Proceedings of the Second International Conference on Press-in Engineering 2021, Kochi, Japan – Matsumoto et al (eds)
 ISBN 978-1-032-10414-0

Silent Piler in Bangkok MRT Orange Line Project

P. Kitiyodom & I. Boonsiri
Geotechnical & Foundation Engineering Co., Ltd, Bangkok, Thailand

ABSTRACT: Thailand's capital city, Bangkok has been planning to construct many underground infrastructure development projects. Recently, MRT Orange line is considered to be one of the most difficult projects in Bangkok because the tunnel alignment passes through the congested urban areas in the city. There are inevitable interactions be-tween existing structures and new construction, such as tunnels, intervention shafts and stations. Many under-pinning works are required along the route. The low-headroom, limited working space and vibration have become concerned issues to be considered during construction. Silent Piler is used in those constraint areas. The result of underpinning works with Silent Piler is shown in this paper.

1 INTRODUCTION

MRT Orange Line Project is implemented by The Mass Rapid Transit Authority of Thailand (MRTA) to develop a train system network in Bangkok Metropolitan Region. MRT Orange Line is divided into two sections, East Section (Thailand Cultural Centre – Min Buri) and West Section (Taling Chan – Thai-land Cultural Centre). Ch. Karnchang PLC. And Si-no Thai Engineering and Construction PLC. (CKST Joint Venture) have been awarded for MRT Orange Line (East Section) Project, Contract E1 and E2. The Contract E1 and E2 involve the construction of about 9.73km, comprises of 7 underground stations, ventilation and intervention shafts, cut-and-cover tunnels, depot access, stack and parallel twin tunnels. Diaphragm wall is used as a retaining wall with an aid of base slab and bored piles or barrettes for deep ex-cavation. One of the difficult issues for the project is constraints of the working area such as low headroom and insufficient distance between the machine and Right of Way.

2 SOIL CONDITION

The soil condition in Bangkok consists of a thick soft to very soft clay layer on the top deposit, namely Bangkok clay, and encountered with stiff to very stiff clay before reaching the first dense silty sand layer. The hard clay is encountered below the first silty sand and underlain by the second very dense silty sand layer. The subsoil profile of MRT Orange Line Contract E1 and E2 are presented in Figure 1 and Figure 2 respectively. Bangkok clay is very sensitive to deformations and has low shear strength. The foundation in Bangkok is the pile foundation. For low rise buildings, the piling work consists of driven pile and jack in pile. For high-rise buildings and highways, BTS sky train and MRT subway, bored pile and barrette pile with the tip penetrated in the second dense silty sand are utilized. The tunnel alignment needs to be adjusted to evade the existing buildings and elevated the expressway as much as possible. However, some part of the project has to conduct underpinning work to mitigate settlement of existing buildings in congested space. The working space, vibration and pollution, especially PM 2.5, have become concerned issues to be considered during construction.

3 CRITERIA FOR UNDERPINNING

The tunnel alignment compels the underpinning works required for the project. As a result, attention has been paid to the alignment design such that minimal clashes occur between the tunnel alignment and the existing structures. In addition, if such a clash is unavoidable, the underpinning work needs to be conducted. Underpinning for the existing structures may be required if the existing structures either clash with the tunnel alignment or are in its close proximity.

For example, if a clearance between the edge of existing pile and exterior surface of tunnel is less than 900mm, this location requires underpinning. This clearance is inclusive of a tunnel driving tolerance of plus or minus 100mm and a construction tolerance of 1 in 100 for the verticality of the existing pile.

