CHAPTER III

GEOLOGY AND SUBSOIL CONDITIONS

A profound understanding of the geology of one area and engineering properties of its subsoils, usually lead to a better design of an underground structure and an accurate prediction of the construction effects. Therefore, the geological and geotechnical investigation is indispensable before starting an underground work within one area. This chapter describes the general geological conditions of Bangkok soil including the special characteristics of the underground water pressure as well as an introduction of the subsoil profile along the tunneling route of this study.

3.1 Geology of Bangkok Soil

The Bangkok subsoil is relatively uniform throughout the whole metropolitan area (Phienwej, 1996 and 1997; Shibuya and Tamrakar, 2003). This subsoil consists of two kinds of deposits: first, the terrestrial or quaternary deposits originated from the sedimentation at the delta of the ancient river in the Chao Phraya and second, the marine deposits occuring due to the changes in sea levels during quaternary period. Bangkok is located in the low lying Chao Phraya plain which is about 20 km north of the Gulf of Thailand (Figure 3.1). The plain becomes a slope towards Tanawsri Moutain range on the west along Thai-Myanmar border and it is developed into Khorat Plateau on the east. The Chao Phraya River and its tributaries such as Tajeen are the major drainage system for the surrounding highlands. Therefore, the Chao Phraya basin is filled with sedimentary soil deposits, which from alternative layers of sand, gravel and clay. The marine clay of Bangkok plain, which is the uppermost clay layer, extends from 200 to 250 km in the East-West direction and 250 to 300 km in the North-South direction. The formation of this layer is known as Bangkok clay and it is believed to be approximately 4000 yeas ago. The deposits, which are confined within the radius of 60 to 80 km from Bangkok, had taken placed during the Pleistocene and Holocene period (Shibuya and Tamrakar, 2003).

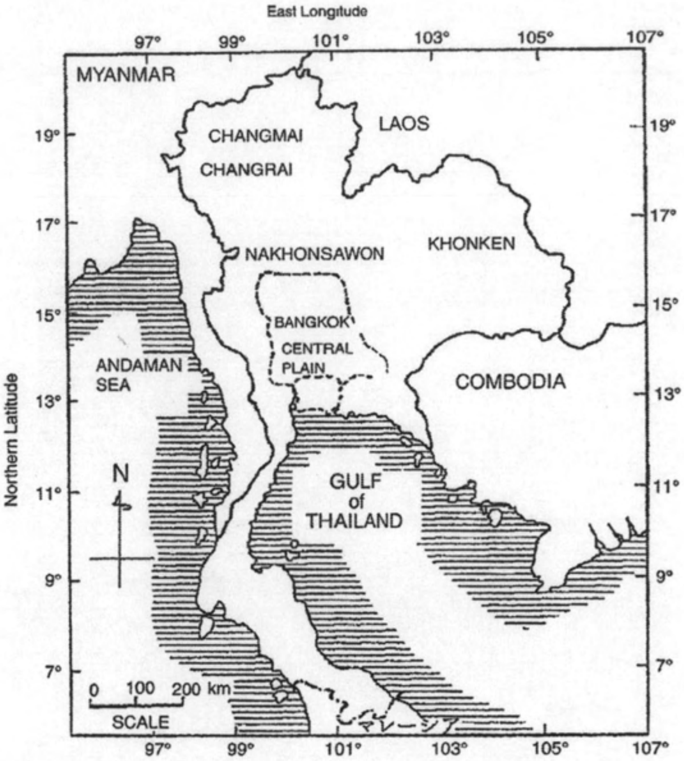

Figure 3.1 Map of Thailand (Shibuya and Tamrakar, 2003)

The general Bangkok subsoil profiles for the top 70 m thickness reported by Teparaksa (1999) based on the Mass Rapid Transit Authority of Thailand (MRTA) subway project is presented in Figure 3.2.

