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Project: Design and construction of Ho Chi Minh City Metro Line & Underground Sections

The Sub Sections of this News Circular

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Chi Minh City Metro Line 1 & Location of Opera House Station and its vicinity

3. Project Summary:

Contract Package 1b (CP1b) is a part of Ho Chi Minh City Metro Line 1 (HCMC MRT Line 1) project which consists of underground construction of two stations, bored tunnels, cut-and-cover tunnel, and transition structure. Each structure has its own distinctive features due to its geographical location, underlying geotechnical layer and construction constrain. Opera House Station, whose construction method categorized as deep excavation (up to 30 m depth) is the first underground metro station in Vietnam which is situated in a cramped downtown and surrounded by old-sensitive shallow-founded buildings. It was built by top-down method as the method offers better control of retaining wall deformation to minimize settlement of adjacent buildings. The other station, Ba Son Station, located next to the riverside, was

protected by double sheet pile structure during its construction. For cut-and-cover tunnel, the rigid steel pipe sheet pile (SPSP) was used to maintain stability for construction in the river and on the weak alluvium clay soil. The underlying alluvium clay also causes a negative skin

Friction issue in the design of pile for the transition structure in Ba Son area. As for tunneling beneath the city, the bored tunnel using Earth Pressure Balance (EPB) Tunnel Boring Machine (TBM) was selected. The TBM was launched from Ba Son Station toward Opera House Station twice: one for the east-bound track, and the other is for the west-bound track. In this project, several instruments were deployed to monitor and to ensure the safety of construction works and surrounding buildings. The data from the monitoring works were also useful for back analyzing and reconfiguration of the construction method. Those features brought challenges for both design and construction stages.

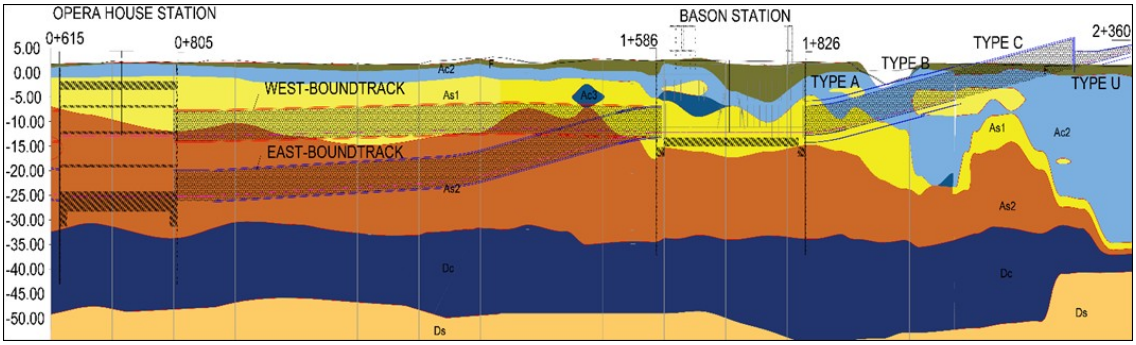
4. Details of Infrastructures:

Covers a 19.7 km length in total and consists of 2.6 km of underground section and 17.1 km of elevated section. The underground section is situated in the downtown area where the space is insufficient for the elevated structure. Contract Package 1b (CP1b) as a part of underground section is covering 1.745 km (chainage 0+615 to 2+360) which consists of two stations, bored tunnels, a cut-and-cover tunnel, and a transition structure.

5. Geology & Soil conditions:

The soil layers in CP1b project is comprised of Fill, Alluvium and Diluvium material (Figure 3). Alluvial deposits of approximately 30-40 m thick overlay the harder and denser Diluvium layers. Alluvium Clay is divided into Alluvium Clay 2 (Ac2) with SPT-N value from 0 to 2 and Alluvium Clay 3 (Ac3) with SPT-N value from 4 to 21. In Ba Son Station and Cut-and-cover Tunnel, the Ac2 layer has an average of SPT-N value equal to 0. The Ac2 layer becomes thicker to the eastern end of the cut-and-cover tunnel section (transition structure area). For Alluvium Sand, it is divided into Alluvium Sand 1 (As1) with SPT-N value up to 10 and Alluvium Sand 2 (As2) with SPT-N value more than 10. Diluvium Clay (Dc) is considered an impermeable and hard layer. It lies just above Diluvium Sand (Ds) layer.

