Proceedings of the Second International Conference on Press-in Engineering 2021, Kochi, Japan – Matsumoto et al (eds)

Repair of flood-damaged New York subway station with pressed-in sheet piles

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ABSTRACT: The New York subway's Canarsie Line tunnel was flooded by Hurricane Sandy in 2012. Although the emergency repair was completed soon after the storm damage, the tunnel's permanent repair is currently ongoing near the 1st Avenue Station in Manhattan. During the earlier part of the repair work, sheet pile walls were constructed for temporary earth retaining in a busy and relatively narrow street in the densely populated district. The sheet piles were pressed-in day and night to expedite construction without disturbing the area's residents or business owners, achieving substantial cost saving compared to the originally designed earth retaining with secant pile walls.

1 INTRODUCTION

Most of the current BMT Canarsie Line (also called L or 14th Street Line) of the New York subway system was completed back in the 1920's. It has been seeing increased ridership in recent years because of accelerating gentrification along the eastern side of the line in Brooklyn. In 2012 Hurricane Sandy flooded the Canarsie line's tunnel section from the East River west to the terminus in Manhattan. Although the line's train service was restored with temporary repairs soon after the storm, the agency fully suspended the train service in the flooded tunnel section for 18 months as part of the 46-month permanent repair work on its damaged tunnel, rail, and electrical systems on a design-build basis. Support of excavation for the tunnel repair and construction of a new entrance to the 1st Avenue Station was one of the early phases of the project. The support of excavation of a large area was built first to expedite the removal of the corroded and destroyed electric and steel components inside the Canarsie Tunnel before using the same excavated area to create a new entrance to the substation. See Figure 1 for the project's approximate location in New York City. With the site situated in a busy and relatively narrow street (East 14th Street) with a high-rise apartment complex on one side and a row of low-rise stores on the other side, construction noise and vibration needed to be significantly subdued. Further, the project's ground was composed of hard boulders mixed in sand underlain by a solid rock layer which limited the choice of earth retaining systems and usable construction equipment. See Figure 2 for general soil conditions with N-values along with the vertical location of the sheet pile wall installed.

2 ORIGINAL AND ALTERNATE DESIGNS OF EARTH RETAINIG STRUCTURES

A new entrance structure, an underground substation, and the associated underground utility rearrangement required extensive support of excavation. Although the selection of the shoring method was up to the contractor's preference, the contract documents suggested use of secant pile walls and/or soldier piles and lagging with jet grouting for water cut-off and closure. See Figure 3 for the suggested shoring plan for one of the structures (a new underground substation) to be constructed in the contract document. The lines of small overlapping circles indicate the locations of the secant pile walls with the hatched area to be jet grouted. Mueser Rutledge Consulting Engineers based in New York City was retained by the contractor (a joint venture between Judlau Contracting and TC Electric) for a more

DOI: 10.1201/9781003215226-54

Figure 1. Project location in New York City. (Base map from Wikipedia on "Boroughs of New York City").

economical shoring plan. Figures 4 and 5 show the alternate shoring plan prepared by the consultants for the underground substation with the sheet pile walls that would be built in lieu of the combination of secant pile walls, soldier piles and lagging, and jet grouting.

One of the key factors for selecting sheet piles as shoring members was to find a viable way to mitigate noise and vibration during their installation, considering the project location being so close to apartments and operating stores plus full of underground utilities. The consulting engineer chose the press-in piling method to satisfy this requirement (White et al. 2002). Figure 6 shows the part of the shoring specifications on the use of hydraulic pile jacking equipment ("Press-in Method") for the alternate design.

3 SHEET PILE INSTALLATION

Press-in piling started off in the fall of 2017 near the 1st Avenue Station on East 14th Street in Manhattan close to the East River. Figure 7 shows the F401-1400 model Silent Piler which installs a pair of Z-shaped sheet piles at a time. The contractor leased the piling machine from Giken America Corp. for the project. The piling work was safely conducted even at locations where the sheet piles were as close as about 1.5 meters to existing buildings and extremely close to sidewalks open to the pedestrian traffic (Figure 8). 14.0 meters long Z-shaped AZ40-

