Trump International Tower and Hotel: A Deep Foundation in a Challenging Urban Site

Winner of the 2009 Outstanding Project Award
Chicago’s dense riverfront neighborhood site presented many challenges, including a restricted work schedule. Trump International Is OPA Winner

Standing 92 stories high and just over 1,362 ft tall, Chicago’s Trump International Hotel and Tower is perfectly positioned at the center of one of the world’s most impressive skylines. The Tower serves as a link between its famous predecessors, Willis Tower (formerly, the Sears Tower) to the south and the John Hancock Building to the north. Originally planned to be the world’s tallest building, the project was scaled back when the developers started questioning the need for super-tall buildings after the September 11, 2001 terrorist attacks. In its River North neighborhood, Trump Tower dominates the skyline as a symbol of Chicago’s last great building boom, standing triumphantly over other high-profile projects that have been postponed due to current economic realities.

It is often said that the three most important factors in real estate are location, location and location. This maxim was not forgotten by The Trump Organization when the site was selected for the International Hotel and Tower. Located two blocks west of Michigan Avenue and Chicago’s famed Magnificent Mile, the site is bound by the historic Wrigley Building to the east, Wabash Avenue to the north and west, and the Chicago River to the south. The building’s position along a bend in the Chicago River allows visitors and residents unobstructed views to the mouth of the Chicago River and Lake Michigan.

Site Challenges

Underneath the site there are approximately 10 to 20 ft of sand and urban fill underlain by soft Chicago blue clay. At 75 ft in depth, the soft clay transitions into Chicago hardpan, a very hard till that was consolidated by the glaciers over 10,000 years ago. Below the hardpan, the till turns granular with cobbles, boulders and water under pressure. Bedrock is about 100 ft below existing grade and has a weathered surface with fractures and clay seams. Unweathered limestone bedrock is sound and hard with unconfined compressive strengths of 10,000 to 20,000 psi.
Chicago's River North urban neighborhood presented many logistical challenges. First, due to the dense residential population, the city of Chicago limited allowable working hours between 8:00 a.m. to 8:00 p.m., Monday through Saturday, making the aggressive schedule even more daunting. Second, Trump Tower sits on the former location of the Chicago Sun-Times building that was demolished in 2004. To support the heavy loads imposed by printing presses and paper storage, the 1950s-era Chicago Sun-Times Building was supported by belled caissons. During its construction, the transition between hand-dug caissons and mechanically drilled caissons had begun, but was not yet complete. Owing to the lack of mechanical belling tools, these caissons were drilled to bearing elevations with powered equipment, then belled by hand labor to 15 ft diameter. Fifty years after their completion, some of these hand-dug bells presented constraints where they conflicted with 43 of the proposed Trump Tower rock caissons. The most severe of these conflicts meant that many hours had to be spent cutting with a 10 ft 6 in core bucket through a large portion of the existing bell. When the size of the equipment and required accuracy are considered, the difficulty of starting this operation on a 60° bell slope becomes clear.

**Project Scope**

In addition to Tower construction, the project included the complete demolition and reconstruction of the adjacent Wabash Avenue viaduct and the construction of a pedestrian plaza to connect the Tower to the city's River Walk and the Wrigley Building. The entire deep foundations system consists of the following:

- For the Wabash Avenue viaduct and pedestrian plaza, the foundation includes 170 caissons, 3 to 5 ft in diameter with 9 to 15 ft diameter bells bearing on Chicago hardpan approximately 80 ft below grade.

- At the Trump International Hotel and Tower, there are 35 permanently cased caissons, 4 to 9 ft in diameter with 10 ft rock sockets bearing approximately 120 ft below grade to support the building's perimeter. In addition, there are 22 permanently cased, 10-ft-diameter caissons with 10 to 20 ft deep rock sockets bearing approximately 120 ft below grade to support the building's core and having a capacity of approximately 40,000 kips. The latter are believed to be the highest-capacity single foundation elements in the U.S. The high bearing capacity required a caisson concrete strength of 10,000 psi.

**Testing**

The city of Chicago building code defines solid rock as sound unweathered rock without visible voids and having a minimum of 8 ft of rock below bearing level free of detrimental voids, seams or fissures. In order to accurately define the elevation of solid rock, AECOM (formerly, STS Consultants, LTD) performed preconstruction rock cores at each rock-socketed caisson location.