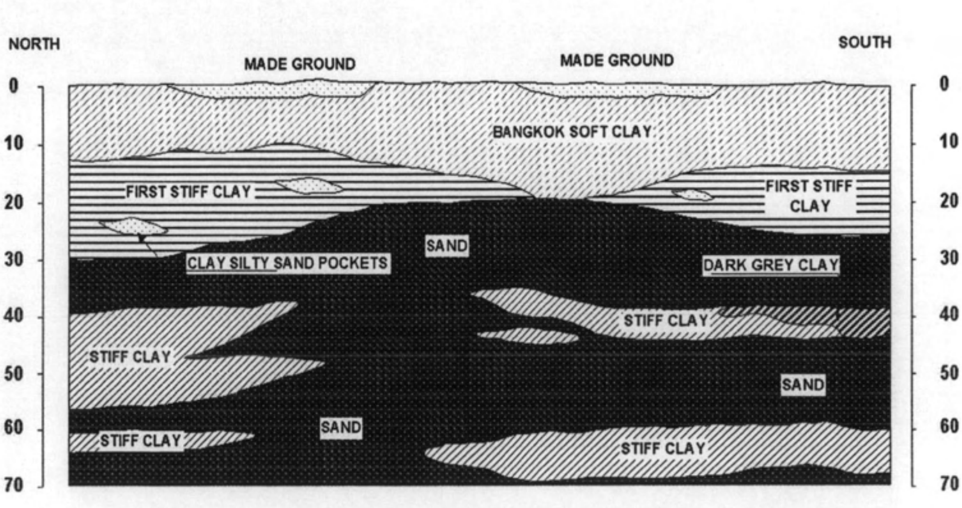

Figure 3.2 General subsoil profile (Teparaksa, 1999)

During this MRTA subway project, which is the first subway project to be built in Bangkok, the subsoil layers along the route were investigated by means of the first six self-boring pressuremeter tests ever carried out in Thailand and more than 200 boreholes were made. The subsoils consist of 13-16 m thick soft marine clay at the upper layer. This clay is sensitive, anisotropic and creep (time dependent stress-strain-strength behavior) susceptible. These characteristics have made the design and construction of deep basements, filled embankments and tunneling in soft clay difficult. The first stiff to very stiff silty clay layer is encountered below soft clay and medium clay varying from 21 to 28 m depth. This first stiff silty clay has low sensitivity and high stiffness, which is appropriate to be bearing layer for underground structures. The first dense silty sand layer located below stiff silty clay layer at 21-28 m depth contributes to variations in skin friction and mobilization of end bearing resistance of pile foundations. The similar variations are also contributed by the second dense and coarse silty sand found at about 45-55 m depth (Figure 3.2).

3.2 Underground Water of Bangkok

The piezometric profile has been known for Bangkok is hydrostatic starting from 1 to 2 m below ground level to a depth about 7 up to 10 m (Teparaksa, 1999; Teparaksa and Heidengren, 1999; Shibuya and Tamrakar, 2003). However, beneath this depth (about 10 m), due to deep well pumping from the aquifers, a successive reduction of water pressure appeared within the lower part of soft clay and the first stiff clay layers and the zero water pressure could be seen again at the depth about 23 m below ground surface as shown in Figure 3.3 (Teparaksa and Heidengren, 1999; Teparaksa, 1999; Yeow et al., 2004). The piezometer profile beyond this depth becomes a hydrostatic profile for a second time. Teparaksa and Heidengren (1999) and Teparaksa (1999) stated that "the low piezometric level contributes to the increase in effective stress, causing ground subsidence in this city. However, the benefit of this low piezometric level is easy to construct bored piles having pile tip in the first stiff clay using dry process and dry excavation for basement construction up to the silty clay level without any dewatering or pumping system". As the stiff clay has a high stiffness, it is expected that the ground loss during the TBM boring is very low or insignificant. Therefore, The MRTA subway tunneling is designed to be seated mainly in the first silty clay layer (Kongdaeng, 1996).

