Innovative Foundations

Historic Niagara Falls Canal Lies Beneath New 26 Story Hotel

By Robert E. Stoller, P.E. S.E.

Located within a short walk from the world famous Niagara Falls, The Seneca Niagara Hotel & Casino opened in Niagara Falls, NY in December 2005. With 604 rooms and 700,000 square feet of space, it is the tallest and largest hotel in the Western New York Region. The hotel tower is 26 stories (370 feet) tall and has quickly become a dominant feature on the Niagara Falls skyline. Adjacent two and three story structures contain an expanded casino; a large, column-free Special Events Center; three restaurants; meeting rooms; a full service spa; and a swimming pool.

The hotel was developed for the Seneca Niagara Gaming Corporation and the Seneca Nation of Indians as an expansion of the Seneca Niagara Casino first opened on December 31, 2002. The original casino is housed in the former Niagara Falls Convention Center, a 1971 Philip Johnson and John Burgee design.

The new hotel is a world class facility. The sleek, steel framed structure with its 5 color glass façade and LED lighted features is a striking building that can be seen from miles away. Unseen by the public, however, is an innovative structural foundation and the building's underground tie to Niagara Falls history.

Underground History

Niagara Falls, NY is located adjacent to the Niagara River and at the brink of the Niagara Falls. The potential hydropower of the Falls was first recognized by Chambert Joncaire, Jr. in 1757. He constructed a short canal from the upper Niagara River to feed his sawmill. Other canals were constructed over the years to supply water to a variety of mills.

Work on a much larger canal was begun in 1853, when the Niagara Falls Hydraulic Power & Manufacturing Company was chartered. Construction of the Hydraulic Canal was completed in 1861 as a 35-foot wide by 8-foot deep canal that traversed much of the City of Niagara Falls. It was first used as a true generator of power in 1875, when water turned wheels in a new powerhouse. The canal was enlarged a number of times over the years until it became100 feet wide and up to 40 feet deep. After a rockslide destroyed the Schoellkopf power station in 1956, a newer and much larger hydroelectric plant was constructed to the north in Lewiston, NY by the Power Authority of the State of New York. When this Robert Moses Power Plant was completed in 1961, the Schoellkopf and a second Adams Station plant were decommissioned and the Hydraulic Canal was filled in.

Unique Foundation

The Seneca Niagara Hotel site is immediately adjacent to the east of the original Seneca Niagara Casino. The former Hydraulic Canal diagonally traverses through the center of the hotel site. Wendel Duchscherer, the project structural engineer, knew of its general location but could not locate any maps or surveys that would accurately locate it or describe its construction. Several test pits were dug to determine its exact location and the nature of any structures built along its length. The old Canal was found to run roughly diagonally through the center of the site beneath the elevator core. *Figure 1* indicates the location of the Canal on the site.

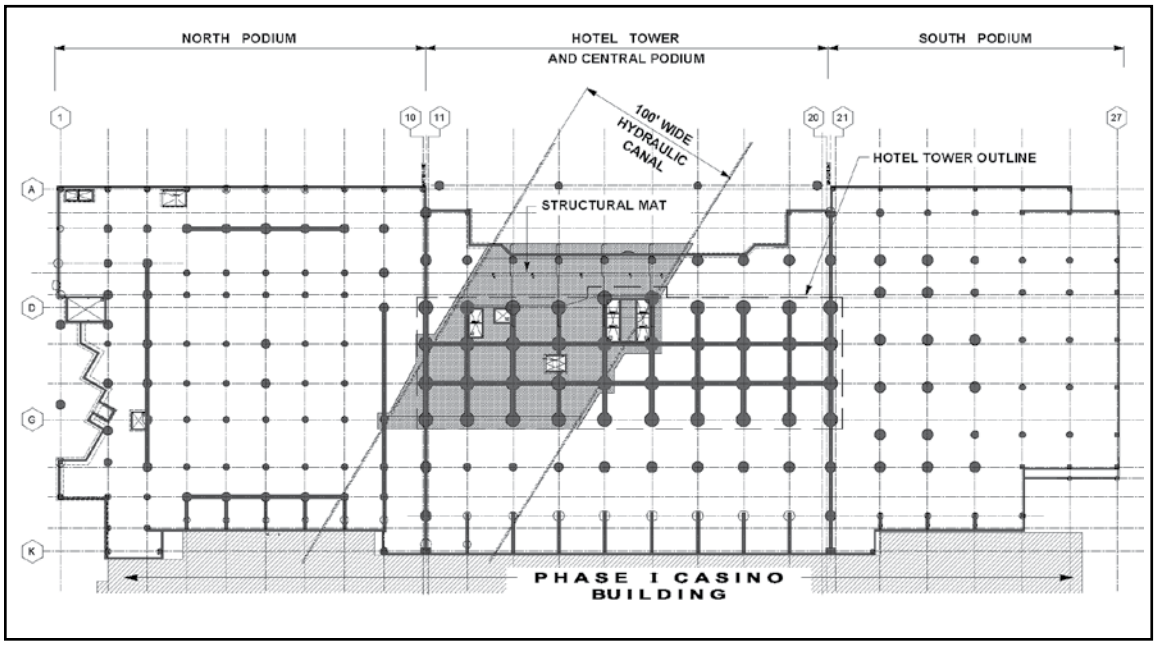

Figure 1: Overall foundation and drilled pier plan

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9-foot diameter drilled piers

