Review paper
UDC: 621.643.038:665.61(282.24 Sava)
DOI: 10.7251/afts.2015.0713.009D
COBISS.RS-ID 5434904

GEOTECHNICAL CONDITIONS FOR CREATION OF THE VERTICAL SHAFT FOR RECONSTRUCTION OF OIL PIPELINE FROM TERMINAL BROD TO CROATIAN BORDER ON SAVA RIVER

Djurić Nedjo[1], Mitrović Petar[1]

[1]*Technical Institute Bijeljina, Bosnia & Herzegovina, e.mail nedjo@tehnicki-institut.com*

ABSTRACT

Reconstruction of share in an existing corridor of Terminal Brod to the Croatian border on the Sava River is part of the corridor, which continues to go across the river to Slavonski Brod. The existing corridor will be replaced on a part of Sava River, where is planned a production of a tunnel with two vertical shafts on the banks of the river. Research in the field of the shafts and tunnels are divided in two parts considering the border line between the countries Bosnia and Herzegovina and Croatia. On the right bank of the Sava River researches were conducted in the development of the vertical shaft.

The complexity of the geological structure and the proximity of of the Sava River require the development of the vertical shaft from the supporting structure of reinforced concrete (RC) midriffs. Also, the flow of water into the shaft is largely expected from its bottom, which requires manufacturing

Key words: *oil pipeline, river, shaft, midriff*

INTRODUCTION

Transportation of petroleum products from the Terminal in Brod to Slavonski Brod was carried out on the pipeline, which today can not meet all needs. By extending the purposes of transport of petroleum products, requires construction of an additional pipeline in the existing corridor. Began the reconstruction of pipeline section on both sides of the river Sava, and looking for the solution of connecting pipeline between the two banks of the river. Sava River is the border between Bosnia and Herzegovina and Croatia, which caused the field research and the proposed design solution works in institutions of both countries, respecting the legislation of these countries.

By working together, it is suggested that pipeline corridor passes through the tunnel under the river basin from one to the other bank of the river, at the same time technical solutions will be agreed upon. Geological and geotechnical field explorations, decided the way of building the vertical shaft on the right bank of the Sava River, which connects the stated tunnel.

GEOLOGICAL CHARACTERISTICS OF THE FIELD OF NARROW LOCATION OF THE SHAFT

According to the geomorphological characteristics, the ground in locations of borehole B - 1 and the immediate environment is a reflection of fluvial - accumulation processes of the Sava River, which has formed the modern accumulation relief. It is characterized by alluvial sediments, with heights up to 100 meters above sea level located within the first river terrace of Sava (t_1) and sediments of the riverbed.

According to the interpreter OGK 1: 1000, sheet Slavonski Brod, the first river terrace of Sava (t_1) je do granične izohipse 100 mnm [1]. Represents the cumulated-alluvial plain situated in a narrow area around the river basin. In the south it borders with Plio-Quaternary sediments and on the north is overflowed by aluvial – floody deposits of Sava. The environment at the time of its emergence corresponded to park - steppe, and later went through climate fluctuations from cold to moderately cold period. The thickness of the terrace is small and ranges from 2.0 - 3.0 m from the normal water level of the Sava. It was built of clay sediments, sand and gravel that are in change, and precipitated depending of the energy of the aquatic environment.

At the location of borehole B – 1 field is sub-horizontal with the absolute height of 87.33 m above sea level, and the immediate environment affected with first Sava river terrace (t_1) is between 86 - 89 m above sea level.

In geologic structure of the field, to researced depth, are represented Quaternary sediments of Pleistocene (Q_1) and Holocene (Q_2) age.

Of Pleistocene age are sediments of the first river terrace of Sava (t_1) and dusty and sandy sediments with occasional removal of thinner layers of sandy gravel sediment of finer fractions.

Immediately on the right bank of the Sava River are sediments of the Holocene, whose origin is related to gradually lowering of Samac and Brod Posavina, and partly by with water saturated because of periodic raising of underground water level. In the Holocene is formed stream of the river Sava, which creates its own alluvium.

To Holocene belong organogenic swamp sediments (ob), classified as sediments of floodplains (ap) and swamp sediments (b). They are located immediately on the right bank of the Sava River are sediments of the Holocene, whose origin is related to gradually lowering of Samac and Brod Posavina, and partly by zabarivanjem because of periodic raising of underground water leof Sava. In the Holocene was formed stream of the river Sava, which creates its own alluvium.

