Talk on 'Some Case Histories on Control of Groundwater in Excavation Works'

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THE talk entitled 'Some Case Histories on Control of Groundwater in Excavation Works' was delivered by Engr. Dr Ooi Lean Hock of Gamuda Engineering on 28 June 2008 at the IEM Conference Hall, Bangunan Ingenieur, at 9.00 a.m. The lecture was attended by 170 participants.

Dr Ooi started his lecture by introducing the need for groundwater control for excavation works. He said that the control of groundwater is inevitable when excavation below existing groundwater level is required. The control of groundwater refers to the method used to maintain a relatively dry platform during excavation and, at the same time, maintain minimal impact on the surrounding environment and structures during excavation works.

In general, there are principally two methods of groundwater control, namely, the dewatering method and the exclusion method. The selection of a suitable method to control groundwater during excavations depends on many variables such as ground condition, depth of excavation, sensitivity of the surrounding structures and the element to be constructed in the excavation. Some case histories were used to illustrate the use of these two methods of groundwater control during excavations.

Once the concept of groundwater control is selected, the flow into the excavation may be estimated for the steady state condition using some published close form solutions or by graphically using flownets. In order to use the aforementioned approaches, the model used to simulate the problem would have to be simplified and a homogenous media would be adopted with a well judged boundary condition. In the age of modern computers, one can model the problem slightly better using finite element methods and, if possible, the use of transient flow would provide a better simulation, in particular, in the initial phase of pumping.

In light of the 'gross' simplification, the variability in the hydraulic conductivity of the ground and its heterogonous nature, it is a big challenge to get the pumping requirements right. Hence, pumping requirement is more art than science, and very often it is a battle at the site when dewatering becomes an issue.

In Malaysia, few incidents on the impact of pumping/dewatering activities were reported. The incidents include, but not limited to, the formation of sinkholes, building settlement and, in some cases, cracks on both structural and non-structural elements.

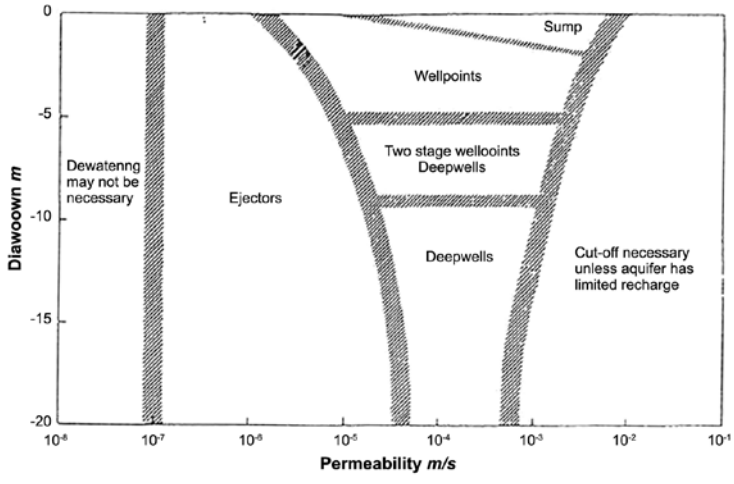
Dr Ooi reported that, in some way, Malaysians are quite fortunate that some form of retention system is used in most of our excavation works. In many cases, the design of the retention system (*eg.* sheet pile wall, diaphragm wall and *etc*) to meet the normal design requirements would have mitigated a large part of the dewatering concerns. The practice of using elaborate retaining systems as part of the permanent works makes it commercially viable to use these 'retention/cut off' in this country.

In some countries where the tanking of underground structures is required, the use of elaborate retaining structures is then not viable and, in such cases, the dewatering system to be deployed becomes more challenging. Dr Ooi further presented some local and overseas case histories of groundwater control.

CASE HISTORIES ON CONTROL OF GROUNDWATER USING DEWATERING METHODS

This is a simple method of keeping the excavation 'dry', however, the influence of the original groundwater level can be quite severe. This method of dewatering is commonly deployed in green field areas or areas where the impact of groundwater level lowering is minimal.

