Dewatering system of a deep of excavation in urban area – Bucharest case study

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Abstract

Many excavations for basement construction will encounter groundwater. If not suitably managed and controlled, groundwater can cause problems for excavation and the buried structures themselves. These problems can range from nuisance seepages that reduce the efficiency of construction operations, through to major inflows that can result in instability, flooding and even collapse of the excavation.

Groundwater can be a significant problem when excavating for basement construction. However, with good planning and the use of suitable methods groundwater need not be a major obstacle.

If an excavation is made without suitable groundwater control various problems can result:
- the excavation may flood as a result of groundwater inflows from water-bearing layers of soil or rocks.
- high pore water pressures in batter slopes at the sides of the excavation may lead to instability or seepage erosion.
- groundwater uplift pressures beneath the floor of an excavation can give the risk of a base heave or piping failure in the base of the excavation.
- groundwater pressures can cause excessive hydrostatic loads on excavation retaining structures such as concrete pile walls.

Dewatering methods (also known as groundwater control methods) can be used to control groundwater and avoid these problems. This is an especial problem when excavating in water-bearing soil (such as sands and gravels) or fissured rock (such as chalk or sandstone). Without suitable control measures, inflows of groundwater can flood excavations or tunnels, and can also lead to instability when the soils or rock around the excavation weaken and collapse – either locally or on a large scale.

The current modern techniques allow the execution of the deep excavations in the urban zones in more difficult geotechnical and hydrogeological conditions.

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The main methods which provide the removal of the groundwater from the deep excavations are:
  
  o Direct dewatering – the direct pumping of the water which penetrates through the walls and the background of the excavation;
  
  o Indirect dewatering – the general descent of the groundwater level, through point wells needle filters or dewatering wells, done before the excavation;
  
  o Achieving of the watertight barrier that prevent the groundwater penetration in excavation.

For the execution dry environment works, in most of the situations it is needed the lowering of the groundwater level. Dewatering works provide the possibility of dry digging execution under the groundwater level.

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Keywords: dewatering system; deep excavation; groundwater; drawdown; wells.

1. Introduction

The construction of deep excavations in the urban environment is a technically challenging problem. The design and execution of deep excavations in urban areas require knowledge of the expected environmental impact which includes two types of the influence: changes of stress state in a subsoil and technological influence.

Groundwater poses a number of challenges to underground infrastructure projects being encountered in excavation underground infrastructure works such as multi story basements or tunnels. Working below groundwater level can be difficult, as the excavation is at risk of instability and flooding, however, modern geotechnical designs and technologies allow groundwater to be safely managed.

While in congested urban areas, space is at a premium, civil engineering often encounters a poorly treated issue, groundwater, a problem when excavating in water-bearing soil (such as sands and gravels) or fissured rock (such as chalk or sandstone). Without suitable control measures, inflows of groundwater can flood excavations or tunnels and can also lead to instability when the soils or rock around the excavation weaken and collapse – either locally or on a large scale.

Traditional methods which provide the removal of groundwater level for the protection of deep excavations encounter several problems specific to each particular project, for example: enclosed buildings, large volumes of water to be discharged, the aquifer homogeneity.

The rapid development of deep excavations in urban areas has generated the possibility of multiple dewatering works or drainages, thus influencing the natural groundwater flow through recharges and discharges of the groundwater system. Most of them can be temporary, during works, but they can be also final to prevent, for example, the appearance of the increase of pore pressure.

2. Case study - Bucharest

The city of Bucharest, Romania, is subjected to a continuous development regarding the infrastructure works, with high underground water tables consisting in confined aquifers, the impact of these new constructions on the environment being increasingly higher, as several hydrogeological studies, carried out over the past several years, have indicated.

As the influence of groundwater works is essential to the impact on the existing buildings and infrastructures, in the design phase of each new project, in the case of deep excavations in Bucharest’s urban area, the influence of dewatering systems is subjected to critical awareness, having minim one aquifer encountered by the excavation works.

