**How to cite:** Beilicci, R.F., Beilicci, E.B.M. (2023) Advance Hydraulic Modelling of Excavation Pit, Study Case ISHO Timisoara, Romania. *2023 "Air And Water – Components of the Environment" Conference Proceedings*, Cluj-Napoca, Romania, p. 66-73, DOI: 10.24193/AWC2023_07.

# ADVANCE HYDRAULIC MODELLING OF EXCAVATION PIT, STUDY CASE ISHO TIMISOARA, ROMANIA

***Robert Florin BEILICCI [1], Erika Beata Maria BEILICCI [1]***

**DOI: 10.24193/AWC2023_07**

**ABSTRACT.** - In the case of the present study, the three-dimensional PMWIN software was used, which is based on the finite difference method. A numerical modeling of the aquifer in the vicinity of the Bega canal where the component buildings of the ISHO study area are located was carried out. The modeling technique carried out allowed the numerical and hydraulic modeling of all types of sediments necessary to lower the water table in order to safely build constructions with a large foundation depth on the site, especially in the conditions of a significant groundwater supply due to the proximity of the Bega watercourse. Considering the complexity of underground hydraulic phenomena for which there are no exact calculation methods without simplifications, the only viable solution was the use of numerical modeling based on existing methods (element finite, boundary elements, finite differences); these modeling's are difficult, especially regarding the calibration and validation of the numerical model. The presented method allows the optimization of the number of boreholes, respectively of the captured flows so that, with a minimum energy consumption and a minimum cost of the execution of the boreholes, it is possible to achieve the water level conditions necessary for the realization of underground constructions.

**Keywords**: excavation pit, numerical modeling, finite difference method, dewatering system, boreholes

## 1. INTRODUCTION

ISHO (Fig. 1) is a complex ongoing project, which proposes a two-part development: (***, 2017)

- An office area consisting of office buildings (built in 3 stages), a multi-storey car park and a hotel under the Radisson Blu brand.
- A residential area, called ISHO Living, consisting of 6 blocks

Spread over an area of 5 hectares between Take Ionescu boulevard and the Bega canal, the complex will finally include a residential area with 1,200 apartments (with 1-4 rooms), the first top international hotel in Timisoara and ultra-modern offices on 50,000 square meters for rent in the office area. At the same time, there will be a

---

[1] Hydrotechnics Department, Civil Engineering Faculty, Politehnica University of Timisoara, Timisoara, Spiru Haret 1A, 300022, ROMANIA, robert.beilicci@upt.ro

variety of related functions: commercial spaces, restaurants, cafes, kindergarten, medical services, leisure areas (park, swimming pool and gym), including a cultural space for events and exhibitions.

The residential complex consists of six blocks with the following height regimes:
- two blocks: S+P+ 6 floors
- two blocks: S+P+15 floors
- two blocks: S+P+20 floors (***, 2017).

**Fig. 1.** ***ISHO Timișoara complex area layout plan.***

The whole complex is designed as a unitary whole. ISHO Riverside A, the 20-storey block located on the Bega river bank, is currently the tallest completed residential building in Timișoara, with a total height of 70 meters (65 meters the maximum height of the building to which the equipment and installations are added from the non-circulating terrace type roof).

At the same time, the building has the highest practicable floor. The Riverside building block D with a height of S+P+20E, covers a built area of 1,549 square meters and has a maximum height at the cornice of +65.18 meters. The building houses 4 spaces for rent for trade and services on the ground floor (the largest area occupied by the Mega Image store), and on the upper floors there are residential apartments of different surfaces and sizes. The building is equipped with an underground parking lot that has 106 parking spaces and booths, 2 elevators, 2 fire escape stairs. It was designed to comply with the regulations in force: minimum area of living rooms 12 square meters, minimum area of closed kitchens 5 square meters and minimum floor height of 2.6 meters (***, 2017).

## 2. PROPOSED WORKS AND METHODOLOGY

To remove water from the site of the ISHO Living development (residential complex) a dewatering system was designed, executed and monitored to ensure adequate working conditions. To begin with, a geotechnical study and a hydrogeological study were prepared (Gabor E., 2018).