There are several methods of dewatering and the selection should be based on the depth of dewatering required and the permeability of the existing ground (see Figure 1).



(Robert, T.O. and Preena, M. Range of application of construction dewatering systems. Groundwater problems in urban areas. Thomas Telford, London, 1994, 415-423)

Figure 1: Selection of Dewatering Methods

(To be continued on page 30)

Plate 1: Two levels of well points employed for the dry excavated site

Plate 2: Well points + diaphragm wall for groundwater control

The successful implementation of a two level well point dewatering system for a cut and cover tunnel was presented. Plate 1 shows the general view of the two levels of well points that was used to keep the excavation 'dry'.

A local project where the use of well points in addition to the 'cut-off' offered by the diaphragm wall to lower the water at the base of the excavation further in order to facilitate the excavation and construction of the lift pit is also presented (see Plate 2).

The deep/tube well system has been successfully used in many parts of the world. However, the recharging and limitation of the commercially available pumps for a given well size and high permeable layer below the depth of excavation should be carefully examined when this system is adopted.

The use of trench and sump pumping was presented as another case history, and for this particular case, deep well system option was abandoned after further evaluation. This was due to a thick gravel layer placed by the reclamation contractor which was at an elevation that was higher than the excavated depth. Furthermore, to have an effective 'cone of depression', the target toe depth of the tube well would have penetrated well into a relatively pervious stratum.

The pumping effort was quite significant with eight numbers of 250m^3/hr pumps deployed for the dewatering. Plate 3 shows the ongoing excavation with trench and sump pumping dewatering method. In hind sight, the move to trench and sump pumping was in the right direction. Trench and sump pumping is more flexible in terms of increasing or reducing the number of pumps depending on the dewatering requirements.

In the case of deep wells, the number of wells would have to be predetermined. Furthermore, the risks could

Plate 3: Trench and sump for dewatering system

be quite high as the pump rate is highly dependent on the recharging, lifting head and associated submersible pump capacity for a given well. The need to create a 'cone of depression' would imply that that the depth of dewatering would be more than trench and sump pumping, hence, requiring more than 2000m^3/hr pumping capacity.

CASE HISTORIES ON CONTROL OF GROUNDWATER USING EXCLUSION METHODS

The exclusion method of control of groundwater generally involves the creation of a barrier to cut off the flow path or, in some case, to create a pressure at the face of the excavation to balance the water head. The latter normally involves the use of air or air fluid interface, and this may be more applicable to smaller sized excavation like tunnels and even caissons.

Plate 4: Momento Presented to Dr Ooi Lean Hock (left) by Engr. Yee Yew Weng

The type of grout to be used for sealing or providing the cut off is related to the particle size. A table showing the range of particles and tentative grout type is presented in Figure 2. The closure method of grouting used to form the 'cut-off' is well established in the dam industry, but it is relatively new in Malaysia especially when it is used to cut off the flow of water into an excavation.

This method requires early planning and treatment is to be carried out first prior to any excavation works. This method of excluding the inflow of water into the excavation is practiced for more delicate or sensitive projects as the method involves treatment to be carried in a preemptive manner and not a reactive manner.

The use of the above method was adopted for the excavation for cross passage for the SMART project (see Figure 3).