The following information will be taken as bases for the design development of the underpinning

DOI: 10.1201/9781003215226-56

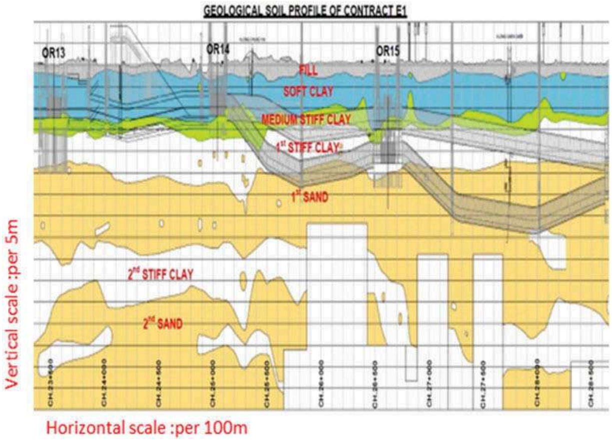

Figure 1. Geological soil profile of contract E1.

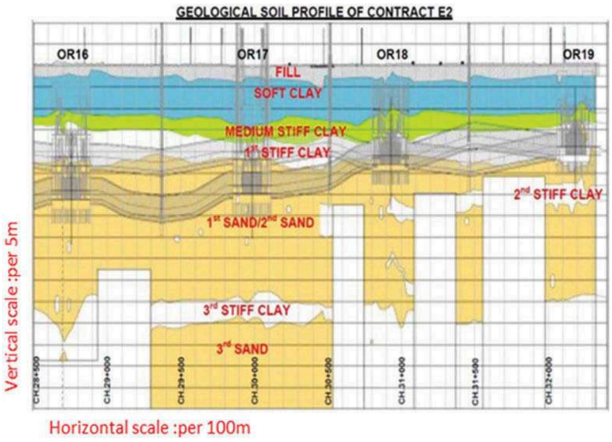

Figure 2. Geological soil profile of contract E2.

work on the project: Tunnel alignment, Station layout, Topographic survey of the site, As-built information and condition survey of the existing structures, Right of Way (ROW) of the project.

4 UNDERPINNING AT RAM KHAMHAENG JUNCTION FLYOVER (CONTRACT E1)

The location of Ram Khamhaeng Junction Flyover has to be underpinned (approximate at Chainage 28+200) as shown in Figure 3. The proposed bored tunnels will pass underneath the existing flyover and will cause an adverse effect on the existing foundation system. Underpinning work is required in order to reconstruct a new supporting system with minimal impact to the operation of the viaduct.

At the beginning, the associated barrettes and temporary steel portal frame will be constructed as the supporting structure for the existing flyover structures. Sheet piles will be installed around the pile cap by Silent Piler as presented in Figure 4 and 5. Where it is acted as permanent structures. The conventional method of pile installation could not be applied due to insufficient headroom under flyover. Temporary

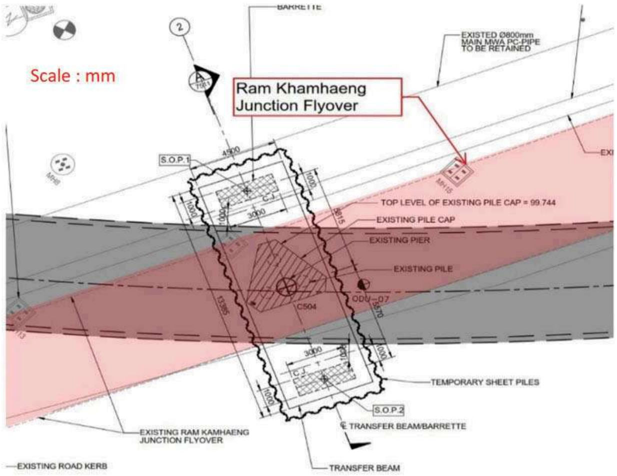

Figure 3. Site location plan of Ram Khamhaeng Junction Flyover to be underpinned at CH.28+200.