The exhaustion plan was drawn up with the aim of facilitating the construction of 2 blocks (S+P+20E, respectively S+P+6E) in the vicinity of the Bega river. 13

boreholes were used to evacuate the underground water present in the construction site (Fig. 2.). For the phreatic aquifer, total depletion boreholes were executed. There were no precautions in the execution of the exhaustion because there are no neighboring buildings in the immediate vicinity (Hai-Min LyuShui, 2018).

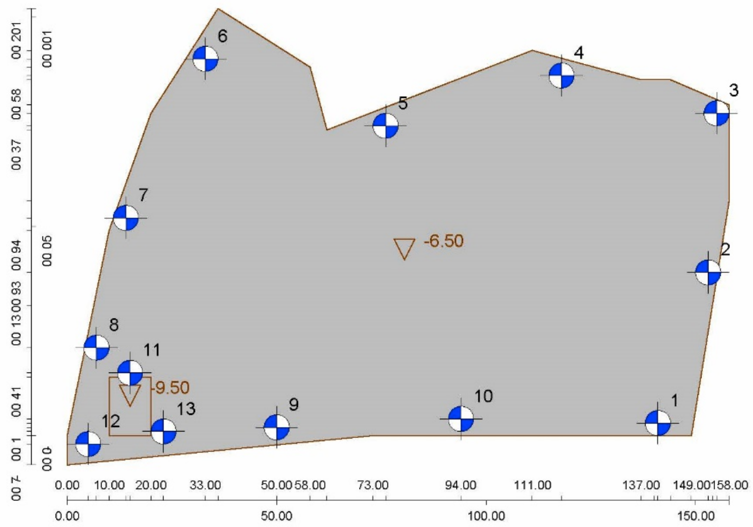


**Fig. 2.** ***Location of boreholes.***

Having a common basement with the neighboring building, U1 (with height regime S+P+4E), the boreholes were designed to serve both buildings (execution being carried out in parallel). Thus, they were distributed according to figure 3.

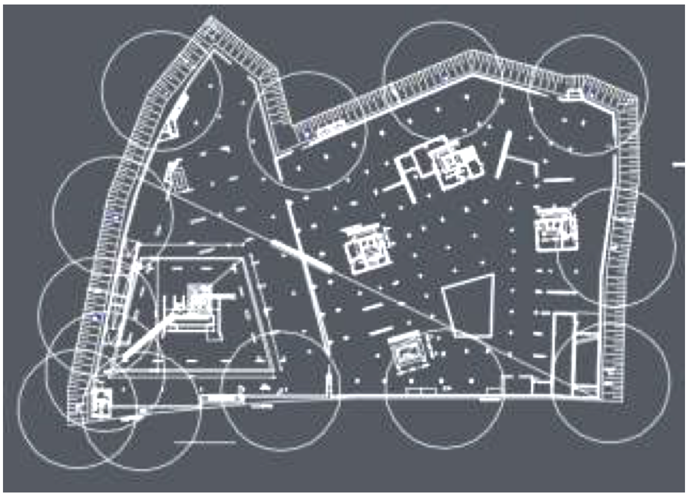

**Fig. 3.** ***Elevation of wells for scum.***

In the case of the ISHO Living project, the boreholes were drilled with a 700 mm diameter pipe and equipped with a 300 mm pipe. Initially, according to the project, 10 boreholes were planned up to a depth of 12 meters. For safety, the underground water level being a high one, but also taking into account the proximity of the Bega River, the beneficiary requested the addition (compared to the initial solution) of the 10 proposed boreholes with 3 more of the same diameters, but up to a depth of 16 m. were equipped in the configuration provided by the designer, respectively with pumps up to 5.5 kW (***, 2017).

Each borehole was equipped with lower and upper-level sensors to keep the water at the optimal depth for the excavation. An automatic alarm system was also provided, which will notify by GPRS call any failure of a pump or interruption of the energy supply.

The objectives of the studies are numerical modeling of the underground water level in the perimeter of the foundation pit (Chao-Feng, 2021).

Processing Modflow (Modular Hydrologic Model) for Windows (PMWIN) is a complex software that allows two-dimensional and three-dimensional simulations used for modeling flow and transport processes in groundwater. The software is widely used by specialists due to the accuracy, reliability and efficiency of the obtained simulations (Chiang W., 2017).

