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GEOTECHNICAL CONDITIONS FOR THE FOUNDATION OF WASTEWATER TREATMENT PLANT FACILITIES IN V. OBARSKA SETTLEMENT NEAR BIJELJINA

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ABSTRACT

Wastewater treatment plant is an integral part of the sewerage systemof the town of Bijeljina and it is located at the distance of 10 kilometers.Given the factthat it comprises several objects of different significance, it was necessary to select a suitable location to set up all facilities required. The site is located immediately next to the MPC – Majevicaperipheral channel that collects water from surrounding areas and drains into the River Sava.By the construction of a mentioned plant, purified water would flow through the channel to the River Sava.

The wastewater treatment plant is accompanied by several objects of different importance, both in dimension and depth of foundations. Detailed geological surveys defined geological composition and geomechanical properties that are the basis for defining the requirements for foundation. Particular importance was given to facilities that require deeper foundations while smaller objects can be based in a layer of the embankment, which will be set up to a certain elevation to establish new alignment field.

Key words: *terrain, lithological composition, facilities, sewerage system*

INTRODUCTION

The sewerage system in Bijeljina is designed with a wastewater treatment plant up to the level thatmeets legal requirementsin order to take wastewater further into the existing river flows. The location in VelikaObarska is selected, which is situated at a distance of about 10 kilometers. Designed plant, in accordance with planned facilities and a construction site requires detailed knowledge of geological and geotechnical characteristics.

Different approach of designers and the need to perform as much as possible investigation works with minimum of resources to obtain necessary characteristics of the terrain does not always produce good results. Therefore, at the existing locationfield survey was conductedin two phases, in order to obtain detailed information on the construction site where significant object will be built.

This paper will provide an overview of the research results essential for geotechnical analyses of the requirements for foundation of the most significant facilities.Conditions of allowable bearing capacity of the soil and soil behavior in terms of object load capacity will be analyzed on the proposed models.

GEOTECHNICAL CHARACTERISTICS OF THE SOIL

Based on the results of field studies and laboratory tests during two phases of the research, geotechnical mediums were defined and parameters for geostatic analysis were adopted.

Geological composition of the construction site is rather simple and is characterized by vertical profile that is distributed throughout the whole area of the Semberian plate. Depth of individual layers varies and that makes a difference. In addition, a local interbed of muddy sediments occasionally occurs, which is significant in terms of observation of microlocation.

Surface and subsurface layer consists of sediments of the first Drina terrace (t_1), which can be found from 4.0 to 5.0 m above the normal level of the rivers Sava and Drina. Sediments (t_1) are of accumulative type and deposited in the valley of the plain formed by the River Sava. They are presented by heterogeneous gravel, sand, alevrit-psammitic clays and alevritic clays of various colors, which build the crown of the terrace. Potential of the terrace sediments increases towards the northeast [1, 2].

Deeper parts of the researched area are built of Plio-Pleistocene - Quaternary sediments (Pl, Q), which are noticed at depth greater than 9.2 m and present paleoreliefcovered with deposited alluvial sediments. According to the Basic Geological Map, sheet Bijeljina, these sediments have thickness of about 30 m and lie on Pontian sediments. They are presented by yellow alevritic clays with carbonate concretions [3].

Field study was conducted using the exploration well and investigationpits. Depth of the wells depended on the type of the object. Previous studies were based more on observation of wider location as a whole in order to determine the properties of the layers up to the gravel bed. Starting with the fact that the gravel bed is of high potential, only three (3) wells were made at depth of 12.0 m at typical spots of individual facilities.

After the surveys were conducted, it was noticed that all investigation pits reached a gravel bed with varying thickness of the surface layer above the gravel. Exploration wells defined that a gravel layer is of smaller thickness and that beneath it lies a layer of sand and only then a layer of clay,which is a substrate of the field.

Once the data were obtained in this manner within the previous phase of the research, the additional phase of the investigation was carried out with six (6) exploration wells distributed over the key facilities,because of the significance of certain buildings.For the SBR Tanks, four (4) wells were made at the angular pointsat depth up to 22.0 m. Remaining two (2) wells, depth of 9.0 m each, were made for the Intel Pump &Coarce Screen and Equalisation Tank, in order to make the research work more intense, Figure 1.

Considering all the research works as a whole, a terrain model was set up, presenting the basis for geostatic analyses. Following geological mediums were extracted with adopted parameters for calculations [4, 5, 6, 7, 8, 9].

