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PROTECTION OF THE CONSTRUCTION PIT OF THE KT PUBLIC GARAGE IN VARAŽDIN (CROATIA)

Protection of construction pit for public garage on Kapucinski Square (KT) in Varaždin was performed in cohesionless soil under high level of underground water. Original design was to seal off pit bottom by jet grouting. That design solution was the result of local experience and practice. In accordance with the proposalmade by geotechnical monitoring, new design solution was done. New design consisted of deepening the diaphragm and continuous pumping of groundwater. There have been additional investigations which have confirmed the design assumptions. The price analyzes showed that the new solution is more economically. Construction of pit and underground garage construction was carried out successfully and in accordance with the new project solution under the constant geotechnical supervision.

Keywords*: construction pit, permeability, supervising geotechnical engineer, monitoring.*

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ЗАХИСТ КОТЛОВАНУ ГРОМАДСЬКОГО ГАРАЖА В М. ВАРАЗДІН (ХОРВАТІЯ)

Захист котловану для громадського гаража на площі Капучинського у м. Вараздін був виконаний у незв'язному ґрунті при високому рівні підземних вод. Початковий проект передбачав ізоляцію дна котловану за допомогою струменевої цементації. Це проектне рішення було результатом місцевого досвіду та практики. Відповідно до пропозиції, внесеної в результаті геотехнічного моніторингу, було прийнято нове проектне рішення. Новий проект полягав у поглибленні водозахисної діафрагми та безперервному відкачуванні води. Також було проведено додаткові дослідження, що підтвердили проектні допущення. Економічне оцінювання показало, що нове рішення дешевше. Улаштування котловану та підземного гаража було успішно виконано відповідно до нового проектного рішення під постійним геотехнічним спостереженням.

Ключові слова*: котлован, проникність, інженер з геотехнічного нагляду, моніторинг.*

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ЗАЩИТА КОТЛОВАНА ОБЩЕСТВЕННОГО ГАРАЖА В Г. ВАРАЗДИН (ХОРВАТИЯ)

Защита котлована для общественного гаража на площади Капучинского в г. Вараздин была выполнена в несвязном грунте при высоком уровне подземных вод. Начальный проект предусматривал изоляцию дна котлована с помощью струйной цементации. Это проектное решение было результатом местного опыта и практики.

Согласно предложению, внесенному в результате геотехнического мониторинга, было принято новое решение. Новый проект заключался в углублении водозащитной диафрагмы и непрерывном откачивании воды. Также были проведены дополнительные исследования, которые подтвердили проектные допущения. Экономическая оценка показала, что новое решение дешевле. Устройство котлована и подземного гаража было успешно выполнено, согласно новому проектному решению, под постоянным геотехническим наблюдением.

***Ключевые слова**: котлован, проницаемость, инженер по геотехническому наблюдению, мониторинг.*

Introduction. The paper describes the course of work on the execution of the construction pit protection structure for the public garage project at the kapucinski square (kt) in varaždin. Previous works on the protection of construction pits at varaždin, which have been going on for more than four decades, have been very difficult owing to the presence of high ground water levels (on average about 4m under the ground surface), while structures in question were considerably smaller in size and had lesser ground depth than the kt garage. Taking into account the mentioned factors and having in mind additional findings about ground conditions in varaždin [1] (that primarily consist of cohesionless materials) from the very beginning of works all participants in the construction were aware that they were faced with a great challenge. The first design solution [2] for the protection of works in dry conditions was sealing (of) the construction pit bottom using jet grouting i.e. Establishing lesser permeability ("bottom clogging"). A problem, however, consisted in a difficult execution of a test field of jet grouting due to the unexpected compactness of cohesionless material in the area of the designed sealing [3, 4]. Following the recommendation of the supervising geotechnical engineer additional investigations that included field and laboratory testing were undertaken [5, 6].

Based on the collected data, established facts and after considering all the aspects the supervising geotechnical engineer was contemplating all the issues, studying them and suggesting alternative options to other participants in the construction and most of all to the design team. After quickly implemented procedures the expert team thought about possibilities to come up with a better design solution which consisted of a considerably simpler approach to the problem. A new solution [7] implied a deeper standard waterproof lateral diaphragm and constant pumping of ground water on several positions within the construction pit. The implementation of this solution was not accompanied by any adverse events as it was the case with earlier projects.

Initial project solution. Initial solution concept of protection [2] to work in dry environment was “sealing” the bottom of the construction pit by using a jet grouting method i.e. By establishing a reduced permeability ("bottom clogging).

This project solution was created with the knowledge of initial geotechnical report [1] which shows that the project location is composed of cohesional material, i.e. mixture of gravel and sand and it is known that such material is theoretically highly permeable (glacial till) [8 – 10] which means that the procedure is impossible to perform without “sealing” the bottom of the construction pit. It's also been known that in the last four decades on to the neighboring locations there have also been major problems even on the simpler structures.