In the case of the present study, the three-dimensional PMWIN software was used, which is based on the finite difference method. A numerical modeling of the aquifer in the vicinity of the Bega canal where the component buildings of the ISHO study area are located was carried out.

The realization of the numerical models required a topographical and hydrogeological database that would allow the establishment of the necessary elements for the construction of the models. These data are:

- the layout plan. The topographical base was necessary in order to determine the elevations of the land in the studied area;

- the hydrogeological studies that resulted in the stratification of the land, the flow rate and the level in the Bega canal;

- the flows extracted from the exhaustion wells (Chiang W., 2017).

This paper shows a plan view and a cross section through a shallow aquifer situated in a valley. In the north the aquifer is bounded by the outcrop of the sediments in the valley, while the south boundary is a river, which is in contact with the aquifer. The aquifer extends several hundred meters to the west and east, it is unconfined, homogeneous and isotropic. The task is to calculate the inflow into the pit and show head contours and catchment area of the pit.

## 3. RESULTS AND DISCUSSIONS

Based on these studies, it was possible to determine the following elements that were the basis for the realization of the numerical models:

- The perimeter of the hydraulically significant area

- Boundary conditions. These conditions that essentially determine the development of underground water movement are the result of natural conditions. These conditions are as follows:

- Level imposed on the Bega canal variable: 83.9 - 84 m;

- Level imposed on the north side variable 83.8 – 83.9 m corresponding to the hydrogeological study ("Romanian Waters National Administration, 2015);

- The limits of the model on the other sides were modeled as a streamline.

- The characteristics of the aquifer - a constant permeability (filtration coefficients of kf = 38 m/day).

The data were entered interactively, with the possibility to modify relatively easily certain parameters such as for example: discretization of permeability, base elevations, granularity of the layers (Xiao Bing, 2022).

The perimeter of the hydraulically significant area was included in the active area of the numerical model, the adjacent areas being eliminated. In the horizontal plane, a discretization of dx = 3.6 m and dy = 2.6 m was used. In the vertical plane, a discretization was used on 1 vertical layer with a free level (50 m).

In the first stage, the studied area was modeled in the initial hypothesis, when there were no investment objectives; in this way, the hydroisoips representing the existing groundwater levels were obtained (Fig. 4.).

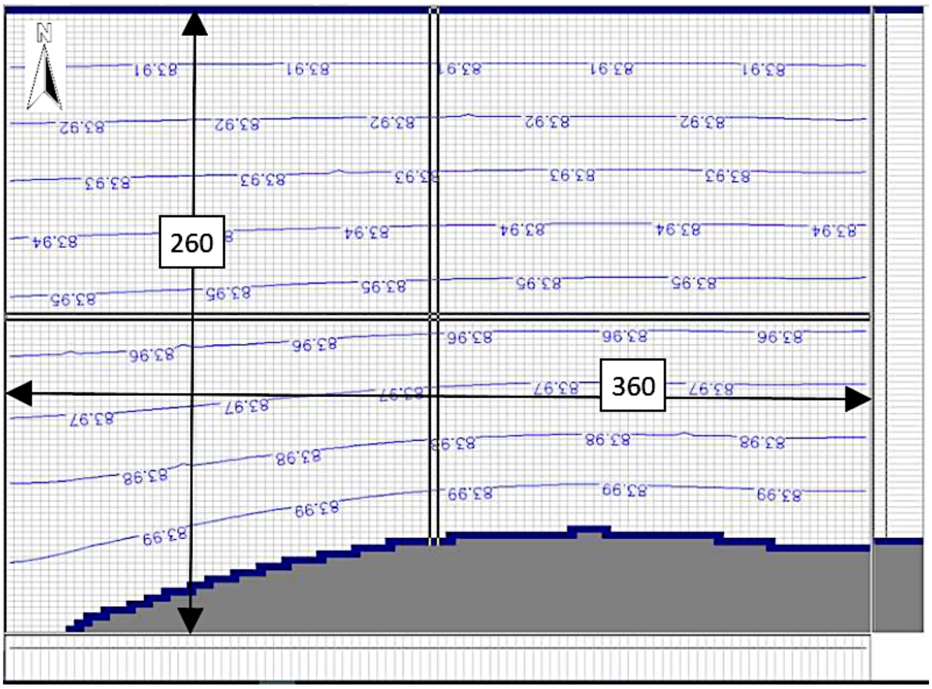


**Fig. 4.** ***Groundwater level – initial stage.***

On the model created in the first stage, after checking the levels obtained with those from the existing hydrogeological studies (resulting in a good correlation), we moved on to modeling the studied area in the hypothesis of the execution of the depletion works. Exhaustion drillings were introduced imposing the used flow rates. (Tao YangLi-yuan., 2023)

