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Three infrastructure projects using geosynthetics in Thailand

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ABSTRACT: This paper describes the use of geosynthetics in three recent major infrastructure projects in Thailand. The first project described, Wat Nakorn-In Project, is part of a larger master plan to ease traffic congestion on the west bank of Chao Phraya River in the Greater Bangkok Area. This project utilized high strength woven polyester geotextile to span pilecaps and geogrid to reinforce steep embankment side slopes. The second project described used paving geotextile to reduce reflective cracking in the resurfacing of the highway from Minburi to Chachoengsao. The third project described, New Bangkok International Airport Project, used surcharging to preconsolidate the foundation. Prefabricated vertical drains were installed to accelerate consolidation for the ground improvement works. To allow effective dissipation of excess pore water pressure, the installed prefabricated vertical drains are connected to a horizontal sand drainage blanket above grade level. One layer of nonwoven geotextile was used as separator between the subgrade and the horizontal sand drainage blanket. The same nonwoven geotextile was also used as separator between the horizontal sand drainage blanket and the surcharge placed above.

1 INTRODUCTION

The three projects are located in and around Bangkok, within the Chao Phraya Plain of Thailand. The Chao Phraya Plain is geologically a broad deep basin filled with sedimentary soil deposits which form alternate layers of clay and sand with gravel, down to about 1,000 m depth (Bergado et al. 1990). These sedimentary layers were deposited from the Quaternary Period and parts of the Chao Phraya Plain were still covered by shallow marine water from as recent as 5,000 years ago. The Chao Phraya Plain is approximately 300 km in the North-South direction and has a width of about 200 km (Figure 1). The three upper most layers consist of weathered clay, soft clay and stiff clay. The thickness of the layer of soft clay increases from North to South with about 15 m in Bangkok. Due to the weak subsoil conditions, stability and settlement problems are encountered with construction within the Chao Phraya Plain.

Land subsidence is also a major problem in and around Bangkok. The phenomenon started around the beginning of 1960 when the rapid growth of the city induced intensive water pumping from the water-bearing strata underneath. It was reported that the city was sinking at about 2 to 8 cm per year, with some areas having subsided more than 150 cm (Rantucci et al. 1990).

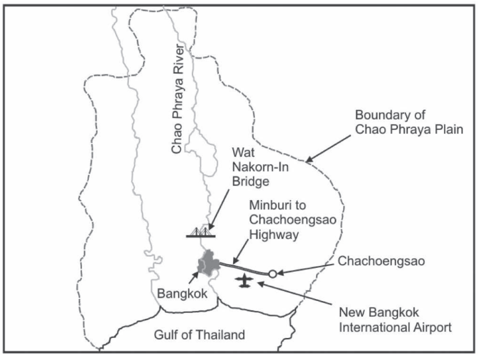

Figure 1. Location of projects within the Chao Phraya Plain.

The existence of a deep layer of soft clay combined with the problem of land subsidence poses geotechnical challenges to construction within the Chao Phraya Plain. Two of the three infrastructure projects described include ground improvement using geosynthetics while the remaining involved the use of paving geotextile to rehabilitate an existing highway.

2 WAT NAKORN-IN PROJECT

The Wat Nakorn-In Bridge and Connecting Road Construction Project is a major infrastructure project and part of a larger master plan to ease traffic congestion on the west bank of the Chao Phraya River in the Greater Bangkok area. The main bridge crosses the Chao Phraya River midway between Rama VII Bridge and Nonthaburi Bridge. The project also involved a network of connecting roads that included the construction of other smaller bridges.

The area is well known for deep deposits of soft clay. Further, the area has been undergoing subsidence as a result of groundwater extraction over time. Consolidation of the soft clay in addition to subsidence can give rise to large differential settlements between the embankments constructed directly on the soft clay foundation and the piled bridge structure. The embankments approaching the bridge abutments were designed with pile support to provide stability as well as to prevent large differential settlements between the embankment and bridge structure. The embankments approaching the bridge abutments were designed with steep side slopes due to lack of right of way.

Figure 2 shows the use of woven polyester geotextile with an ultimate tensile strength of 1,000 kN/m to span pilecaps. Figure 3 shows the use of geogrid with an ultimate tensile strength of 60 kN/m to reinforce a steep embankment side slope.