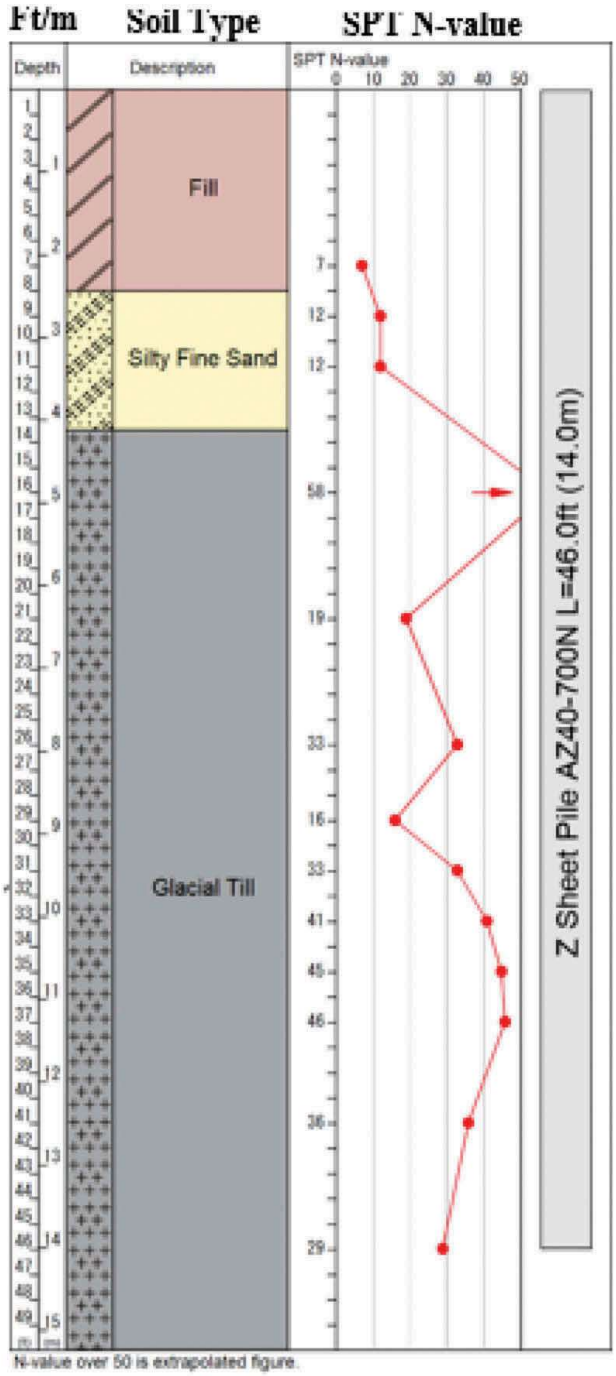

Figure 2. Typical soil conditions.

700N sheets were used for shoring the aforementioned substation construction while 10.7 meters long Z-shaped NZ20 sheets were used for other locations.

An auger attachment was used to install sheet piles through hard soil and obstructions. Some of the obstructions encountered consisted of concrete and some steel materials from foundations of old buildings that stood in the area from early on in the 20th

