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DISCUSSION ON "GEOTECHNICAL HAZARDS IN BANGKOK - PRESENT & FUTURE", BY S. SHIBUYA, S. B. TAMRAKAR AND W. MANAKUL, LOWLAND TECHNOLOGY INTERNATIONAL, 5(1), 95-104

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DISCUSSIONS

The writers read with great interest the contribution on "Geotechnical Hazards in Bangkok - Present & Future". The writers had a long time interest in the subsidence of Bangkok since 1973 (see Piancharoen and Chuamthaisong, 1976; Piancharoen and Isarangula, 1974; Ramnarong, 1974) or so. The subsidence of Bangkok is a challenging area of research in Geotechnics, and Prof. Prinya Nutalaya (AIT, 1981; Sodsee, 1978; Thammakumpee, 1978; Tonyagate, 1978)) and his team including the second writer (Dr. Noppodol Phienwej) have done excellent work on the subsidence due to deep well pumping while the Water Resources Division at AIT (Asian Institute of Technology) has concentrated on the depletion of the aquifers and the flooding aspects.

The prediction of the exact rate of subsidence is further aggravated by the interconnection of the aquifers (see Brand and Paveenachana, 1971; Brand and Balasubramaniam, 1976), which are described as leaky in nature. In addition, the thickness of the aquifers and aquitards seem to vary widely. The most informative work related to the land subsidence in Bangkok was carried out by AIT, under the leadership of Prof. Prinya on a Royal Thai Government sponsored Project from 1978 to 1981 (AIT, 1981). Under this project, sub-soil investigations were carried out as deep as 400m, and subsidence in the entire city was monitored by settlement gauges at various depths, predominantly in the upper 50 m and extending to as deep as 200 m or so.

After the AIT period of observations, these subsidence measurements were continued for several years by the Royal Thai Army. These continuous measurements of subsidence were updated by Prof. Prinya and the second writer at AIT, and have been a very useful source of information for all the major projects in the Bangkok plain, such as Expressways, MRT, Airport expansion, Sewerage, Water and Gas pipelines, and tunnels. Perhaps some of the measurement are somewhat affected by the mal-function of the measuring devices over the period of time.

It will be of great importance in Geotechnical Civil Engineering practice in Bangkok, if new settlement measuring devices are installed, and the settlement of the existing structures with foundations at various levels (30m, 50m, etc) are monitored on a long term basis. Some of the issues related to the effect of deep well pumping on Geotechnical Civil Engineering Design are discussed below.

PILED FOUNDATIONS

It is common to carry out pile load tests on both driven and bored piles for various major projects (see Sambhandharakasa and Pitupakorn, 1985). These pile load test data are then used directly to estimate the working load. However such data needs further interpretation using an effective stress analysis, since the effective stress in the Bangkok subsoil is increased because of the piezometric draw down (see Fig. 1), as such both the load carried in skin friction and in end bearing estimated from the load test correspond to a higher effective stress rather than that due to hydrostatic pore pressure conditions. Though such a piezometric draw down will continue to prevail in the future as well, yet the possibility remains that if the deep well pumping is strictly controlled, recharge of ground water will take place and the effective stress will begin to reduce to the conditions of hydrostatic pore water pressure with no pore pressure decline.

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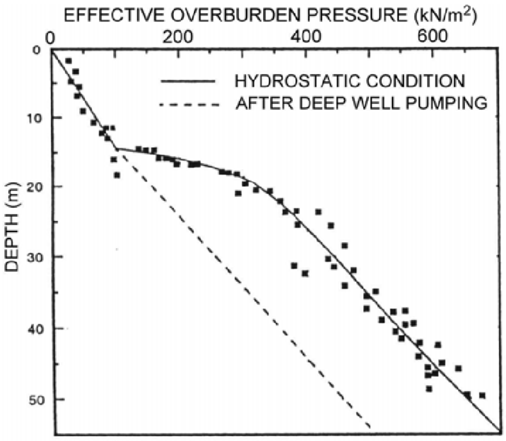