Layer 1, silty, sandy, muddy clay, isolated as a single layer, though it can be furtherparsed into the surface part made of silty clay,which in deeper layers turns gradually into silty, sandy, muddy clay, Figure 2. The layer is of varying thickness from 0.5 to 2.5 m with occasional lenses of fragile components. It is necessary to define this interbed in more details during the construction of the facilities considering that it deteriorates geomechanical characteristics of the layer. Adopted parameters for geotechnical calculations are as follows:

$$\gamma = 19{,}3\ kN/m^3, \varphi = 15^0,\ c = 10{,}0 kN/m^2,\ Mv_{(0\text{-}100)} = 2500\ kN/m^2$$

Layer 2, silty, muddy sand, fine-grained up to medium-grained of uneven thickness from 0.2 to 1.8 m. This is a water-bearing layer. Parameters adopted for the calculations are as follows:

$$\gamma = 19{,}5\ kN/m^3, \varphi = 17^0,\ c = 5{,}0 kN/m^2,\ Mv_{(0\text{-}100)} = 2000\ kN/m^2$$

Layer 3, sandy gravel, with pebbles of heterogeneous composition with grain sizes from several mm up to 10.0 cm. Grains of smaller diameteres are more rounded unlike the larger grains. The layer is of variable thickness, from 2.8 to 5.8 m and water-bearing. Parameters isolated for geostatic analyses are as follows:

$$\gamma = 19{,}7\ kN/m^3, \varphi = 38^0,\ c = 0{,}0 kN/m^2,\ Mv_{(SPT)} = 30000\ kN/m^2$$

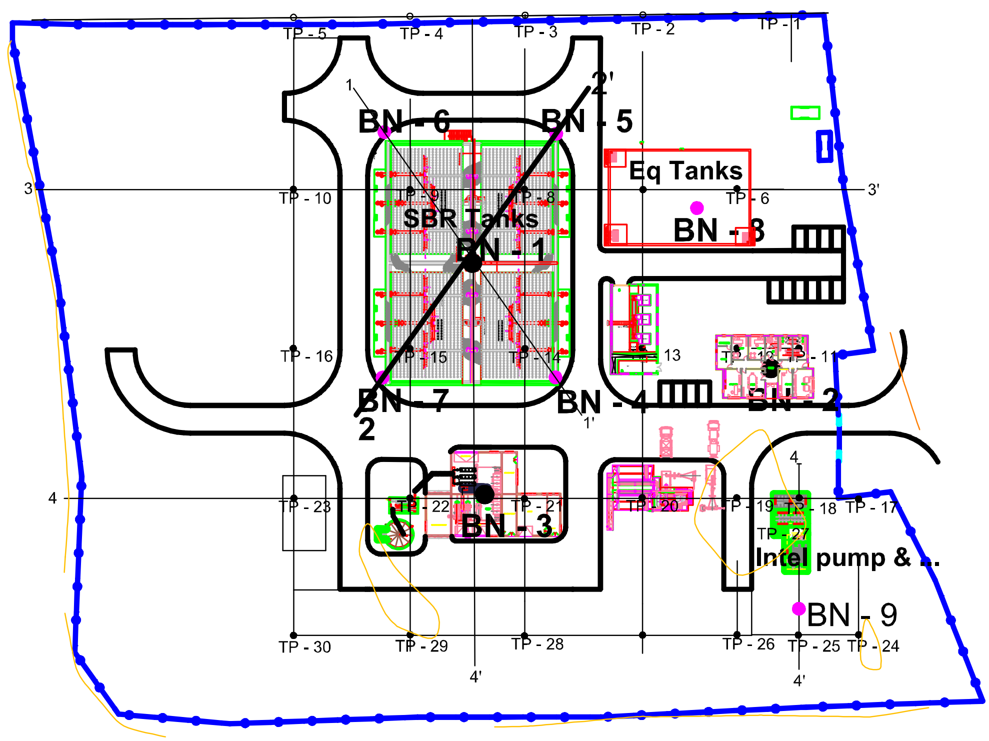

Figure 1. Schedule of research works on the installation site
Previous research phase: TP 1-30 investigation pits, B 1-3 explorations wells
Additional research phase: B 4-9 exploration wells