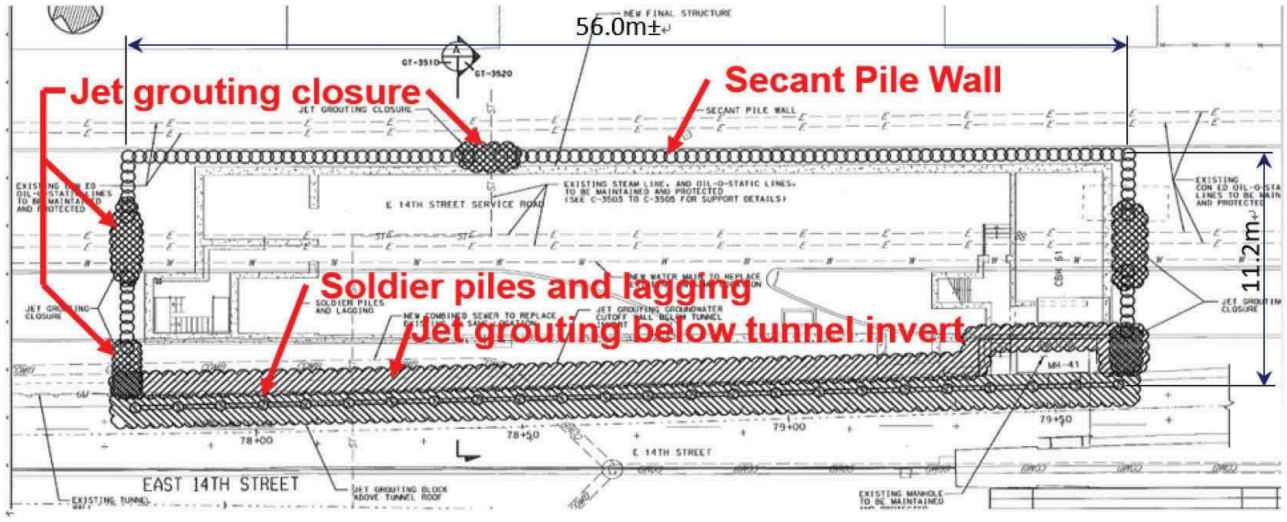

Figure 3. Original shoring design for Avenue B Substation (secant pile and soldier pile and lagging walls plus jet grouting, Courtesy: Judlau – TC Electric JV).

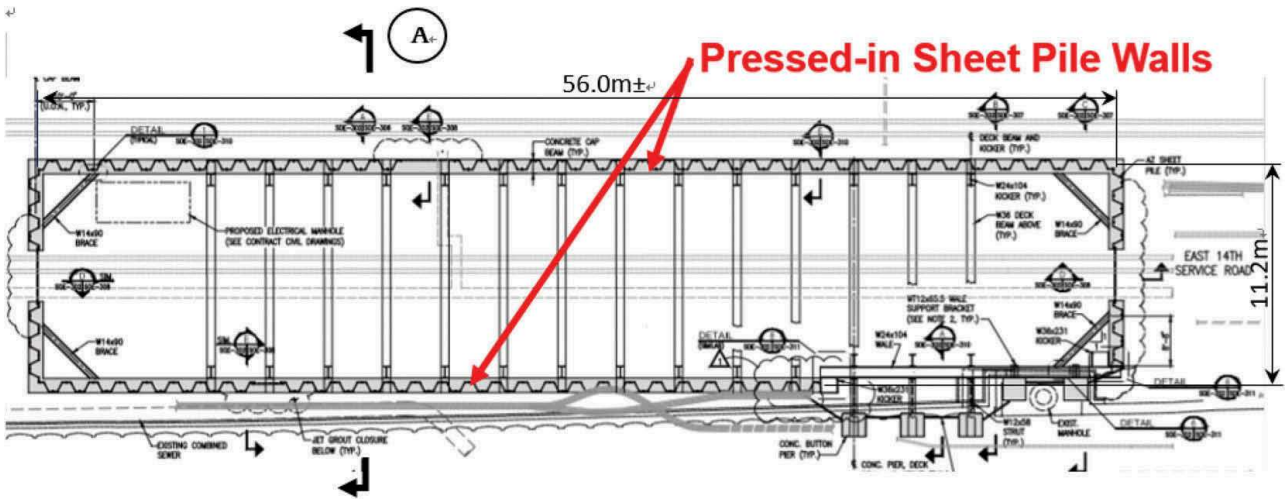

Figure 4. Alternate shoring design (Pressed-in sheet pile walls, Courtesy: Judlau – TC Electric JV).

Century before these buildings were torn down to widen East 14th Street. See Figure 9 for the major components of the auger attachment.

The auger attachment was able to overcome such obstructions and allow for successful pile installation (Takuma et al. 2018). Predrilling with another machine prior to pile installation would have been necessary without the use of the auger attachment, which would have taken much longer time in completing the piling operations.

Piling work in front of some of the stores such as a popular coffee shop could be only done while the stores were closed late at night. See Figure 10. The press-in piling enabled piling installation in the middle of the night without disturbing local residents at rest. The pile installation work was conducted between December 2017 and April 2018.

Additionally, an on-site presentation on the press-in piling was well attended with the representatives of local agencies and consultants in spite of chilly winter weather as shown in Figure 11.