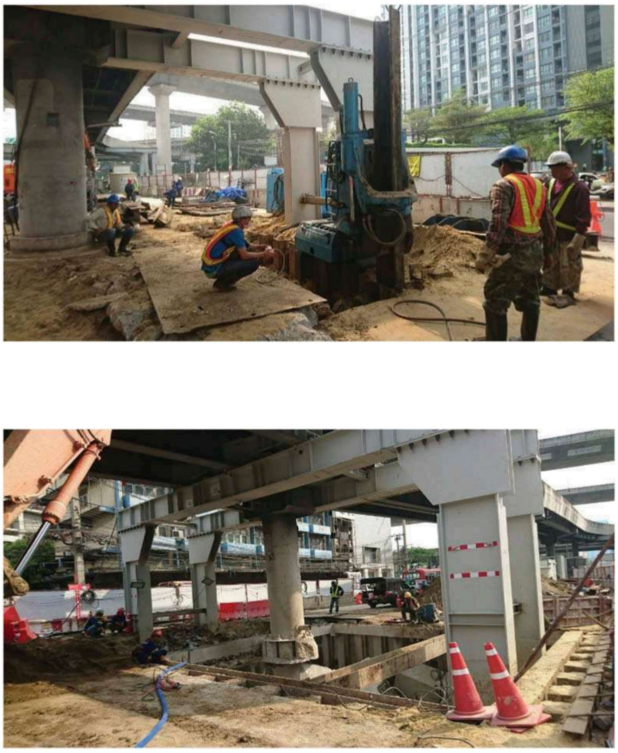

Figure 4 & 5. Site location of Ram Khamhaeng Junction Flyover to be underpinned (CH. 28+200).

vertical jacks between portal frame and existing girder will be placed. Subsequently, preloading will commence to alter the load path from existing flyover piled foundation to the new barrette foundation through the vertical jacks and portal frame.

After the preloading, the existing steel pier will be disconnected, followed by demolishing the existing pile cap and piles. Thereafter remaining portions of the transfer beam will be constructed. A steel pier will be reinstated and connected to the transfer beam in order to remove the temporary jack to complete the load transfer. Finally, TBM works will be carried out underneath the underpinned foundation structure after the completion of load transfer.

5 UNDERPINNING AT RAM KHAMHAENG JUNCTION FLYOVER (CONTRACT E2)

The location of Ram Khamhaeng Junction Flyover has to be underpinned (approximate at Chainage 29+300.) As the proposed bored tunnels will pass underneath the existing flyover and will be partly in conflict with the existing foundation system, underpinning work is required in order to reconstruct a new supporting system with minimal impact to the operation viaduct as presented in Figure 6. Headroom under flyover is less than 5.0m. Therefore, Silent Piler needs to be used for sheet pile installation as shown in Figure 7. The sheet pile needs to be divided into short length and reconnected by welding during the sheet pile installation as presented in Figure 8.

The sequence of underpinning is similar to the underpinning at CH. 28+200. However, after the preloading, a gap between the existing deck soffit and the portal beam will be grouted in order to remove the temporary jack. The second cast of pile cap for connecting to the existing cap will be constructed. TBM works will be constructed underneath the underpinned foundation structure after the completion of load transfer.

6 DESIGN ANALYSIS APPROACH

For underpinning works, internal forces of the structural members have been carried out by two computer programs – PLAXIS 2D and Sap2000. PLAXIS 2D is used to analyze the effects due to TBM tunneling. However, the load transfer and the

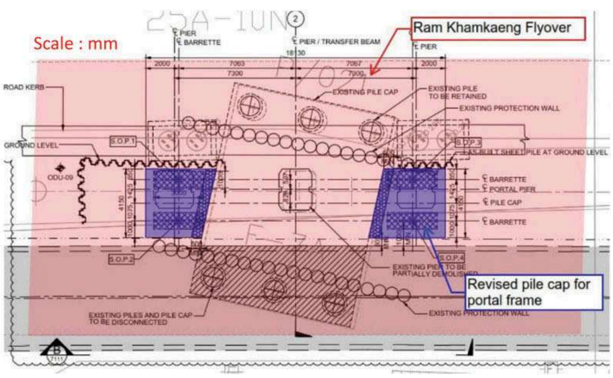

Figure 6. Schematic plan of Ram Khamhaeng Junction Flyover to be underpinned at CH.29+300.