In this way, the level of underground water resulting from the modeling of the extraction wells was obtained (Fig. 5).

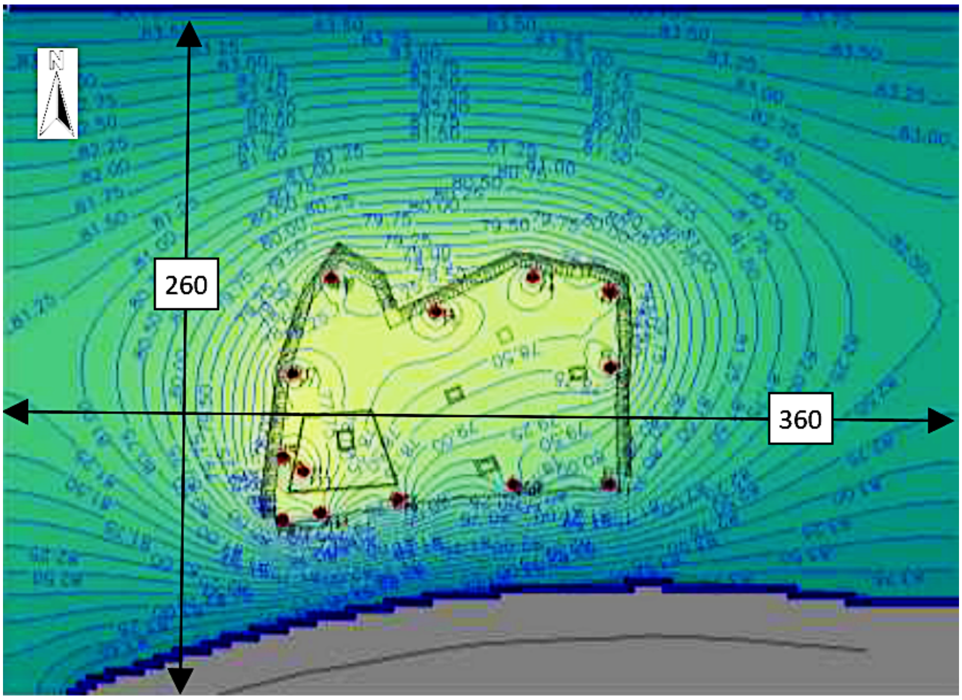


**Fig. 5.** ***Groundwater level – exhaustion stage.***

During the execution period, periodic measurements were made in the boreholes. Following the comparison of the modeled values and those measured in the field, a good correlation resulted according to the adjacent figure (Fig. 6) (Horris K., 2022).

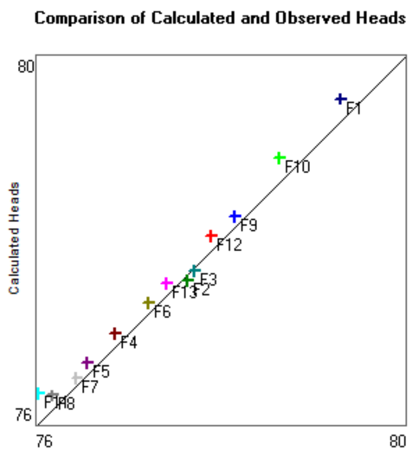


**Fig. 6.** ***Correlation diagram between modeled and measured values in the field.***

## 4. CONCLUSIONS

A building is considered tall if it has more than 11 floors without a ground floor and very tall if the floor of the last level is at a minimum height of + 45 m.

In the 20-story building studied in this paper, a dual structural system was used, consisting of the perimeter frames (consisting of the closing beams and the facade pillars) and the structural walls of the central core (made of reinforced concrete).