Sediments of floodplains (ap) are bordering with the lacustrine swamp sediments (jb) that south of the Sava River are covering its first terrace (t_1). In flood periods are deposited alluvial floodplain sediments, whose precipitates consist of finely clastic sediments where the largest presence have sands and clayey sands. Completion of sedimentation of these genetic types represent a backwater with significant precipitates.

Seamp sediments (b) are characterized by small plastic material from plant remains. Prevailing are dark green and dark gray clay, exclusively of illite composition, and there are also fine-grained sands, and smaller lenses grained gravel. The thickness of these sediments does not exceed 2.0 m, while the total thickness of the Holocene sediments is in the range of 30.0 to 50.0 m.

Alluvial deposits of river Sava is located in the river bed and its banks, which have a slight slope. There is no greater distribution, and is built of sandy gravel sediments of different sorted samples and roundness.

Hydrologic characteristics of the location of shaft, are related to geological structure and water - physical properties of individual lithological members who participate in its constitutionThere are distinct sediments of differing permeabilities depending on the presence of clay component. The least represented are poorly water-tight up waterproof sediments, represented by clay with sediment with different contents of clay and silty fractions. They spread from the surface to a depth of about 5.0 m, which according to the hydrogeological function represents roof seam hydrogeological insulator.

Under these sediments are permeable sediments, which can be classified as well permeable sandy gravel sediments, and they spread in the footwall of clay sediments. According to the hydrogeological function, they make the collector groundwater. In these sediments is formed aquifer.

GEOTECHNICAL CHARACETRISTICS OF LITHOLOGICAL MEMBERS

To define the characteristics of the environment, on location of the vertical shaft, was drilled one exploration borehole depth of 30.0 m. Detailed examination of the core boreholes and the results of laboratory tests on the samples taken, defined the physical and mechanical characteristics to the depth of research [2,3,4]. Often removal of individual lithological members along the vertical, demanded details in analyzing. Featured are lithological members, figure 1, as the natural environment deluged with water, which characterize a certain parameter values necessary for geotechnical analysis.

Parameters of cohesion and angle of internal friction layer of dusty sandy clay were determined through laboratory, while the angle of internal friction dusty, sandy and gravel sediments were determined on the basis of the experience of standard penetration (SPT), which are carried out in the borehole, table 1.

Table 1. The values of friction angle on the basis of request of the Standard dynamic penetration (SPT)

Boreh. number	Depth (m)	Type of layer	Number of strokes (SPT)	Adjusted number of strokes N*	Ugao smič. otpornos. ϕ^0
	4.15 - 4.45	Dust sandy	16	12	30
	6.50 - 5.80	Sand pulverulent	12	9	29
	8.75 - 9.05	Sand pulverulent"	28	21	34
	10.65 - 10.95	"	42	31.5	37
	12.65 - 12.95	"	45	33.5	38
B - 1	14.65 - 14.95	Sndy gravel	45	33.5	38
	17.15 - 17.45	Sand	25	18.5	33
	19.65 - 19.95	"	>51*	38*	39*
	22.15 - 22.45	"	>51*	38*	39*
	24.35 - 24.65	"	>51*	38*	39*
	26.65 - 26.95	Sandy gravel	>51*	38*	39*
	29.15 - 29.35		>51*	38*	39*

* calculated for N = 51 stroke

- The surface layer of humus which gradually passes into the loamy clay, which is loose, low plasticity (CL), to thickness of 0,7 m

- Silty sandy clay, medium (CI), thickness ranging from 1.7 m. Featured parameters for geotechnical analyzes are:

  - volume weight $\gamma = 19{,}88 \ kN/m^3$
  - the angle of internal friction $\varphi = 13^0$
  - cohesion $c = 20 \ kN/m^2$
  - water permeability coefficient $k = 4{,}98 \times 10^{-11}$ m/s (for interval of burden 100 – 200 kPa).