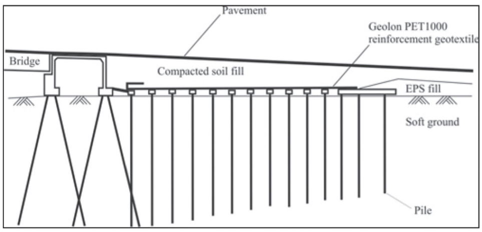

Figure 2. Longitudinal cross-section of bridge approach embankment at Wat Nakorn-In Project, contract EW1 (Yee 2005).

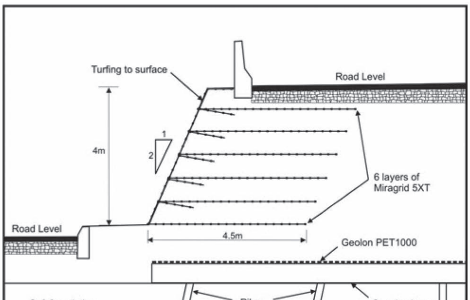

Figure 3. Cross-section of reinforced embankment side slope at Wat Nakorn-In Project, contract EW1.

Because of the overall size, the project was awarded in five contracts, each involving the construction of bridges and embankments using the ground improvement technique described above. The embankments can accommodate up to ten traffic lanes. Installation of the woven polyester geotextile reinforcement for the first package, contract EW1, started in 2000. Figure 4 shows the laying of the woven polyester geotextile at during construction for contract EW1. Figure 5 shows the completed geogrid reinforced steep sided embankment adjacent to a bridge abutment for the same contract. The bridge approach embankments have shown no signs of significant differential settlements with the bridge structure till now.

Figure 4. Laying of high strength woven polyester geotextile at Wat Nakorn-In Project, contract EW1.

Figure 5. Geogrid reinforced steep embankment side slope at Wat Nakorn-In Project, contract EW1.

3 MINBURI TO CHACHOENGSAO HIGHWAY REHABILITATION PROJECT

The onset of pavement cracking can lead to a significant increase in the rate of deterioration of the pavement because of the increased amount of water that can infiltrate into the pavement through the surface cracks.

Alleviation of cracking in pavements is normally done by the use of pavement overlays. One problem with overlays is that, unless they are relatively thick, existing cracks will reflect through the overlays relatively quickly. When this occurs, the problem of water entry will start all over again.

A cost effective pavement maintenance technique that reduces the amount of reflective cracking in bituminous overlays is the use of a paving geotextile laid in-between and bonded, through the saturation of bitumen, to both the existing pavement and the overlay. The function of the paving geotextile is to enable a degree of strain relief at the interface of the cracked existing pavement and the overlay that dissipates the onset of reflective cracking. Additionally, the bitumen-saturated geotextile will act as a moisture barrier to prevent the infiltration of surface water into the pavement structure. Figure 6 shows the conceptual use of paving geotextile associated with bituminous overlay to reduce reflective cracking.

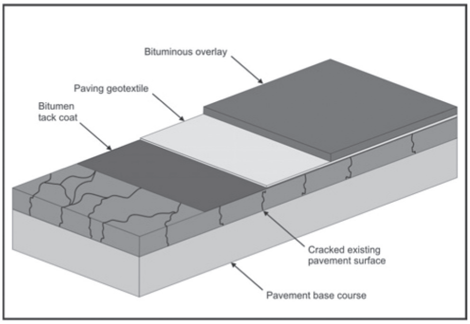

Figure 6. The use of paving geotextile associated with bituminous overlay to retard reflective cracking.

In 2002, the project for the Rehabilitation of Highway No. 304 Minburi – Chachoengsao was awarded. Minburi is about 60 km from the centre of Bangkok. The highway is a four-lane dual carriageway road. The contract works involved the supply and laying of paving geotextile and placement of bituminous overlay for the carriageway in-bound towards Bangkok.

The construction works started in November 2002 and was completed in December 2003. A total of 400,000 m^2 of paving geotextile was supplied for the contract. The roll widths supplied ranged from 4.6 m to 5.5 m, made to correspond accordingly to the actual width of overlay at site.

The existing pavement was prepared first by sweeping away of dust and debris. A bituminous tack coat was sprayed onto the existing pavement at a rate of between 1.1 to 1.2 liter/m^2. The paving geotextile was then rolled onto the existing pavement, which has been sprayed with bituminous tack coat (Figure 7). Good contact between the paving geotextile and the existing pavement was ensured by carefully brooming the laid paving geotextile prior placement of bituminous overlay. The geotextile used for this project was made of polyester, which meant that the paving geotextile was not sensitive to the lay-down temperature of the asphalt. The lay-down temperature of asphalt may be typically around 150°C but can often be higher. The melting temperature of polyester is about 250°C. The rehabilitated road is performing satisfactorily today.