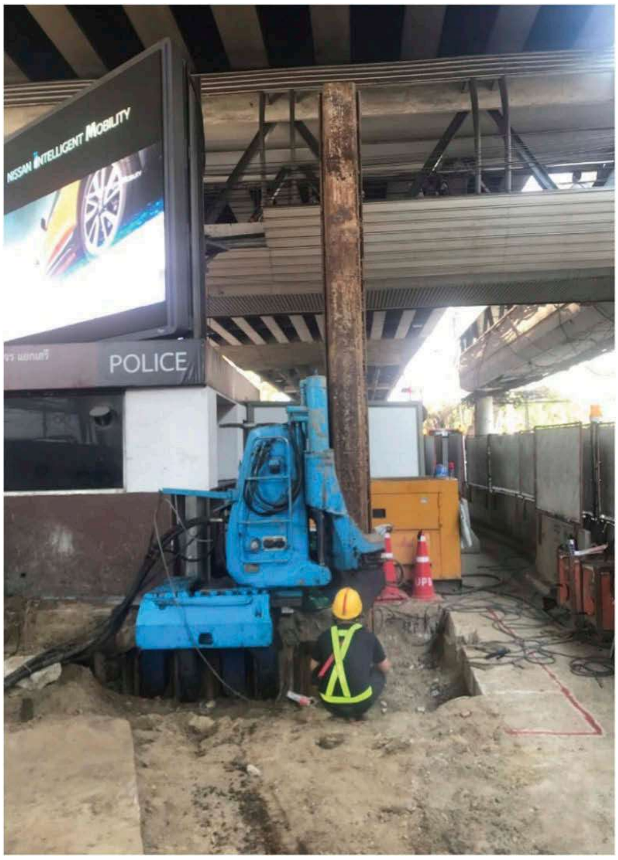

Figure 7 & 8. Installation of sheet pile under Ram Khamhaeng Junction Flyover by Silent Piler (CH. 29+300).

loads from flyover will be analyzed by Sap2000. Figure 9 shows the section of the load transfer system in Sap2000. Jack loads were installed on between the existing deck and the newly constructed portal beam. Installation of a sheet pile by Silent Piler will be applied around the newly piled cap and the existing pier to act as a retaining wall. The load transfer due to volume loss during tunneling will be acquired by PLAXIS 2D as shown in Figure 10.

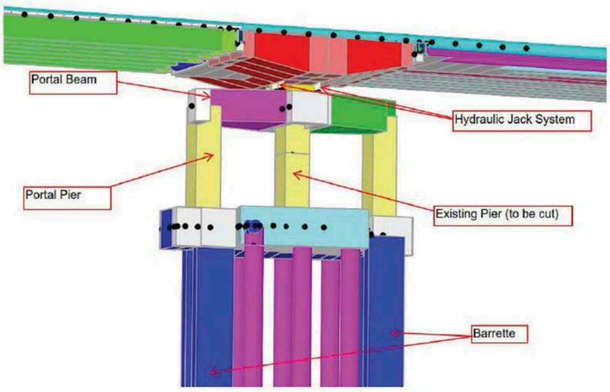

Figure 9. Example section of load transfer system at CH.29+300 by Sap2000.

