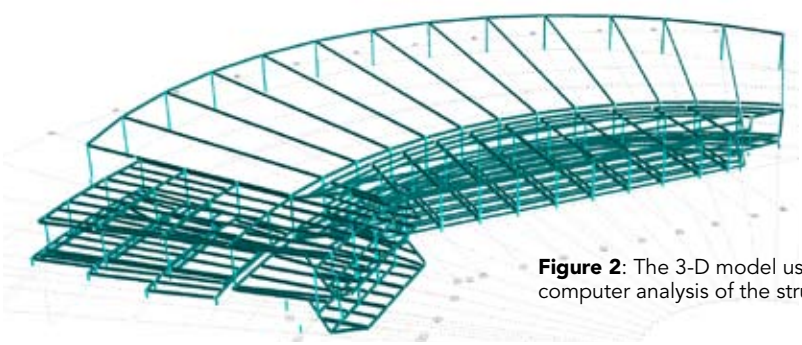
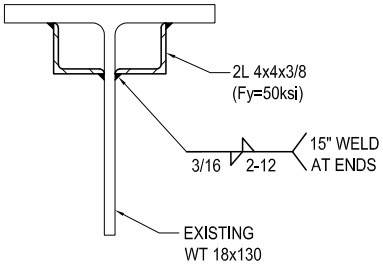


Figure 2: The 3-D model used for the computer analysis of the structure.



photos this page by: Thornton Tomasetti

Photo & Figure 3: Adding office space atop what was previously the roof required reinforcing the existing steel roof trusses.

The last challenge was transferring the wind loads from the new curtain wall down through the building to the existing foundations (see photo 2, previous page). The existing lateral force resisting system is a combination of steel trusses and concrete moment frames. A 3D analysis of the existing system determined that there was no reserve capacity for the new wind load (see Fig. 2). To resist the increased wind load, existing masonry walls were reinforced and steel braced frames were added within the building.

Truss Reinforcement

The Oceanarium amphitheater was designed for multi-species marine mammal shows with theater lights and sound. Design issues for the amphitheater revolved around the existing roof structure composed of steel roof trusses spanning more than 160 ft supported by steel columns. During the design phase it was determined that the trusses were performing at capacity and could not accommodate additional loads.

In addition to the amphitheater loads, the trusses were to be used as supports during construction. In lieu of scaffolding spanning from the bottom of the pool to the roof structure, the contractor selected a moving platform supported by the trusses to work in reinforcing the trusses and providing necessary mechanical upgrades in the roof space. Welding steel angles to the existing steel WT top and bottom chords provided the additional capacity required for the temporary condition and the new final condition. Figure 3 and photo 3 show an example of the steel angle added to the existing truss top chord. Angles were also added to select angle web members.

Construction began in the summer of 2008 for the new offices while much of Shedd Aquarium remained open to the public. Work was completed by the following Memorial Day weekend and Shedd Aquarium was again fully open to the public. Shedd is currently pursuing LEED certification. While the goal of the renovation was pool maintenance and upgrades, the animals were the primary design consideration; from accommodating their behaviors, to their weights and the support facilities that are required to feed and house these great animals! MSC

Owner
John G. Shedd Aquarium, Chicago

Architect
Valerio Dewalt Train Associates, Inc., Chicago

Structural Engineer
Thornton Tomasetti, Chicago

Construction Manager
Walsh Construction, Chicago

Steel Fabricator and Detailer
K&K Ironworks, McCook, Ill. (AISC Member)