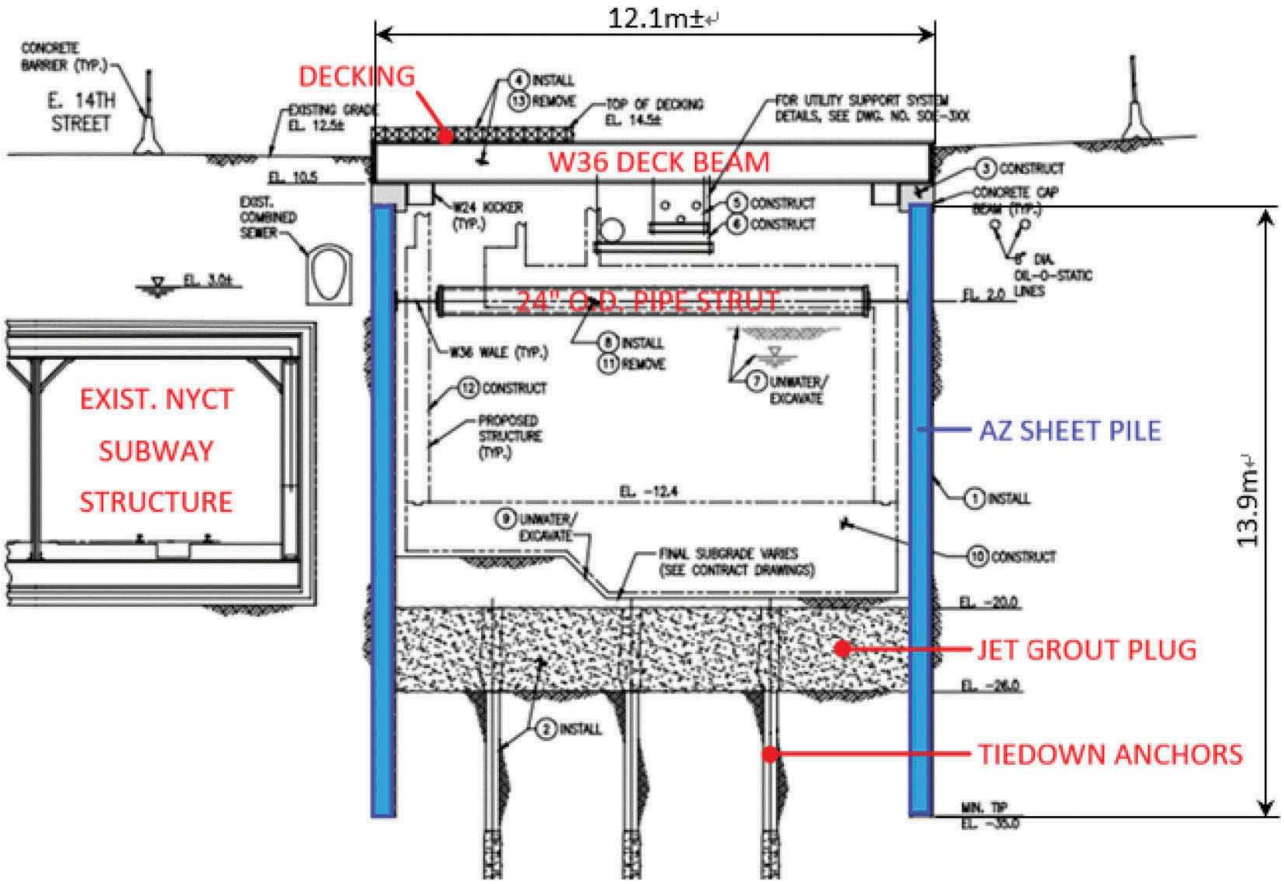

Figure 5. A-A Section of the alternate shoring design for Avenue B Substation (Judlau – TC Electric JV).

PILE INSTALLATION EQUIPMENT: USE HYDRAULIC PILE JACKING EQUIPMENT TO INSTALL SHEET PILES ("PRESS–IN METHOD"). EQUIPMENT SHALL BE SUITABLE FOR THE TOTAL WEIGHT OF THE PILE AND THE CHARACTER OF SUBSURFACE MATERIAL TO BE ENCOUNTERED. OPERATE PILING EQUIPMENT AT THE RATE(S) RECOMMENDED BY THE MANUFACTURER THROUGHOUT THE ENTIRE INSTALLATION.

