ABSTRACT

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This dissertation has two main objectives. The first one is to propose and justify a tunnel excavation procedure for a tunnel which will be excavated between concrete walls in recent deltaic sediments and below ground water level. The second objective is to analyse the possible barrier effect of the walls during the operating period of the tunnel and to study the measures aimed to reduce this effect.

With these objectives in mind geologic and hydrogeologic information of the area has been collected. A detailed stratigraphic and hydrogeologic study has been realized throughout the alignment of the tunnel. The compilation of data has been done from interpretation of previous campaigns in the area, drilling cores and correlation of these with CPTU results. Experiences on wells and piezometric tubes, and the realization of hydraulic tests (pumping and pulse tests) have also provided the data needed.

The hydrogeologic information obtained throughout the alignment confirms the Llobregat's Delta model of the GHS*. The alignment of the tunnel passes through the *Silt Wedge*, a sequence of fine sand, silt and mud. This wedge lowly-consolidated and behaves as an aquitarde which separates two aquifers. One of them is superficial and it is found above the inverted vault of the tunnel. Considering the concrete walls essentially as an impermeable element and non-permanent flow parallel to the alignment of the tunnel, this aquifer could be affected by a barrier effect. The *Main Aquifer* (under the *Silt Wedge)* represents an strategic water supply reservoir. With the aim of protecting this reservoir the depth of the walls has been limited.

Under these constructive and hydrogeologic factors no simple solution can guarantee the non-siphoning of the soil during the excavation process. The solution proposed advises to drain the soil below the inverted vault of the tunnel using bleeder draining wells. By doing these, it is intended to reduce the groundwater level so it sis possible to work on a dry surface, to avoid siphoning phenomenon and to reduce vertical gradients at depths near the excavation surface. It is also intended to limit the sweep of the fine fraction and to promote the preconsolidation. The main objection against this solution is that no previous experience has been carried out on the drainage of this type of material.

The siphoning risk evaluation, performed with or without the use of bleeder draining wells, as well as the estimation of the vertical gradients and the water pressure on the walls, has been carried out by means of the sensitivity analysis of a finite element model. The data for the analysis of the *Silt Wedge* hydrogeologic behaviour has been obtained from a pumping test using a single well and three control piezometric tubes which have been designed as proposed. The interpretation of this test has been done with the use of a computational model. This has allowed the estimation of permeability and store coefficients for the simulation in transient state of the proposed scheme. The results obtained have confirmed the feasibility of draining this soil in time periods shorter than a month. This can be possible if only joint continuity does not occur between wall block. Joint continuity would increase wall permeability. The pumping test has confirmed that it's possible to drain part of these sediments without significant sweeping of the fine fraction if an adequate filter is used.

The barrier effect has been evaluated in a regional scale. It has been simulated adding the alignment of the tunnel to the calibrated Llobregat's Delta Model developed by the GHS*. The evaluation has been carried out in transient regime in a time period of 36 years discretized in monthly ranges. The corrective measures proposed consist of a series of lance drillings that connect both sides of the tunnel. The simulation of these drillings in the model has been done assuming an equivalent transmissivity.

The ground water levels have been obtained and compared in three scenarios in a reference period of time: without the tunnel, with the tunnel and without the corrective measures and finally, with both the tunnel and corrective measures. The ground water levels used as reference are more unfavourable than the obtained from measurement campaigns. As a result, the reference ground water levels chosen are conservative values. In this period of time the ground water levels descents behind the barrier scored values over half a meter throughout almost 1 km of the alignment of the tunnel. In the worst scenario in time, the descents would vary from 3.5 meters to 0.5 meters if corrective measures are assumed. In consequence, it is advised to adopt these measures.

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