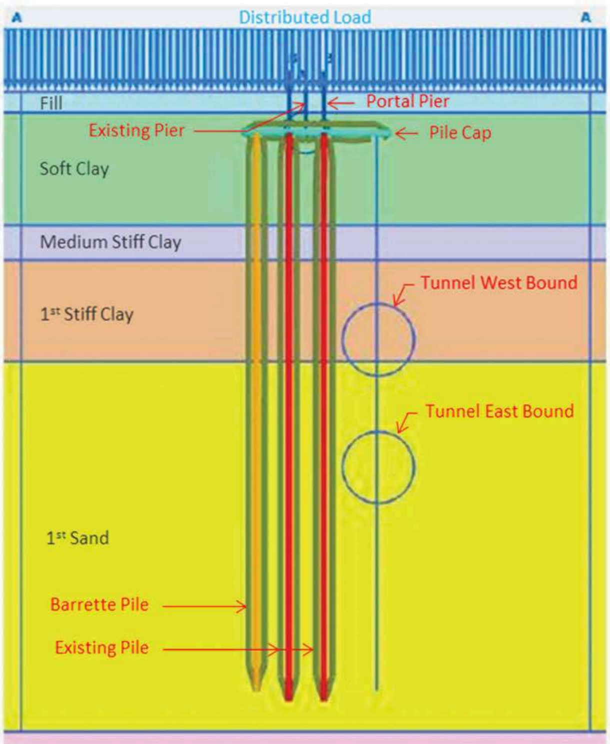

Figure 10. Example of PLAXIS 2D model for underpinning at CH.29+300 with TBM.

The flyover structures are supported on piled foundations where it is affected by sub-surface soil movement due to TBM tunnelling works. The vertical soil movement induces negative skin friction on the piles. The lateral soil movement also induced additional bending moments on the piles.

These additional stresses on the piles and consequences of underpinning works are analyzed on PLAXIS 2D. The results will be checked against the structural and geotechnical capacity of piles to assess the impact on the piles due to ground movement by tunnelling works. The methods of assessment on the flyover are summarized by the following:

First, preliminary assessment on the existing pile according to the free-field ground movements induced by tunnelling using PRAB computer program which is developed by Kitiyodom et al, 2005.

Second, for such pile foundations which are susceptible to damage by tunnelling as determined from preliminary assessment, further assessment is performed by using Sap2000.

7 CONCLUSION

Silent Piler is very useful to be applied in the constraint condition such as low head room, limited working area and nearby operating transportation. For MRT Orange Line Project, it is compulsory that the traffic needs to be operated during the underpinning process. In addition, the conventional sheet pile installation using a vibro hammer causes excessive noise and ground vibration. These results exceed the limit tolerable by human and the vibration may generate adverse effects on existing buildings.

ACKNOWLEDGEMENTS

The authors would like to appreciate to Mass Rapid Transit Authority (MRTA) and CKST Joint Venture for their kind support.

REFERENCES

Basile, F. (2014). Effects of Tunnelling on Pile Foundations. *Soils and Foundations*, 54(3), 280–295.

Jongpradist, P., Kaewsri, T., Sawatparnich, A., Suwansawat, S., Youwai, S., Kongkitkul, W. and Sunitsakul, J. (2013). Development of Tunneling Influence Zones for Adjacent Pile Foundations by Numerical Analysis. *Tunnelling and Underground Space Technology*, 34, 96–109.

Kitiyodom, P. and Matsumoto, T. (2002). A simplified analysis method for piled raft and pile group foundations with batter piles, *International Journal for*

Numerical and Analytical Methods in Geomechanics, 26, 1349–1369.

Kitiyodom, P. and Matsumoto, T. (2003). A simplified analysis method for piled raft foundations in non-homogeneous soils, *International Journal for Numerical and Analytical Methods in Geomechanics*, 27, 85–109.

Loganathan, N. and Poulos. (1998). Analytical Prediction for Tunneling-Induced Ground Movements in Clays. *Journal of Geotechnical and Geoenvironmental Engineering (ASCE)*, 124(9), 846–856.

Pang, C.H. (2006). The Effect of Tunnel Construction on Nearby Pile Foundations. *Ph.D. thesis, National University of Singapore*, 362.