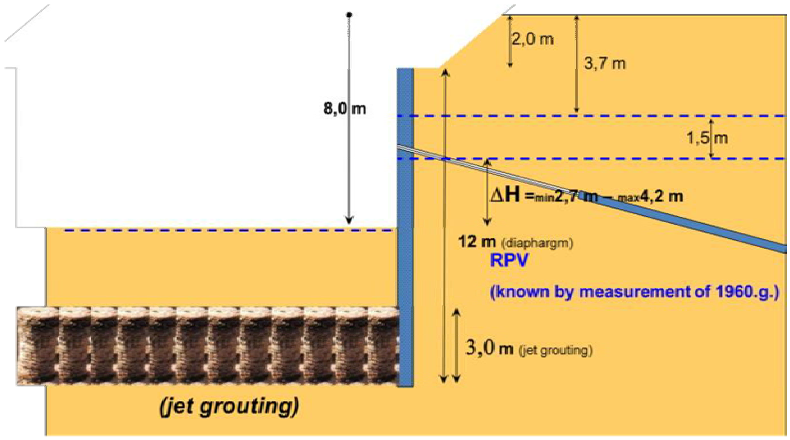

Fig. 1.The initial solution for protection of construction pit

Calculating the percolation using known theoretical interval of limits of water permeability coefficient for the cohesionless materials the result showed huge quantities of water in specific period of time, i.e. more than 500 liters per second for subject construction pit considering the situation without bottom improvement ("bottom clogging").

Due to problem arising at the only beginning of the performance i.e. difficulty performing experimental jet grouting field because of the unexpected compactness of cohesionless material in the area of the designed sealing, supervising geotechnical engineer decided for fast additional investigations.

Observations - research during construction. When predicting the behaviour of geotechnical interventions is difficult then it is appropriate to apply the approach known as “observation methods” (methods of scientific observation or monitoring) in which project designs/amends during the process of construction on field [11].

Course of research was agreed and concluded among other things, must be:

- Monitoring reveals whether there is justification for observation, ie supervising geotechnical engineer decides whether the outcome will be within acceptable limits,
- Feedback and testing results must arrive fast enough in relation to the possible development of events in the system performance, and it is necessary to meet the deadlines
- Additional tests during construction ie observation results confirms supervising geotechnical engineer.

Additional research consisted of:

- additional investigations of cohesionless material from project location that included field and laboratory testing
- gathering information about the construction pit protection from water on similar sites, and examining the preserved records, photos, articles,

interviews and more.

Field testing of permeability was examined by depth in boreholes [5]. Based on the more in depth test results were obtained with slightly lower permeability coefficients but not yet promising because after the calculation with this lower coefficients the result was still a considerable amount of water. Hope for further study were those that these field test permeability coefficients were horizontal and not vertical. The assumption was that the vertical permeability coefficient is much smaller than the horizontal one.

Laboratory tests [6] of particle size distribution (granulometric tests) were quite promising for permeability of the specific soil layer just below the depth of the construction pit but it was still rated as layer of insufficient thickness and position.

Second Project Solution. After this information and during the next research supervision proposed a new solution with 3 m deeper standard waterproof lateral diaphragm compared to the initial solution. Expert team accepted new project solution which consisted of deeper standard waterproof lateral diaphragm and 2,5 m layer of jet grouting or less if justification for that is noticed during the performance.

Third (final) project solution. Supervision still proposed a new research method. Additional studies after the field and laboratory testing took place. It was only field test which included smaller excavation pit in the middle of the construction pit same depth as the final construction pit and pumping the underground water with option for reducing ground water level to the required one.

With this possible lowering of groundwater level, piezometers were installed in and out of the construction pit to measure the water depth (for observing the water pressure at a depth below the bottom of the construction pit). The water level was lowered to the required level with decreasing >3,5 m with pumping 70 liters of water per second.

After these results, which were contented because water level dropped to the project designed level only with water pumping and at the same time taking into account the water pressure in the piezometers at a depth below the bottom of the pit.

After these results, a new project solution III [8] is suggested (and the final one) which consisted of deeper standard waterproof lateral diaphragm along with bottom pit drainage with drains and groundwater pumping in the middle of the construction pit. Along with this solution [8], in addition to the stability of the construction pit, supervision proposed pumping water from drilled wells depth of 7 m below the bottom of the construction pit.

This solution with additional pumping from drilled wells consisted of the total pumping capacity of 100 liters of water per second until establishing the equilibrium pressure of the weight from the building and water pressure (buoyancy).

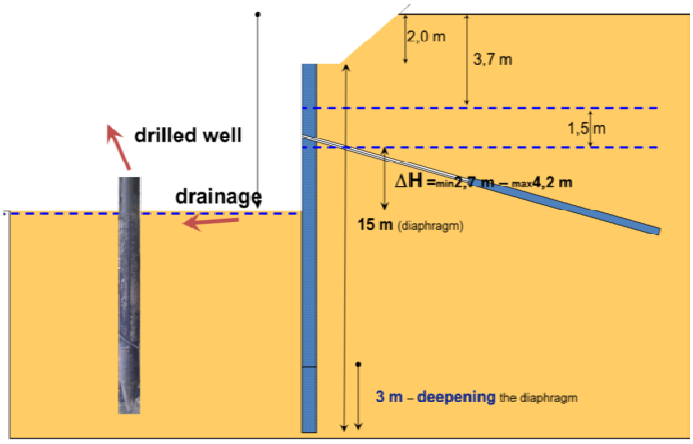

Fig. 2. Final project design solution

Conclusion. Observing the whole process performance, in addition to proposing additional research during construction supervision has proposed and designed solutions during the construction progress [12]. Gathering information about the construction pit protection from water on similar sites played a major role in this. Final project solution was successfully performed, without any adverse events, with achieving economically, easier and simpler solutions compared to the previous project solutions on the same object and in relation to projects in the past on the nearby buildings with the same problems and the same goal.

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