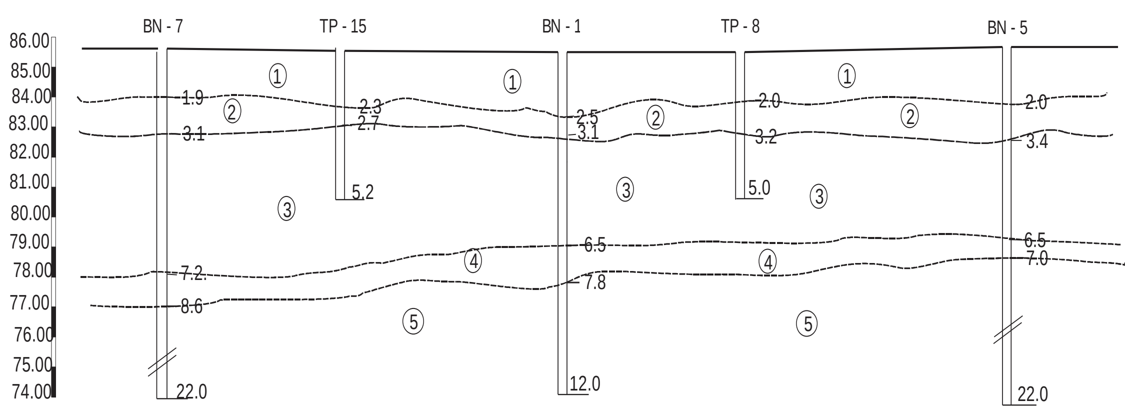

Figure 2. Geological profile of the field
1.silty, sandy, muddy clay 2. silty, muddy sand 3. sandy gravel
4.sand 5. silty clay – substrate of the field

Layer 4, sand, fine-grained to coarse-grained, presents the lowest layer of alluvial sediments of the River Drina. It was found at depths higher than 6.4 m and its thickness ranges from 1.5 to 3.0 m. It is a water-bearing layer. Geomechanic properties for the purpose of analysis are as follows:

$$\gamma = 19,0 \text{ kN/m}^3, \varphi = 30^0, c = 0,0\text{kN/m}^2, Mv_{(SPT)} = 15000 \text{ kN/m}^2$$

Layer 5, silty clay, presents the substrate of the field and a depth of its occurrence starts from 7.0 m. The thickness of the layer is not determined by exploration works and it reaches the depth of the research works of 22.0 m. Clay is dusty and contains small inclusions of decomposed $CaCO_3$. Following parameters were adopted:

$$\gamma = 20,1 \text{ kN/m}^3, \varphi = 16^0, c = 23,0\text{kN/m}^2, Mv_{(0\text{-}100)} = 3500 \text{ kN/m}^2$$

Layers of sand and gravel are water bearing and the amount of water changes throughout the year depending on the groundwater regime. In the springtime when water levels are the highest, layers are entirely submerged while during the rest of the year water level is reduced and layers remain above the levels. Water regime depends directly on the regime of water in surface streams of rivers Sava and Drina. Observation of the regime has not been carried out for a long period in order to determine the lowest levels, that is the most favorable period for the construction. At the time of the field survey, water level was about 2.0 m.

Seismic activity of the terrain is not stated and according to the Seismological map of Yugoslavia in 1987, maximum intensity of expected earthquakes is $I = 5^0$ MSK – 64 and probability of occurrence is 63% for the return period of 50 years. Lifetime of the facilities is 40 years, which means that construction can be performed for the low level of seismicity. However, considering that the lifetime of the object will be significantly longer, seismicity for return periods of 100 and 200 years was also analyzed where maximum expected earthquake intensity is $I = 7^0$ MSK – 64 and probability of event occurrence 63%.

CHARACTERISTICS OF THE OBJECT

Wastewater treatment plant within its complex includes several buildings, varying in importance. The method of their foundation is also different. The most significant buildings will be founded on a layer of gravel, while most of the facilities will be based in the embankment that will be built subsequently. The content of the facilities is as follows:

- Inlet Pump & Coarse Screen, dimension 6,15 x 17,9 m.
- Fine Screen & Grit Chamber, dimension 7,9 x 17,5 m
- Equalisation Tank, dimension 15,1 x 30,8 m
- SBR Tanks, dimension 37,3 x 52,7 m
- Sludge Holding Tank, dimension 8,0 x 8,0 m
- Sludge Building & Workshop, dimension 13,75 x 29,3 m
- Blower & Transformer Building, dimension 6,9 x 28,0 m
- Administrator Building, dimension 17,3 x 28,9 m
- Washwater Tank, dimension6,3 x 11,2 m

The present ground level is about 85.0 m and the final elevation with the constructed embankment is 89.0 m. All planned structures will be based on a foundation slab. Following facilities were selected as the most important:

- SBR Tanks, dimensions 37,3 x 52,7 m, depth foundation 3,0 m in a layerof gravel
- Intel Pump & Coarse Screen, dimension 6,15 x 17.90 m, depth foundation 4,7 m in a layerof gravel
- Equalisation Tank, dimension 15,1 x 30,8 m, depth foundation 1,0 m in a layer ofdustsclay

Remaining facilities will be founded shallower in a layer of the enbankment after its construction.