Layout of CP1b project



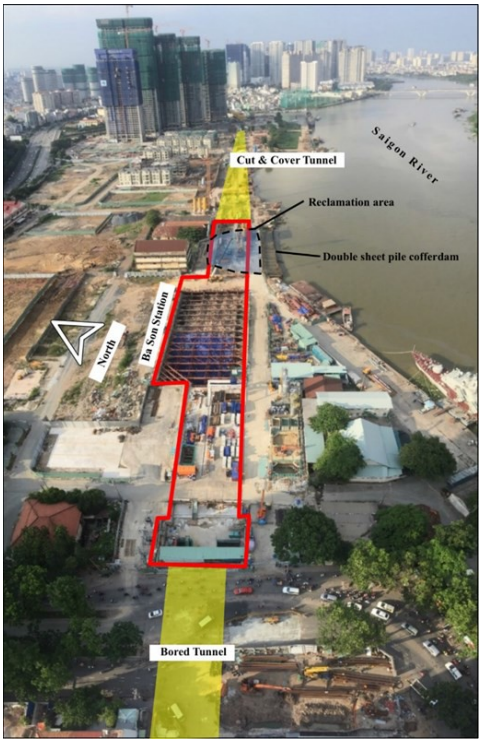
Soil profile in CP1b project

6. Opera House Station

Opera House Station was designed as a station box supported by diaphragm wall (D-wall) (1.5 m thick; 44 m deep) as part of its permanent structure. D-wall is embedded into Dc layer which creates a water cut off boundary. Thus, dewatering during excavation progress will not cause ground water level down in the vicinity. The thick Dc layer (14 m) and the friction between D-wall and soil provide enough safety against uplift from aquifer water pressure below Dc layer. Temporary works of D-wall was designed by using elastoplastic method according to DSRSC – Cut and Cover Tunnel (RTRI, 2001).

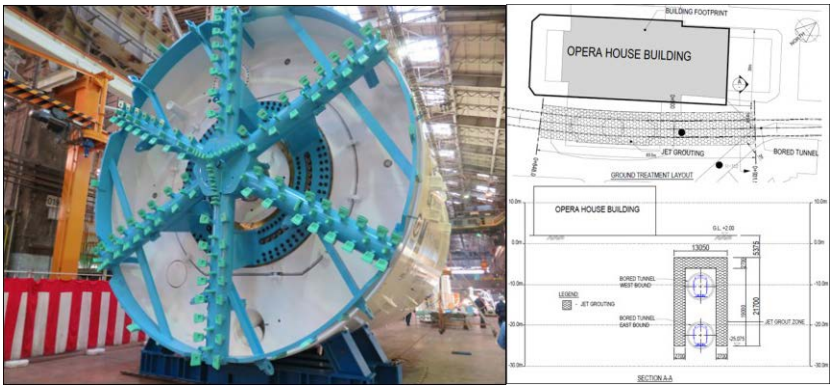
7. BA SON STATION

Ba Son Station is located in the east side of Opera House Station and is situated in the riverside. It has two level basements and one ventilation tower. Ba Son Station also has five entrances. The station is 240 m long, 18 m deep and has a total of 26,230 m2 floor area. Ba Son Station area is used to be a shipyard. It was then redeveloped for residential area. Since there are no sensitive adjacent buildings in the vicinity, the settlement limitation is not as strict as Opera House Station case. In the case of Ba Son Station area, a ground settlement of up to 70 mm is allowed.



8: BORED TUNNEL

The tunnel segment connecting end of Opera House Station (chainage 0+805) and start of Ba Son Station (chainage 1+586) was built by bored tunnel method involving Earth Pressure balance (EPB) type of tunnel boring machine (TBM) with cutter head of scraper type as shown in Figure 10. Tunnel length is 2 x 781 m (for east-bound and west-bound tunnel). The tunnel segment lining has an outer diameter of 6.65 m, 300 mm thickness and 1.2 m length. Twin tunnel bored at similar elevation when commencing from Ba Son Station and made transition to a stacked profile before arriving at Opera House Station B2F and B4F. The maximum and minimum overburden depth is 22.3 m and 8.7 m, respectively. The tunnel segment lining was designed using a two-beam-spring model in accordance with DSRSC – Shield Tunne (RTRI, 2002). Modelling was done in SAP2000 software. The beam spring model isadapted. The model represents segments of a tunnel as beams and the circumferential and longitudinal joints as springs. The segment rings are modeled as beam. The segment and ring joints are modelled as rotational springs and shear springs respectively.



Tunnel Boring Machine (TBM) & Jet grouting column as a protective measure against tunneling-induced settlement

9. CUT-AND-COVER TUNNEL AND TRANSITION STRUCTURES

From chainage 1+826 to 2+360, the cut-and-cover tunnel and transition structure were constructed. This section is passing a small bay which used to be a big dry dock. The section comprises of box structure (Type A, Type B and Type C) and transition structure (Type U) The end of the transition structure is connected to the elevated section of HCMC MRT Line

Construction of FCB and sand backfilling used to receive TBM at Opera House Station B4F (number indicates construction order)

Geotechnical Challenges:

The scope of CP1b project which consists of various ground conditions provides comprehensive challenges. It covers many design aspects in geotechnical engineering such as retaining structures, deep excavation, soil-structure interaction, slope stability, tunneling and consolidation. The challenges arisen during the construction encourage the selection of the most optimum solution. The followings are some highlights from the design and the construction experience of HCMC MRT Line 1 CP1b:

The deep excavation project in the city center requires a robust monitoring plan and a sufficient understanding of the existing structures in the vicinity. The selection of the top-down method was suitable for such a condition.The use of inclined strut optimizes the top-down construction method by creating bigger working space and reducing the quantity of steel strut compared to that of horizontal strut.FCB and sand backfill was effective as a preventive measure to avoid the leakage during TBM arrival into the station. The steel pipe sheet pile is proven to be feasible and practical to create a temporary cofferdam for construction in the river area. The selection of a solution for the negative skin friction risk shall consider the time constrain. Therefore, a friction cutter for pile was selected over the embankment for consolidation.