- Sandy dust of low plasticity (ML), mightiest of 2.4 m, with the following parameters:

  - volume weight $\gamma = 18,53$ kN/m^3
  - the angle of internal friction $\varphi = 29^0$
  - cohesion $c = 9$ kN/m^2
  - coefficient (by USBR) $k = 1,50 \times 10^{-5}$ cm/s

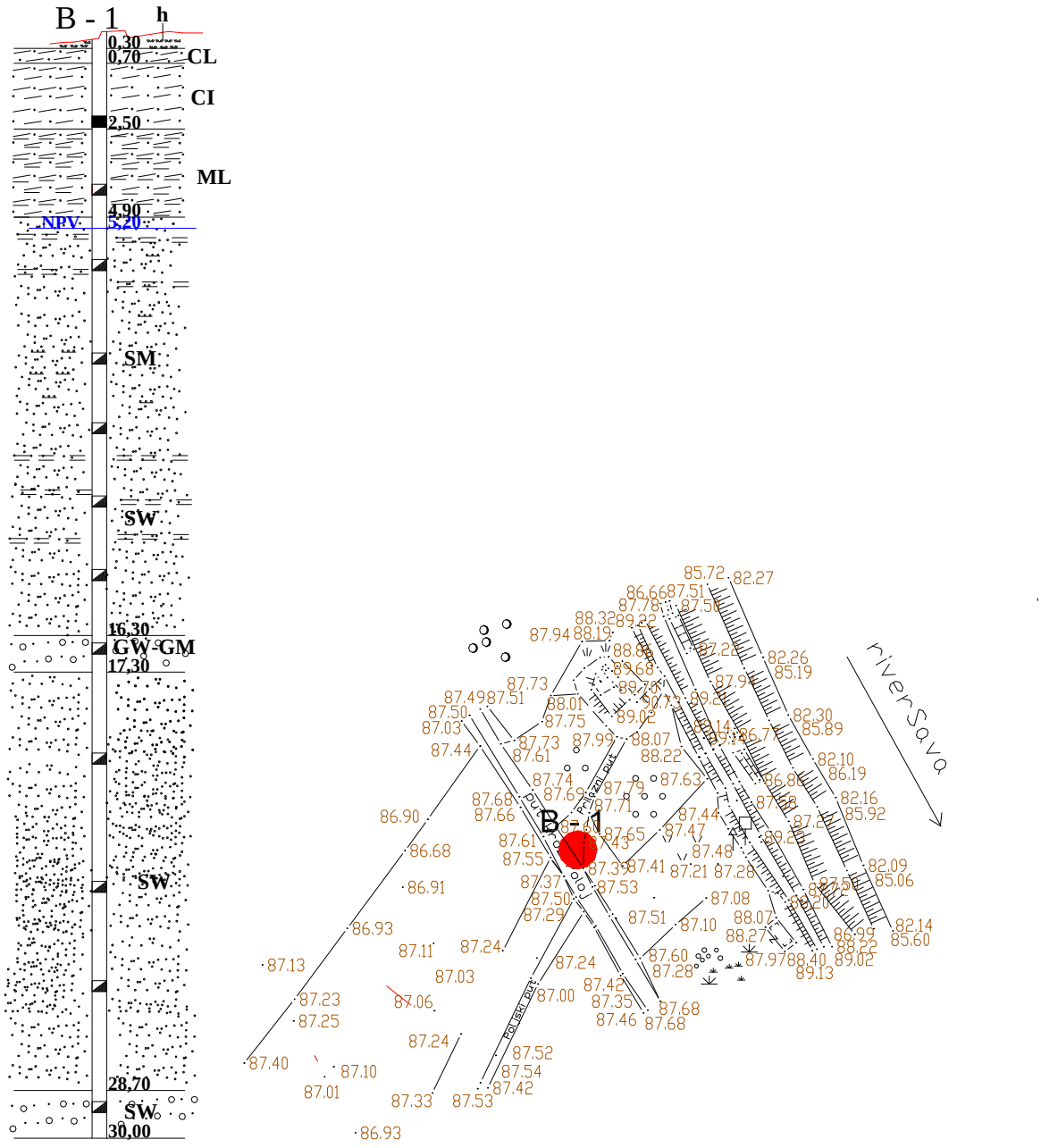

Figure 1. Lithological column of exploration borehole and its position in relation to the river Sava

- Sandy dust medium to coarse-grained (M, W), mightiest of 11.4 m, has the following characteristics obtained by field and laboratory tests:

  - volume weight $\gamma = 18,8$ kN/m^3
  - the angle of internal friction $\varphi = 36^0$
  - coefficient (by USBR) $k = 1,69 \times 10^{-2} – 8,80 \times 10^{-5}$ cm/s

- Sandy gravel (GW, GM) mightiest of 1.0 m, fine to medium-grained, with the following values of parameters:

  - volume weight $\gamma = 19,5 \ kN/m^3$
  - the angle of internal friction $\varphi = 33^0$
  - coefficient (by USBR) $k = 3,32 \times 10^{-3}$ cm/s

- Medium-grained sand (SW) with small parts of gravel, mightiest of 11.4 m, well compacted, with the following parameters:

  - volume weight $\gamma = 20,1 \ kN/m^3$
  - the angle of internal friction $\varphi = 39^0$
  - coefficient (by USBR) $k = 1,94 \times 10^{-2} – 5,40 \times 10^{-4}$ cm/s.