The modeling technique carried out allowed the numerical and hydraulic modeling of all types of sediments necessary to lower the water table in order to safely build constructions with a large foundation depth on the site, especially in the conditions of a significant groundwater supply due to the proximity of the Bega watercourse.

Considering the complexity of underground hydraulic phenomena for which there are no exact calculation methods without simplifications, the only viable solution was the use of numerical modeling based on existing methods (finite element, boundary elements, finite differences); these modeling are difficult, especially in terms of calibrating and validating the numerical model.

The presented method allows the optimization of the number of boreholes, respectively of the captured flows so that, with a minimum consumption of energy and a minimum cost of execution of the boreholes, it is possible to achieve the water level conditions necessary for the realization of underground constructions.

The results obtained through modeling were verified during the execution of the works; currently, the works being completed without problems and there being no inconsistencies between the modeling and the current situation in the field, the accuracy of the program was proven / the accuracy of the PMWIN program was confirmed and the need to use a hydraulic modeling program to be able to optimize a foam system.

The desire and ambition to build buildings as high as possible leads to the need to adopt new and more complex technologies, to use high-performance materials, but also highly qualified workforce.

The optimization of foundation solutions leads to projects executed with minimal consumption of materials and technology, but which at the same time ensure resistance and safety in operation.

The choice of the most efficient method of depletion is made according to: the dimensions of the excavation, the period of time in which the excavation remains open, the characteristics of the soil layers and the water pressure in each layer.

The development of hydraulic modeling by means of the specialized application PMWIN following which, by running the program, the levels and transit flows in the studied location were obtained, allowed the comparison of these data with the measurements actually made in the field. Obtaining similar results (from modeling with values from the field) demonstrated the importance of realizing well-structured projects, drawn up with specialized modeling in advanced calculation programs prior to the execution of the works, because only in this way can optimization of costs be achieved and the most effective solutions. The values obtained from the modeling were also measured in 90% proportion, which confirmed the fact that the model was well validated and calibrated.

## REFERENCES


1. National Administration “Romanian Waters”, Banat Branch, Data from various documents and studies, Timisoara, Romania, 2015-2022.
2. *** - Project "Construction of housing and complementary functions in P+20E height regime", Timisoara, 2017
3. Chiang W.H., „3D-Groundwater Modeling with PMWIN.A Simulation System for Modeling Groundwater Flow and Transport Processes”, 1987
4. Harris T, „How Skyscrapers Work:Making it Functional”, HowStuffWorks, 30 October 2018
5. E. Gabor, E. Beilicci and R. Beilicci “Advanced Hydroinformatic Tools for Modelling of Reservoirs Operation”, The World Multidisciplinary Civil Engineering – Architecture – Urban Planning Symposium - WMCAUS 2018, Praga, Czech Republik, vol. 471, 2018.
6. Chao-Feng ZengXiu-Li XueMiao-Kun Li „Use of cross wall to restrict enclosure movement during dewatering inside a metro pit before soil excavation”, Tunnelling and Underground Space Technology, 21 March 2021Volume 112 (Cover date: June 2021) Article 103909
7. Horris K. NangulamaZhou JianFeng-Feng Yuan. “Stage-by-stage control effect field analysis of steel material servo enhanced support system on lateral displacement and bending moment during deep basement excavation”, Case Studies in Construction Materials13 April 2022.. (Cover date: November 2019)Article 103169
8. Xiao Bing XuQi HuMin Yun Hu , “Seepage failure of a foundation pit with confined aquifer layers and its reconstruction” Engineering Failure Analysis30 April 2022, Volume 138 (Cover date: August 2022)Article 106366
9. Tao YangLi-yuan TongXin Yan , “Hydraulic head difference at two sides of suspended waterproof curtain during multi-grade dewatering of excavation”, Underground Space24 January 2023, Volume 10 (Cover date: June 2023)Pages 137-149
10. Hai-Min LyuShui-Long ShenAn-Nan Zhou , “Calculation of groundwater head distribution with a close barrier during excavation dewatering in confined aquifer”, Geoscience Frontiers18 September 2020, Volume 12, Issue 2 (Cover date: March 2021) Pages 791-803