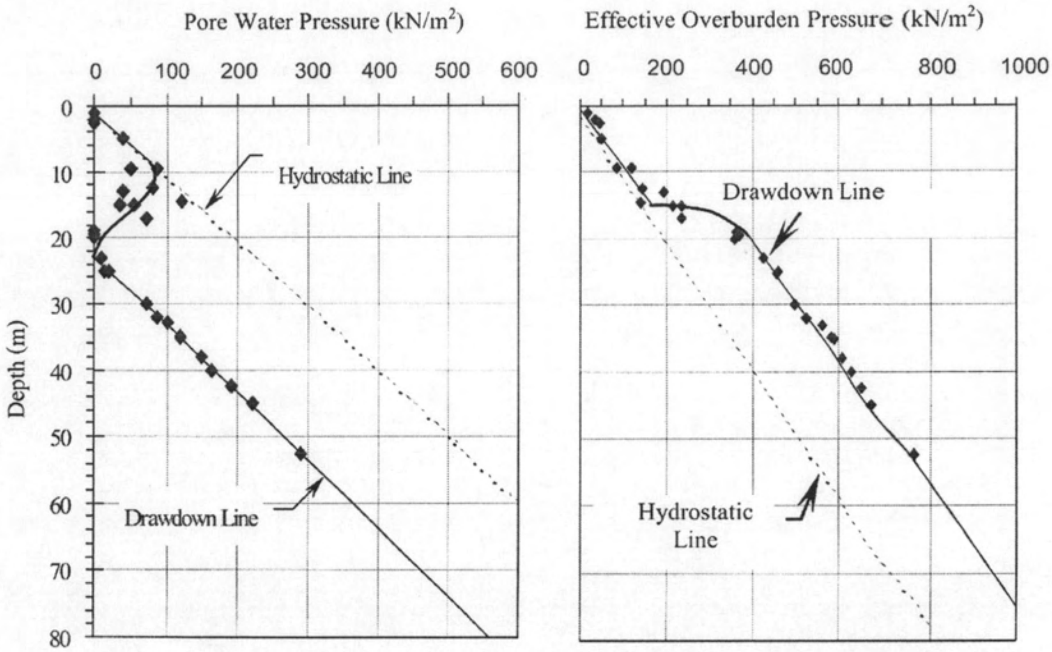

Figure 3.3 Piezometric level of Bangkok subsoils (Teparaksa, 1999)

3.3 Subsoil Conditions along the Tunneling Route of the Project

Although the various soil investigations have been previously done approximately everywhere in the Bangkok city, the additional 23 boreholes and Field Vane Shear tests were carried out along the tunneling route of the Bangkok Metropolitan Administration (BMA) Saensaep-Latphrao Phrakhanong flood diversion tunnel project. As the quality of geotechnical works depend mainly on the certainty of soil information in the vicinity of the project, this supplementary ground investigation was done in order to elucidate the following characterizations:

- the soil boundaries between different layers, and the representative of typically geotechnical sections.
- the material and engineering properties of the different layers along the route and provide parameters for designing or using in the model of calculation.
- the ground water conditions along the working route.

The location of each borehole and the typical subsoil profile along the BMA Saensaep-Latphrao Phrakhanong flood diversion tunnel are shown in Figure 3.4.