For a local project situated in Bucharest, with a surface of about 3300 m², a deep excavation of approximately 19,00 m is required.
3. Site Conditions

The geotechnical report available for the site indicates a uniform alternation of soil layers, mainly consisting in thick layers of sand and silt, with local thin layers of clay. The Romanian norm describes the project’s geotechnical risk as major, characterized with 19/22 points.[1]

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00m ... -2.95m</td>
<td>Filling</td>
</tr>
<tr>
<td>-2.95m ... -13.00m</td>
<td>Sand and gravel</td>
</tr>
<tr>
<td>-13.00m ... -14.00m</td>
<td>Clayey silt</td>
</tr>
<tr>
<td>-14.00m ... -16.00m</td>
<td>Sand and gravel</td>
</tr>
<tr>
<td>-16.00m ... -24.00m</td>
<td>Stiff silty clay</td>
</tr>
<tr>
<td>-24.00m ... -31.00 m</td>
<td>Sandy silt</td>
</tr>
</tbody>
</table>

From a hydrogeological point of view, there are two confined aquifers which will be encountered during the excavation works and must be taken into consideration in the design phase of the project:

- A superior water level, confined in the Colentina gravels horizons, with a groundwater level intercepted at depth of about -4.00m;
- An inferior water level, confined in the Mostistea sand horizons, with the groundwater level was intercepted at depth of about -6.00m, being under pressure with 19.0m of water table.

4. Dewatering system

Due to the project’s structural peculiarities, structural solutions consisting in water tight barriers, such as cut off walls, secant piles or diaphragm walls embedded in the inferior clay layer were not applied. In order to avoid the loose of stability of the ensemble and safely reach the final excavation level, dewatering works were necessary for lowering the inferior aquifer’s pressure with approximately 10.0m of water table, against hydraulic cracks and uplift effects.

The structural configuration of the project imposed the dewatering system to be carried out on the exterior of the excavation outline. By reducing pressure of the confined aquifer, the base soil is protected against hydraulic lift during the excavation process.[1]
For this purpose, a dewatering system consisting in 14 dewatering wells positioned on the exterior of the diaphragm wall enclosure has been developed, pumping water from the under pressure aquifer at a rate of approximately 160 m$^3$/h.

![Fig. 2. Plan with the positioning of the dewatering wells](image1)

The seizing of the dewatering system is based on tests made on four boreholes symmetrically situated around the excavation;

The results obtained from pumping tests was used to estimate the hydrogeological parameters in order to dimension the entire group of wells.

![Fig. 3. Plan with the positioning of the sample wells](image2)

The hydrogeological parameters resulting by calculation in order to dimensioning the contour system of dewatering drilling are presented in table 2: [2]
The final drawdown provided by the dewatering system was of 12.0 m, sufficient to allow a safe operation and development of the construction inside the excavation pit, ensuring conditions against uplift and hydraulic fracturing were obtained.

Due to the high quantities of evacuated water, confirming the limited influence of the dewatering system on neighboring areas was necessary and imposed by means of monitoring of the aquifers, carried out through piezometers, for both the superior water table and for the inferior confined aquifer, thus also confirming the performance of the designed dewatering system and providing an ensemble view on the in-time global behavior of the system.

To follow the efficiency of the dewatering system, the groundwater levels it was monitored, it can be seen in the next figure.

<table>
<thead>
<tr>
<th>K (m/zt)</th>
<th>Va (m/s)</th>
<th>Q (m³/h)</th>
<th>T (m²/s)</th>
<th>R (m)</th>
<th>Qtotal (m³/h)</th>
<th>n (-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.6</td>
<td>0.000867</td>
<td>12.0</td>
<td>0.00135</td>
<td>360.0</td>
<td>160.0</td>
<td>14.0</td>
</tr>
</tbody>
</table>

Fig. 4. The evolution of the underground water level

The necessary time for a dewatering system it expands during execution time of the excavation works and during execution for the work on structural strength, subsequent for a sealed foundation.

5. Conclusions

Throughout its operation the pumping system did not affect the surrounding buildings, and neither the groundwater level.

The main problems made by the drainage and the dewatering works, are the evacuated and the exhausted debits, also the risks by mechanical effects such as the hydrodynamic of the small particles, the hydraulic breaking of the base, of the excavation, subsidence, the reducing of the passive resistance mobilized on the supportive buried sheet works.

It is indicated that the dewatering system adopted to heed the following, when is possible:

- for excavation, the sides of the excavation to remain all the time stable under the effect of the downhill of the underground water, also, may not occur the excessive swelling or the breaking of the base, for example because of an excessive pressure of the water under an less permeable layer;
the adopted system do not occurred excessive subsidence or damage to the neighboring building;
the adopted system to avoid the excessive loss of the land due to the water flow true the wall or true the excavation based;
for the drilling it must ensure an efficient filter to avoid the significant transport of mud together with the pumped water;
the dewatering system to be designed, and installed such as to maintain the water levels and the pressures in the pores that are in the project without significant fluctuations;
to have an corresponding reserve of the pumping capacity and an backup facility available in case of a power failure failure.
There are many example of underground construction provided to be achieved to a certain depth and which, because of the weakness to descend the underground level without influence the surrounding buildings, the constructions had to be reduced like depth.

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References