Figure 6. Part of shoring specifications for sheet pile installation.

Figure 7. Starting press-in piling.

Figure 8. Press-in piling next to sidewalk.

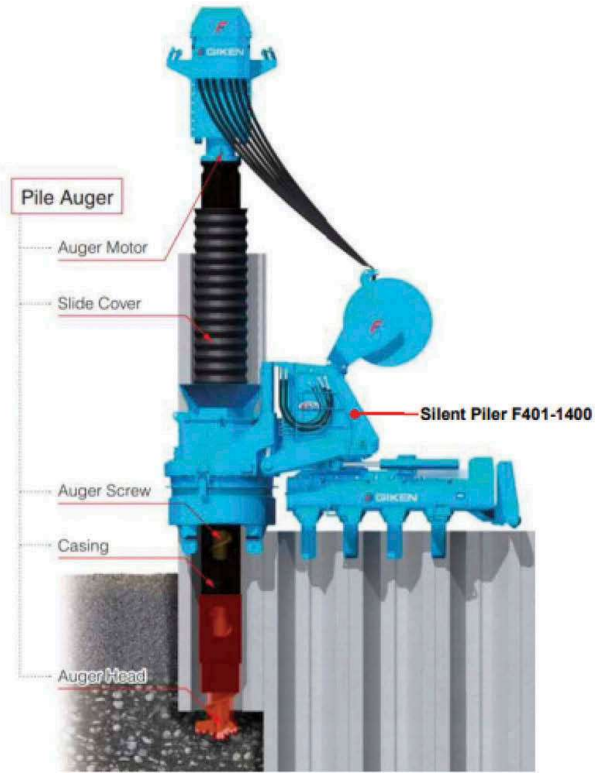

Figure 9. Auger Attachment and F401-1400 Silent Piler.

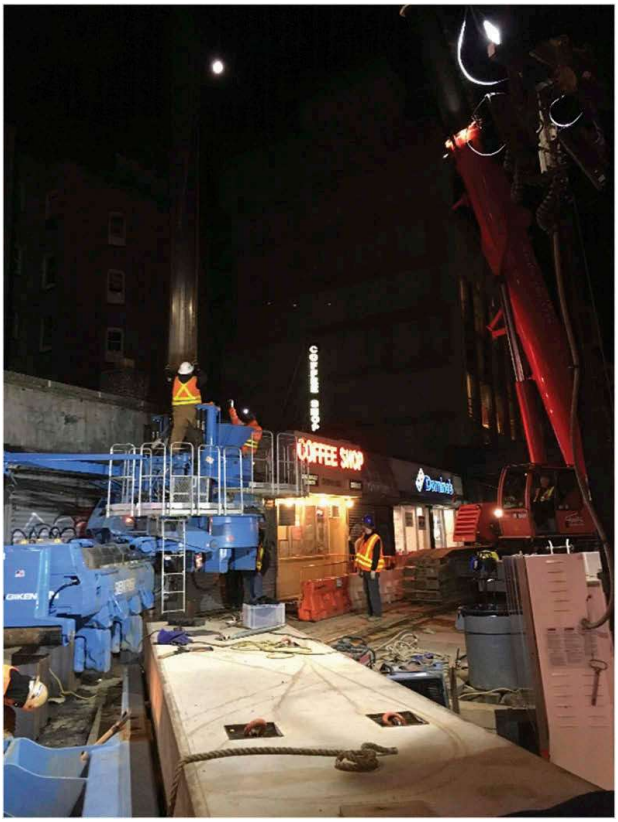

Figure 10. Press-in piling conducted at night while stores are closed.

Figure 11. Onsite presentation for local agencies and engineers.

4 CONCLUSION

Earth retaining walls with steel sheet piles can be constructed faster than secant pile walls with likely cost savings. The press-in piling method enables otherwise very difficult sheet pile installation in a densely populated urban area with its low noise/ extremely low vibration features and the ability to efficiently press sheet piles into hard soil. New York and other metropolitan areas around the world will be further benefitted with the advantages of the press-in piling method.

REFERENCES

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