



## Geotechnical Engineering of the 600m Chicago Spire

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### Summary

The 600 meter high Chicago Spire, being developed by Shelbourne Development, is now under construction. Santiago Calatrava provided the architectural and engineering design, Thornton Tomasetti is the structural engineer of record, and STS is the geotechnical engineer of record for the project. The Chicago Spire has a very innovative structural system that is a true integration of architecture and engineering. While the project will be very well known as the tallest building in North America, it will also have the deepest basement in Chicago. The top-down method of construction will enable the tower construction to commence much earlier than the conventional bottom-up method. Because of the depth of the excavation and the proximity of adjacent structures, a significant analytical effort to predict and monitor ground movements is being conducted in concert with the construction.

**Key Words:** High rise; caissons; slurry wall; secant pile wall; geotechnical; instrumentation; top-down construction; finite element; performance modelling.

### Executive Summary

The Spire project site is located in the Streeterville neighbourhood of downtown Chicago, Illinois. The development is bordered by the Ogden slip on the north, the Chicago River on the south, and Lake Shore Drive on the east. East North Water Street bisects the site into north and south parcels. Private residential town homes are located along the west side of the north parcel, and a residential high rise tower with perimeter town homes is located on the west side of the south parcel. The Spire development includes a 600 m high tower with seven basement levels and an eight level below-grade parking garage. The tower will be located on the north parcel, and the parking garage will encompass the majority of the south parcel. The tower will be supported on a deep foundation system consisting of rock socketed caissons. The garage and podium will be supported on belled caissons bearing in hardpan soils.

The perimeter basement wall surrounding the tower and garage will consist of two systems. The west wall (along the town homes) and north wall (along the Ogden slip) will consist of secant piles reinforced with wide flange steel sections. The remaining east and south walls will consist of reinforced concrete slurry panels.

The garage will be constructed using top-down methods. The tower will be constructed using conventional bottom-up methods coincident with, or even in advance of garage construction. The excavation to construct the circular grade beam for the tower over the core caissons and the core mat will be supported using a temporary sheet pile cofferdam braced with reinforced concrete ring beams.



*Figure 1: The Chicago Spire as seen from Lake Michigan (image courtesy Shelbourne Development)*

Extensive field testing was performed to validate the strength parameters developed for the foundation design. Full scale Osterberg load tests were performed on production rock socketed caissons, and pressuremeter tests were performed on the hardpan foundation soil for the belled caissons.

A 2-dimensional finite element analysis of the top-down construction was performed using the commercial computer program Plaxis. This analysis was performed to estimate ground movement and assess the potential impact of the excavation on the public and private property in the vicinity of the project site.

Site instrumentation includes inclinometers, vertical and lateral survey points, tilt plates, strain gauges, and monitoring wells. The survey points were installed on all major structures (Lake Shore Drive bridge, existing seawalls, East North Water Street, adjacent town homes) surrounding the project site. Although the only activity on site (at the time of this paper) is foundation construction, more than 180 points are currently being surveyed in parallel by two independent firms. The 15 active inclinometers installed just outside the perimeter walls are read on a weekly basis.

Upon completion, the Chicago Spire will be a major structural and geotechnical engineering accomplishment. The Spire will be the tallest structure in North America with the deepest basement ever excavated in Chicago.