Concrete gravity retaining walls up to several feet thick were found along the two edges of the Canal, a few feet below the existing grade. These concrete walls defined the edge of the Canal above the upper bedrock level.

A geotechnical investigation revealed that the site consists of 4 to 10 feet of fill and indigenous overburden overlying Dolostone bedrock. The surface bedrock was generally of a poorer quality containing soil filled voids, solution cavities and fractured zones. This poorer quality bedrock extended to a depth of about 5 feet.

Ledge cut into rock at canal edge. Note drilled pier straddling the edge.

The Hydraulic Canal had been constructed through the bedrock to a depth of about 40 feet. With the natural top of bedrock approximately 8 feet below the surface level, the old Canal construction had required the removal of about 32 feet of solid rock. Consequently, the bedrock quality at the bottom of the Canal was quite good.

The fill within the confines of the former Canal was very variable, with a high concentration of man-made components such as brick, cinders, glass, concrete, asphalt and rock boulders. It was definitely unsuitable to support a high rise structure with column loads of about 3000 kips. The geotechnical engineer recommended a drilled pier foundation with allowable end bearing pressures of 25 KSF at the bedrock surface, 60 KSF for piers socketed 5 feet into bedrock and 90 KSF for piers to the bottom of the Canal.

The design team decided that a conventional slab on grade was suitable for most of the site except for the area over the Canal. A structurally supported floor system was recommended over the Canal, due to the higher potential of settlement of the thick profile of unknown fill.

New York State had adopted the new IBC Building Code in January 2003. The Seneca Niagara Hotel was one of the first high rise buildings, and certainly the tallest in Upstate New York, to be designed under this much more stringent Code. The previous New York Code had no seismic design provisions.

The new Code determines a building Seismic Site Class based on the depth and composition of the top 100 feet of the site soil profile. The shallow depth to bedrock would classify the majority of the site as Seismic Site Class B. At the Canal, the greater depth to bedrock requires a Seismic Site Class C. This was a unique situation in that a man-made event, the construction of the Hydraulic Canal, had created such a sharply different soil profile. Given the dual Site Class, the entire Hotel Tower was designed using Site Class C. The adjacent low rise buildings were separated from the Tower by expansion joints and designed to the lower Site Class B requirements.

When determining the Seismic Site Class, the Code makes no distinction between a deep foundation supported through softer soils to rock versus a shallow foundation supported only on the softer soils. This is an area where research could provide future Codes with more guidance in distinguishing between the two situations.

The engineering solution for this building foundation is quite unique. All the tower columns are supported on drilled piers to bedrock. Nine foot diameter drilled piers are used to support the column loads of approximately 3000 kips. Over the canal, a structural mat was designed to support both the vertical loads above it and as a horizontal diaphragm to transfer lateral loads to the adjacent higher rock level. The mat is constructed at the same elevation as the adjacent natural rock level. It acts as a "rock substitute," so that the column base shears were all resisted at a common elevation. This is desirable for overall building performance. The mat supports the weight of the 8 feet of soil and concrete above it and transfers it to the drilled piers. The drilled piers carry these loads and the Hotel column loads to the high quality rock at the base of the Canal. A continuous ledge was cut into the rock along the Canal edge. The 24- to 30-inch thick concrete mat was supported and epoxy doweled to this rock edge. *Figure 2* is a schematic section of the foundation system.