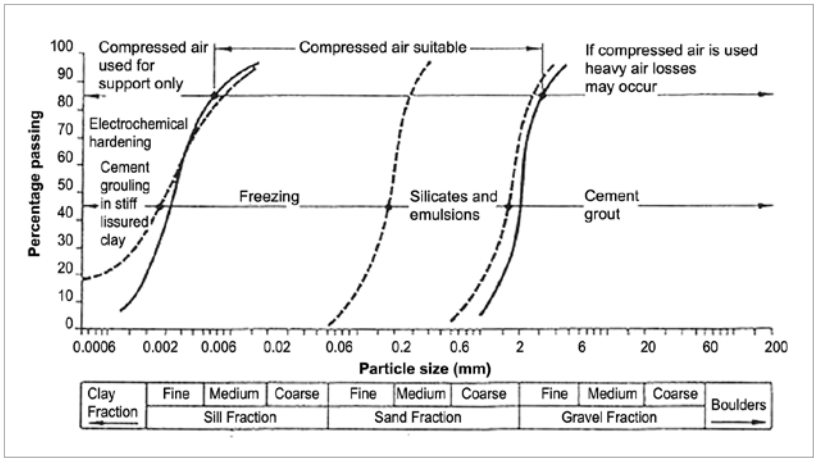


Figure 2: Tentative Ranges of Soil for Groundwater Exclusion Method (CIRIA)

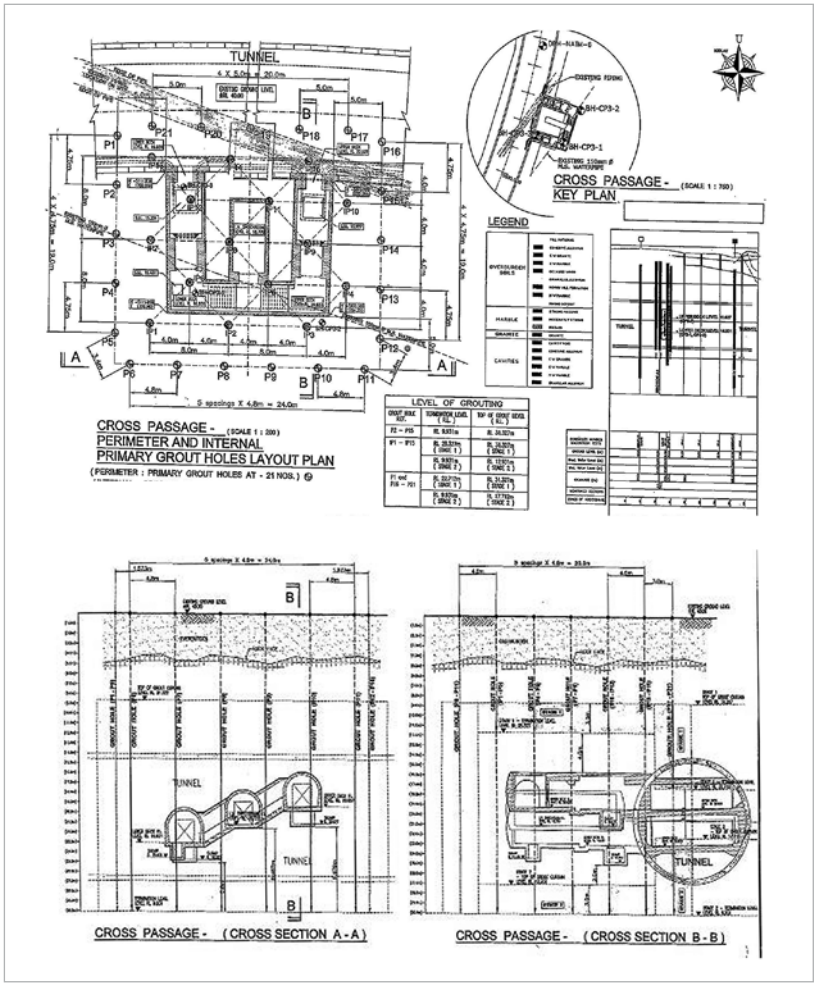


Figure 2: Tentative Ranges of Soil for Groundwater Exclusion Method (CIRIA)

The same project had also successfully used the slurry shield method to support the mixed face condition during tunnel excavation.

The talk ended at 11.00 a.m. with some interesting questions from the floor. Engr. Yee Yew Weng, Chairman of the Geotechnical Technical Division presented a certificate and token of appreciation to Dr Ooi for delivering the informative talk (Plate 4). ■