Fig.1 Variation of effective overburden pressure with depth

The authors have quoted ground improvement schemes with vacuum drains. It is concluded from two separate field tests with vacuum preload that, it was difficult to maintain the vacuum, one with large diameter sand drains and the other with PVD as well. The use of vacuum method of accelerating consolidation has in many other instances revealed that, the vacuum is difficult to maintain at depths in excess of 10m or so in terrain even without deep well pumping and associated piezometric draw down. Some of the case history in the Bangkok plain indicated the possibility of hydraulic connections between the large diameter sand drains or very closely spaced PVD and the deeper aquifers, which are under heavy piezometric draw down. Thus continuous consolidation settlements take place with the use of vertical drains even after the primary consolidation was complete from the surcharge load but because of hydraulic connections. An interesting case history is presented below.

Fig.2 shows the piezometric draw down at the site in which the Second International Airport is currently built. It is noticeable that the piezometric draw down continues to grow with time and this would imply that the soft clay properties would also change with time. And additional effect communicated by Prof. Raymond Yong in relation with the joint subsidence studies with Prof. Prinya and AIT, is the weathering effect of the soft Bangkok clay in the dry season when high temperatures are encountered and very large magnitude of suction pressures could develop in the clay due to capillarity action. This is one of the reasons often for new projects a set of new site investigation is carried out to check the variability in the soil property from the previous investigation carried out perhaps a decade or more before.

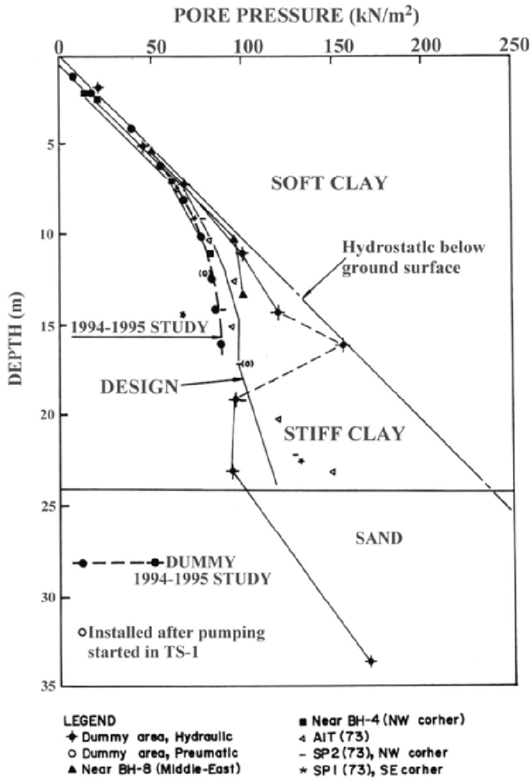

Fig. 2 Changes in piezometric drawdown with depth.

Fig. 3 shows the compressibility characteristics of the clay layers (see Leerakomson, 1979; Tonyagate, 1978) below the plain. The upper 10 to 20 m of the sub-soil is soft clay with very high compressibility and low shear strength. Since the land is low-lying, most of the areas are prone to heavy flooding during the rainy season and most development projects are on filled ground to raise the land above the flood level.

At the Second Airport site, it has been necessary to check the consolidation settlement arising from pore pressure dissipation with surcharge fill and PVD with the corresponding settlement observed from surface and sub-surface settlement plates. Thus an interpretation was made to calculate the consolidation settlement from pore pressure dissipation below the test embankment.

In Fig. 4, ML denotes the hydrostatic pore pressure distribution without any pore pressure decline. ABC denotes the in-situ declined pore pressure distribution prior the surcharge load. DEF represents the position of the pore pressures just after a surcharge of 75 kPa and prior to any dissipation of pore pressure. The end of construction pore pressure profile is also shown with the notation EOC. Subsequent pore pressure profile in June 1995 is also shown. Finally, when all the excess pore pressure dissipated the final stabilized ground water pore pressure condition is AMNPQ. This final pore pressure conditions indicate the PVD has re-charged the water table to near hydrostatic conditions up to 12m depth, the zone where PVD is used. However, the profile NPQ indicates a deficiency from hydrostatic pore pressure condition and this then extends in the sand layer below as well. A comparison of the degree of consolidation computed from pore pressure dissipation with those computed from settlement measurements is shown in Fig. 5

DEEP EXCAVATIONS AND TUNNELS

The piezometric draw down in the upper sand layer and the clay helps in the deep excavation works for basements of buildings, MRT stations, sewerage pipeline shafts etc. No boiling effect of the first sand layer is come across and the excavations are always dry and neat during the construction phase.