Figure 7. Laying of paving geotextile in pavement overlay work for Minburi to Chachoengsao Road Rehabilitation Project.

4 NEW BANGKOK INTERNATIONAL AIRPORT PROJECT

The New Bangkok International Airport (also known as Suvarnabhumi Airport) was conceived in 1960s. The Airport Project site is located about 30 km to the east of Bangkok Metropolis and covers an approximate area of 3,200 ha with boundaries of approximately 8 km long and 4 km wide. The Government of Thailand approved construction of the Airport Project on May 7, 1991. Opening of the Airport is expected to be in 2006.

The Airport Project site is situated on a swampy land with an average elevation of less than 1 m above mean sea level. Prior to construction, the area was mostly covered by fishponds or agricultural usages with several crossing canals. Figure 8 shows the general ground profile and soil properties at the Airport Project site.

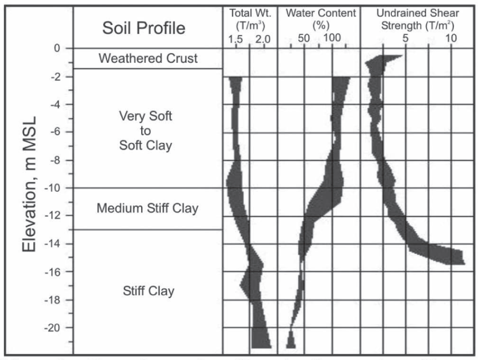

Figure 8. General ground profile and soil properties at New Bangkok International Airport Project (adapted from Moh & Lin 2005).

The overall site development concept is to construct facilities at existing ground level with polder system around the Airport site for flood prevention as opposed to the alternative of elevating the site. Temporary surcharge load provided by between 3.8 to 4.2 m of embankment fill is applied to improve the in-situ ground for a period of between 6 to 11 months with the aim of achieving 80% of primary consolidation. This surcharge is greater than the permanent load on the foundation and would reduce post construction settlement as well as improve the shear strength of the soft clay layer.

Prefabricated vertical drains were installed at 1m square distances to lengths of 10 m. A 1.5 m thick horizontal sand drainage blanket sandwiched between 2 layers of nonwoven geotextile used as separator was provided for (Figure 9). The contractual specification required the geotextile to have a minimum mass of 130 g/m^2 and a minimum tensile strength of 8 kN/m at a failure elongation of 50%. Figure 10 shows the installation of prefabricated vertical drains while Figure 11 shows the laying of nonwoven geotextile to protect the integrity of the horizontal sand drainage blanket.

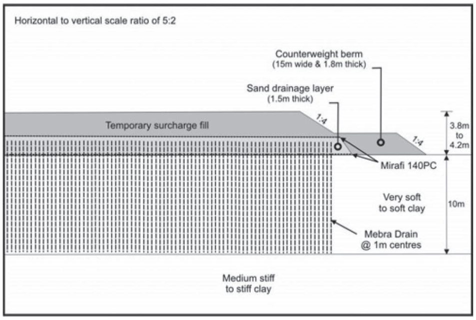

Figure 9. Typical cross-section showing use of prefabricated vertical drains and geotextile separator at New Bangkok International Airport Project, phase 2.

Figure 10. Installation of prefabricated vertical drains at New Bangkok International Airport Project, phase 2.

Phase 1 of the ground improvement works which involved the West Runway and associated works commenced in November 1997 and was completed in June 2002. Phase 2 of the ground improvement works which involved the East Runway and associated works started in December 2002 and lasted until August 2004, utilizing 2.2 million m^2 of nonwoven geotextile and 9.5 million m of prefabricated vertical drains. Ground improvement works for the Third Runway started in 2005 and is expected to extend until middle of 2006 with a further consumption of 4.2 million m^2 of nonwoven geotextile and 17 million m of prefabricated vertical drains. The ground improvement works using prefabricated vertical drains and geotextile to protect the integrity of the horizontal drainage sand layer has worked very well. The objective of achieving 80% of primary consolidation has been achieved generally within shorter time frames than had been originally expected.

Figure 11. Laying of geotextile separator at New Bangkok International Airport Project, phase 2.

5 CONCLUSION

The use of Geosynthetics at Wat Nakorn-In Project and Minburi to Chachoengsao Highway Rehabilitation Project has performed satisfactorily till now. The use of prefabricated vertical drains and separation geotextiles to protect the integrity of the associated horizontal drainage blanket for the New Bangkok International Airport Project has been very successful in achieving the desired consolidation settlements well within design time frames.

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