The rock caisson section of the Chicago building code includes a formula that allows for 100 tsf bearing capacity for drilling one foot into solid rock and a 25 tsf increase for each additional foot of embedment into solid rock to a maximum value of 200 tsf. To maximize design efficiency, a code variance was approved to increase the allowable bearing capacity to 250 tsf with confirmation testing by LoadTest on an 8-ft-diameter rock caisson. An Osterberg load cell on the bottom of the caissons was loaded to its maximum capacity of 750 tsf, and the engineers observed only negligible movement.

Eventual acceptance testing of the caissons included crosshole sonic logging, sonic impulse response testing and full depth cores required by the city.

Construction of each caisson supporting the Tower began with installing approximately 40 ft of oversized temporary surface casing placed through urban fill, sand and clay to the top of caisson elevation. Workers drilled an oversized open hole shaft down to about 80 ft below grade. Polymer slurry was added, and the shaft was flooded to offset water pressure within the granular soils overlaying the bedrock. The excavation was then completed under polymer slurry support to the top of rock, typically encountered approximately 100 ft below working grade. After the surface of the rock was cleaned and leveled, a full length design diameter permanent steel casing was rotated through the weathered rock and seated into solid rock.

![Osterberg load cell used at the site](image)
Case Foundation used Calweld 200 CH and Hughes CLLDH Titan drilling attachments to install the temporary casing, excavate through the overburden and place the permanent casing into rock. The Titan is the largest and most powerful drilling attachment in the Case fleet; due to its weight and torque, it was necessary to mount it on a Manitowoc 4100W crane.

Due to the limited space associated with working in a congested urban site with several trades, construction required a large service crane capable of reaching and lifting without having to track to each caisson location. A Manitowoc 999 (275 ton) hydraulic crawler crane with 180 ft of boom was used to handle the heavy loads of the temporary and permanent steel casings.

**Rock Sockets**

Historically, rock-socketed caisson projects in the city of Chicago required multiple shifts. Typically, a day shift would tackle excavating the overburden soil and setting full-length permanent steel casing to rock. The night shift would be responsible for excavating the rock socket, but a city ordinance prohibits night work in the site neighborhood. Case Foundation decided to invest in new technology to speed up the installation process to meet the aggressive schedule imposed by the construction manager, Bovis Lend Lease.
Case used downhole hammers housed in L.P. Drill canisters designed and manufactured by Center Rock, Inc. Percussion tools were designed and built for the project to drill the sockets with small-diameter downhole hammers housed in canisters of varying diameters. These cluster drills were configured as full-face pilot bits, along with donut-shaped openers that enlarged the pilot bores. The 10-ft rock caissons required 3 runs to cut the complete socket; 60-in pilot, followed by 90 in, then 114-in opening cuts. The hammer drills reduced the limestone to sand and small gravel-sized fragments, which were evacuated from the cutting face by direct air circulation. Using these tools required that the larger diameter rock sockets be excavated in steps. Working with a shaft permanently cased to rock, a 59-in-diameter conductor casing was centered and set to rock. Next, a 5 in L.P. Drill was used to excavate the initial pilot hole. Additional passes were then made to the final rock was encountered. In these few instances, workers used conventional core barrels and chisels to complete the rock socket. The air tools were supported and turned by a Hughes CLLDH SuperDuty drilling attachment mounted on a Manitowoc 3900W crawler crane with 190 ft of boom. Since the responsibility of this equipment was to only drill rock, it was set up with an 11 in x 140 ft single-air Kelly bar.

After workers completed the rock sockets, they placed reinforcing steel and concrete. To make these steps easier, the annular space between the overburden soils and permanent casing was pressure grouted. This measure greatly reduced the amount of water inflow penetrating the excavation at the soil and rock interface and allowed several caissons to be poured by free-fall methods. In certain cases where water inflow exceeded the allowable 5 GPM, the caissons were flooded and the concrete was placed by tremie method.

**Summary**

Working within the confines of a tight urban site with several other trades in one of Chicago’s most upscale neighborhoods, Case Foundation was able to beat the construction manager’s tight schedule and overcome city-imposed working restrictions by combining the best of the old technology with the best of the new technology. By combining 45-year-old Calweld and Hughes drilling attachments with state-of-the-art Manitowoc cranes and L.P. hammer drills, Case was able to install 230 caisson—comprising 16,000 cu yd of concrete and 2,400 tons of reinforcing steel—safely, on time and within budget.
OPA Winner: Construction along a busy stretch of the Chicago River