ANALYSES OF GEOTECHNICAL CONDITIONS FOR THE FOUNDATION OF FACILITIES

Analysis of geotechnical conditions was carried out in order to determine allowable bearing capacity of the ground beneath the foundation slab of the object as well as subsidencedue to a specified load of the building. The most important object is SBR Bio Tanks, which will be based in a layer of gravel. Surface part of the soil that is built of silty, sandy, muddy clay and sand will be excavated and the most significant object will be founded on a gravel layer. Depth of the foundation of the object compared to natural elevation of the field is 3.0 m.

Intel Pump & Coarse Screen is a structure that will be based at depth of 4.7 m in a gravel layer, which is under water throughout the year.

Equalisation Tank is located outside the part that will be excavated for SBR Tank needs, so it will be based in a bed of clay that is a subsurface layer.

All calculations are given in relation to the current elevation of the field that is 85.0.
Geotechnical model of the field for mentioned purposes was made to depth of the field research and comprises following lithological members with their parameters, Table 1.

Table 1. Geotechnical model of the field

Layer	Geological medium	Layer Thick. (m)	The waterlevel (m)	γ (kN/m^3)	φ^0	c (kPa)	Mv (kPa)
1.	Clay silty, sandy, muddy	2,0	2,0	19,3	15	10	2500
2.	Sand silty, muddy	1,0		19,5	17	5	2000
3.	Gravel sandy	3,0		19,7	38	0,0	30000
4.	Sand	2,0		19,0	30	0,0	15000
5.	Silty clay	12,0		20,1	16	23	3500

Table 2.Allowable bearing capacity and subsidence of the ground

Facility	Dimensions (m) / Form of the foundation	Depth of the foundation (m) / Layer	Properties of the ground: Allowable bearing capacity q_a (kN/m^2)	Properties of the ground: Subsidence s (cm)	Properties of the facility: Load q (kN/m^2)	Properties of the facility: Subsidence s (cm)
SBR Bio Tanks	37,3 x 52,7 m / Slab	3,0 / 3	135.27	5,07	100,00	3,51
Instel Pump &	6,15 x 17,9 / Slab	4,7 / 3	428,21	23,11	80,00	2.73
Equalisation Tank	15,1 x 30,8 / Slab	1,0 / 1	117,21	6.65	55,00	2,67

Obtained values of object subsidence due to the specified load are within the acceptable limits especially for the objects based in the layer of gravel, because subsidence will be mainlyperformed in the phase of their construction. It is typical for specified location that extended layers are not of the same thickness over the whole research field. Different depth of individual layers is especially noticeable. In this particular case, a layer of gravel is the most important layer because the most significant objects SBR Tanks and Intel Pumm& Coarse Screen will be based in it. Depth to the formation roof is different, so during the construction of the object, in certain parts,it will be necessary to dig deeper than 3.0 m to reach the layer of gravel. In that case, it is necessary to perform material filling and its compression to 60 MPa in order to achieve the alignment of the field at depth of 3.0 m. In addition, in order to reduce subsidence it can be approached to foundation slab expansion in width and length determined by designer.

For the EqualisatonTankt that will be based in a layer of silty, sandy clay, subsidence is within the acceptable limits.

The embankment of height from 4.5 to 5 m will be built above the current surface of the groundafter the foundation of mentioned facilities, where smaller objects will be based. The quality of materials built into the embankment and a method of its disposition should be satisfying considering that smaller structures have their own significanceas various types of pipelines interconnect facilities with the main SBR tanks.

CONCLUSION

As a part of the construction of the Sewerage system in Bijeljina town, a wastewater treatment plant is being constructed. Selected site is located approximately 10.0 km from the town of Bijeljina towards the River Sava. Selected location previously containedmud dump of the existing sugar refinery, which has been abandoned in the meantime.

For the overview of geological and geomechanical characteristics of the terrain where 16 structures, different in their dimensions and technical importance, will be built, particular field research works were carried out. Explorations were performed in two phases given that the previous phase of the research did not provide detailed insight into all necessary properties of the terrain. In additional phase of the research, a lithological structure of the terrain and basic geomechanic characteristics of each layer were defined.

Based on isolated parameters for geostatic analyses, foundation depths were proposed for the most significant facilities in the plant, which require deeper foundations. Featured objects are SBR Tanks, Intel Pump & Coarse Screen and Equalization Tank. Remainingstructures will be based in the layer of the embankment that will be made at a later stage.

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