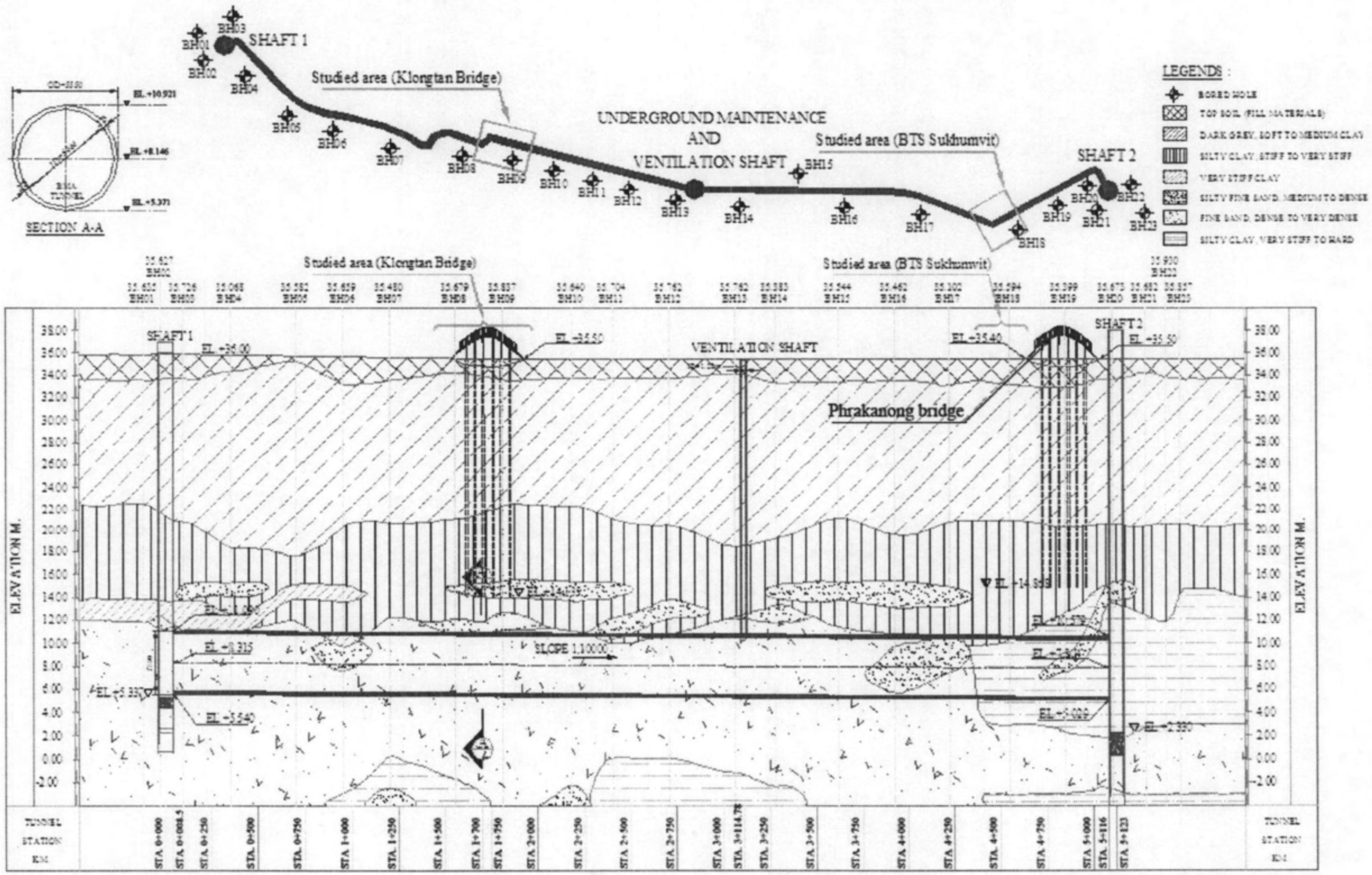

Figure 3.4 Boreholes and soil profile along the route of the BMA flood diversion tunnel (Saensaep-Ladphrao Phrakhanong)

The groundwater table measured 24 hours in the boreholes (surface water) was found at a depth between 0.5 and 1.1 meters from the ground surface. The geological condition and groundwater level indicated here are very similar to those mentioned in the above sections (section 3.1 and 3.2). However the BMA flood diversion tunnel is designed to be located mainly in the dense to very dense fine sand layer about 27.5 m depth below ground surface, which is found just below the stiff to very stiff clay layer since these layers had given place for the other previous tunnel projects already. Seeing that the tunnel crown is so close or gets in touch with the stiff to very stiff clay layers (Figure 3.4), the selected location of current flood diversion tunnel is expected to offer a low ground loss during and after TBM boring.

In chapter V, the more details of subsoil profiles for the analysis section will be extensively described including the research project the selected locations for Finite Element (FE) simulations and the different types of instrumentation used in the project. However, the engineering properties used in each simulation will be mentioned in numerical method and analyses (Chapter VI).