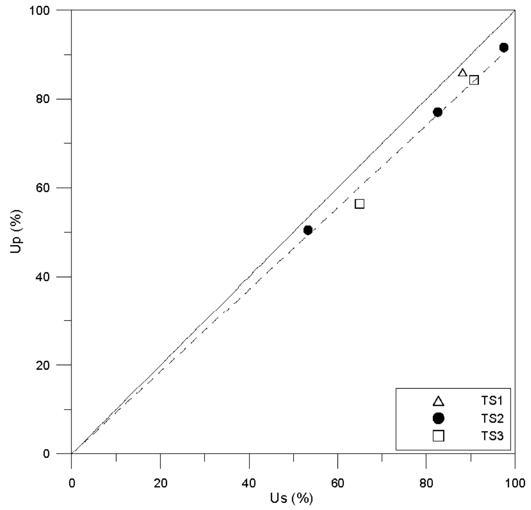

Fig. 5 Comparison of degree of consolidation from pore pressure dissipation with those computed from measurements

The writers' contributions are more related to the geotechnical civil engineering aspects of the subsidence. Hope these comments can further supplement the excellent material presented in the paper. The subsidence studies are far from being completed, since the analytical studies need to be carried out. Excellent work in this direction was done by Premchitt (1981), and Premchitt and Gupta (1981) as doctoral studies, and recent studies are continued by the second writer.

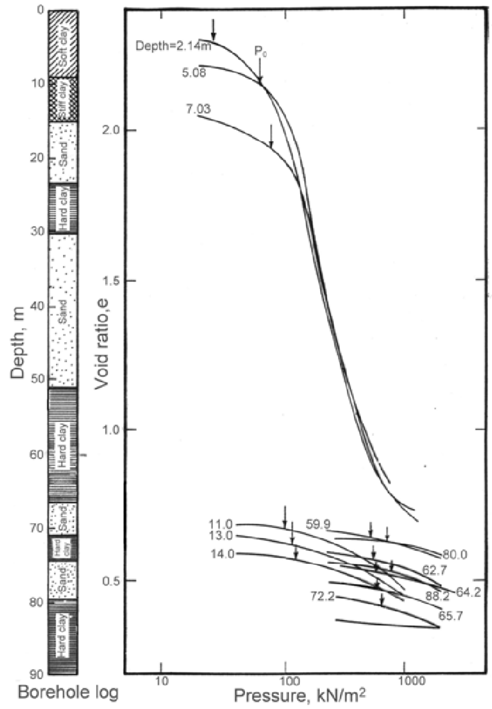

Fig.3 Compressibility characteristics of Bangkok clays up to 90 m depth

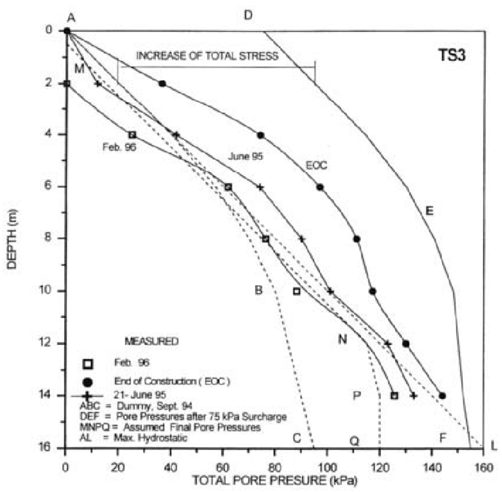

Fig.4 Excess pore pressure dissipation below test embankment with PVD

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