40-foot deep drilled piers at Hydraulic Canal

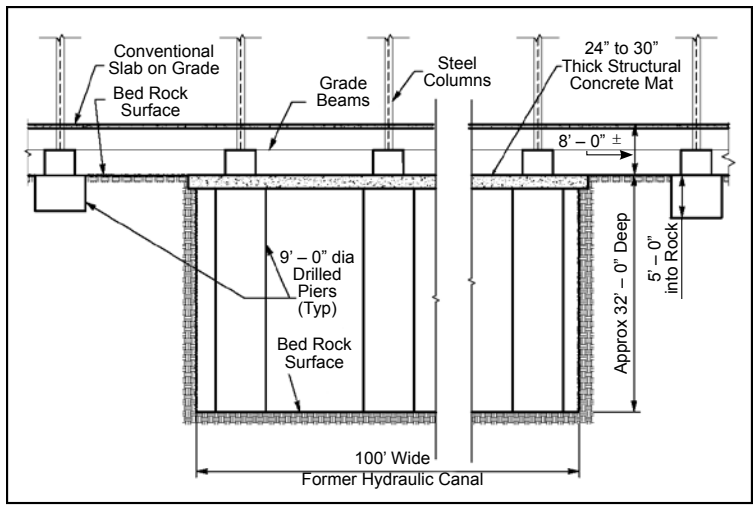

Figure 2: Schematic section of the foundation system

More typically, the structured slab is placed directly at grade level. Such a design would have many penetrations for elevator and escalator pits, underground pipes and electrical duct banks. Placing the mat 8 feet lower allowed all these elements to be constructed above the mat. This was especially desirable in this fast-tracked project, since many of these design elements were not finalized until much later. A conventional slab on grade was constructed above the Canal at the first floor. Its composition is identical to those areas not over the canal. The conventional slab on grade has the additional advantage that it can be removed and replaced, as needed, to accommodate any desired changes in underground services and utilities.

Structural mat and drilled piers over the Hydraulic Canal

Construction of the foundation was not without challenges. Murphy's Third Law of Geometry ensured that some of the major tower drilled piers would occur exactly on the edge of the old Canal. It required skill by the subcontractor to maintain a plumb pier while drilling a 9-foot diameter hole 40 feet deep, half in fill and half in solid rock. The concrete mat contained over 1200 cubic yard and was placed in two pours. A system of grade beams and pier caps was placed above the mat. The 2-inch diameter anchor bolts and block outs for the base plate shear keys were carefully set into the pier caps with templates. With base plates up to 7½ inches thick and columns up to W14 x 665, there was little room for error in accurately setting these elements.

Placing concrete in the mat

Once the mat was installed, the balance of the underground work went smoothly. The area above the Canal was treated exactly the same as the areas with the higher natural rock. No differential settlements have been observed between areas inside and outside the Canal.

Concrete grade beams and pier caps above structural mat

Summary

A unique foundation system was developed to deal with a unique foundation challenge — supporting a 26 story hotel on an abandoned historical Hydraulic Canal. The solution combined several common elements: drilled piers, structured slabs on grade, grade beams and pier caps in a new way. It allowed fast track construction to proceed before many of the underground utilities and services were designed.

Anchor bolts and shear keys set into pier cap

The Hotel has been a great success for the Seneca Nation. Niagara Falls, NY now has a first class hotel to accommodate tourists from around the world. The Canadian side of Niagara Falls has seen tremendous growth of casinos and hotels in recent years. The Seneca Niagara Hotel is expected to be the stimulus for additional economic growth on the New York side of the border.▪

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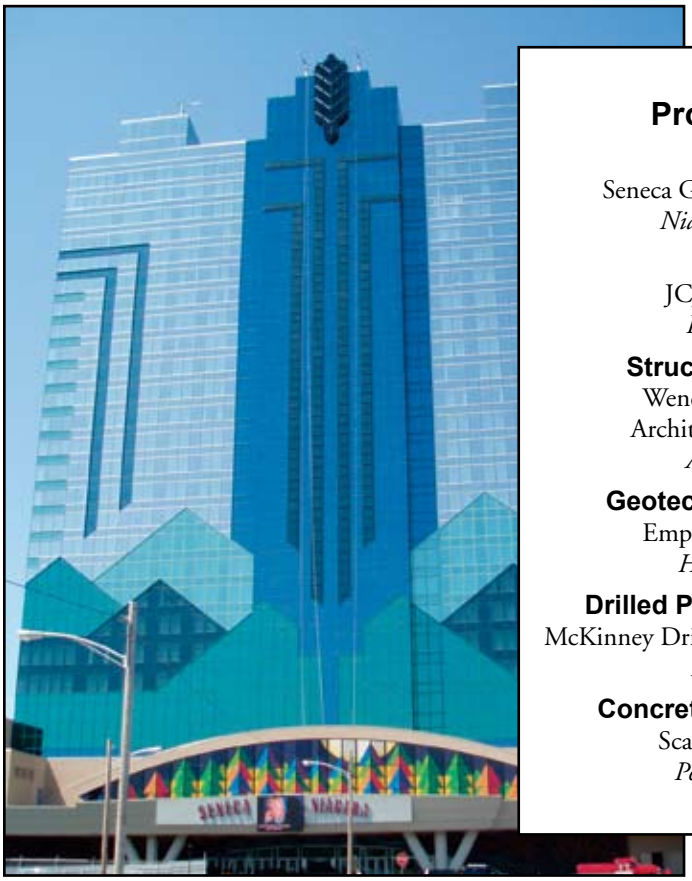

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