- Sandy gravel, well-compacted (GW), mightiest in the lithological pillar 1.3 m, but is much greater under the depth of research.

  - volume weight $\gamma = 21,3 \ kN/m^3$
  - the angle of internal friction $\varphi = 39^0$
  - coefficient (by USBR) $k = 1,88 \times 10^{-2}$ cm/s

Groundwater level was registered at 5.2 m. During the year, the groundwater level fluctuates, and at the time of the hydrologic maximum is raised to the surface.

PROPOSAL OF MAKING A VERTICAL SHAFT

By studying the terrain on which it will be built a vertical shaft, by reconnaissancing, sound drilling and analysing of the results of laboratory tests, it was suggested the best solution for providing shaft by creating the supporting structure of reinforced of concrete (RC) diaphragms [5,6,7,8].

As a basic security measure, it is necessary to design the diaphragm to the entire foundation pit, and the boundary lines of the object, whose internal dimensions of the cross section are 5.0 x 15.0 m and shaft depth 12.0 m. Creating AB diaphragm means excavation of soil in the sections with special machine, then reinforcing and concreting. Performing AB diaphragms requires the engagement of specific equipment, accessories and tools for these types of works.

An important quality conditions AB vertical shaft is impermeability to water, since it will largely be a shaft below the groundwater level, and in some periods of the year completely under water. The complexity of these issues increases the proximity of the river Sava, figure 1. The greatest danger of inflow of water into the shaft is from the bottom of the shaft, where is necessary to carry out gasket (cap) of alone mountable concrete of mark MB20. Height cap will be determined on the basis of input parameters by specific budgets.

CONCLUSION

Reconstruction and expansion of the existing pipeline from the Terminal in Brod to Slavonski Brod requires the construction of a tunnel under the Sava river. On the bank will be done shaft that will connect the route of the pipeline from the terminal to the tunnel and continue through the tunnel to the shaft on the left bank of the river basin, and Slavonski Brod.

Carried out geological studies and laboratory tests provided data on the lithological composition of the terrain and the physical and mechanical characteristics. According to geological structure and

significance of the facility it was suggested a variant of the construction of the vertical shaft with the development of the supporting structure of reinforced concrete diaphragms AB. The presence of the Sava River reflects to the level of groundwater in the hinterland, and thus the area of the vertical shaft, which requires specific equipment for the construction and quality materials for installation according to the environmental conditions.

(Received March 2015, accepted April 2015)

LITERATURE

[1] Osnovna geološka karta SFRJ, R 1:10000. Tumač za list Slavonski Brod. Savezni geološki zavod, Beograd, 1980.
[2] Elaborat o geotehničkim istraživanjima za rekonstrukciju dionice naftovoda s dopunom namjene transportom naftnih derivata u postojećem koridoru od Terminala Bosanski Brod do granice na rijeci Savi. Tehnički institut Bijeljina. 2011.
[3] Standard Test Procedures Manual. Fondation investigation – Dynamic cone Penetrometer, Saskat chewan Highways and Transportation. 1992.
[4] Mn Road – Office of Minesota Road Reaserch – User guide to the Dinamic cone Penetrometer.
[5] Horodecki, G.A., Bolt, A F., Dembicki, E. (2003). Geotehnički problemi projektiranja i ponašanja građevnih jama. Građevinar 55.
[6] Roje – Bonacci, T. (2005). Potporne građevine i građevne jame. Građevinsko arhitektonski fakultet Sveučilišta u Splitu. Split.
[7] Modeling Floor Diaphragms in STAAD.Pro 2007. Bentley. RAM/STAD Solution Centar. www.bentley.com/en-US/Products/STAAD.Pro
[8] Suljić, N. (2010). Potporne konstrukcije. Univerzitet u Tuzli. Rudarsko-geološko-građevinski fakultet. Tuzla.