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THE IMPORTANCE OF GEOTECHNICAL INVESTIGATIONS FOR THE CONSTRUCTION OF TRANSFER STATION "PRELICI" ON LANDFILL IN CACAK - SERBIA

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ABSTRACT: For the purpose of the facilities construction within the transfer station „Prelici" in Cacak, specific geotechnical investigations were carried out based on which the technological project with the facilities schedule was developed. Significant deviations in relation to the presented results were determined during earthworks, so the additional geotechnical investigation works were carried out. Since the new investigation works have determined a different cross section of the terrain, it was proposed to move the planned facilities which led to the production of a new technological project. For these reasons, the importance of geotechnical investigations performance is presented within this paper.

Keywords: landfill, geotechnical investigations, transfer station

1. INTRODUCTION

Sebia's EU accession implies significant progress in the field of environment, and one step is the construction of a large number of transfer stations. Based on the waste management strategy in the Republic of Serbia and reached agreement to dispose waste at regional landfills, the construction of the transfer station and the center for selection and recycling of waste is planned at the existing municipal waste landfill „Prelici" used by the city of Cacak (Serbia). The existing landfill has existed as a dump since 1973, and then it has been placed out of the city area. However, by the urbanization of the city and especially by the expansion of the industrial zone, landfill has become the integral part of the inhabited area. The landfill covers an area of about 13.5 ha, and the estimated volume of disposed waste is about 1800000 m^3. The landfill is formed in alluvial plane of the left valley side of the West Morava River, i. e. left valley side of the Atenica River, which also represents eastern border of the landfill and which flows into the West Morava River in the landfill zone. Unfortunately, this is a very common case in many municipalities in Serbia, where city landfills are located next to the rivers or in their vicinity (Rakic, 2013).

Until 1994 at the city landfill „Prelici", waste was disposed completely uncontrolled both in terms of technology and in terms of waste origin. This uncontrolled disposal led to the fact that landfill was closed in a longer period of 1994.

Transfer station and Recycling Waste Center have been put into operation in 2016, and together represent the first project of this kind in Serbia. The facilities within the complex of transfer station were built on an area of around 2.2 ha. Waste that is brought and selected in this Recycling Centre, is

transported and disposed daily at regional landfill „Duboko“ which is used by eight more municipalities, and the landfill itself is located close to the city Uzice (Figure 1).

Figure 1. The locations of the transfer station “Prelici” and regional landfill “Duboko” (some images downloaded from https://duboko.rs/)

2. SHORT REVIEW OF MUNICIPAL PRACTICE IN SERBIA

The modern way of waste management implies that instead of the current practice of municipal landfill construction, go over to the new solutions which include quantitative (avoiding and reducing the number of waste) and qualitative prevention (avoiding and reducing of harmful effects). Basically, quantitative prevention means: reducing the total mass of municipal waste and finding ways to recycle secondary raw materials from municipal waste (Rakic, Milovanovic & Jakovljevic, 2011).

In this regard, the modern technological solutions are proposed which are usually consisted of several parts, such as: the area for selection of municipal waste (primary and secondary), area for use and processing of unselected waste (biological treatments, thermal treatments) as well as area for mechanical treatment of waste, which significantly reduces waste volume before final disposal at the landfill, either by shredding or compaction (Rakic et al, 2011).

For municipal practice in Serbia can be said that it is in development, since the harmonization of our legislation with the European Union (EU) legislation in the field of environmental protection and waste management started in 2000, and the new Law on Waste Management adopted in 2016. Until fifteen years ago, the only way of waste management was disposal on municipal waste landfills, which in most cases do not meet even minimal protection measures, and therefore, most of them represent dumps. They are usually already filled, so they must be closed and repaired or recultivated as soon as possible (Rakic, Coric, Basaric & Jankovic, 2017). For these reasons, ecological standards are gradually improving in Serbia, relevant legal provisions are changing, and accompanying regulations harmonize and modern systems of municipal waste treatment prescribe. Serbia's EU accession includes the construction of a

large number of transfer stations, as it was performed at the city landfill in Cacak.

Certainly, many specificities are noted in practice, which reduce the desired effects, making it difficult and sometimes impossible to implement the imaginary strategy and technical solutions. The most common barriers that arise in everyday practice, and refer to technical solutions related to the collection and separation of waste are (Rakic, Basaric, Caki & Coric, 2018):

- poor or non-existent infrastructure for the setting of collecting elements for primary selection,
- inadequate configuration of terrain for installing equipment at the locations of existing landfills,
- the lack of adequate municipal infrastructure (roads, water supply, sewerage, electrical installations) at locations outside urban areas, so the costs of preparing the terrain often exceed the costs of establishing a recycling yard, i.e. transfer station,
- increasing investment and exploitation costs for equipment and labor.

3. PRESENTATION OF TRANSFER STATION „PRELICI“ WITH SELECTION AND RECYCLING CENTER

As a part of the transfer station “Prelici”, the following technological units are designed: for receiving, compacting, pressing and disposal of municipal waste in transport roll containers, as well as facilities for temporary storage of treated waste until further transport to the regional landfill „Duboko“. Part of the area is designed for temporary storage of specific waste (waste from electrical and electronic equipment, waste tiers, bulky household waste etc.). The transfer station complex itself contains technological units which are defined by zones in which different working operations are carried out: receiving-departure zone, transporter zone, zone for receiving and temporary storage of recyclable waste and specific waste, zone for washing of vehicles and containers, wastewater treatment zone and waste separation zone from primary separation. As a precondition for the construction of mentioned facilities in technical-technological sense, we started from the following points (Rakic et al, 2011):

- analyses and terrain preparation based on local geotechnical conditions,
- the possibility of joint use of related equipment and space, without doubling the costs of technical relocation of facilities,
- technological connection of planned units,
- use of existing infrastructure facilities and their integration into existing planning guidelines and
- fitting structures and equipment into the urban industrial environment.

In addition, an analysis of the available waste composition data and their comparison with the total mass of waste with data from different parts of the world and the average data for Serbia.

4. ANALYSIS OF GEOTECHNICAL CONDITIONS FOR THE CONSTRUCTION OF THE TRANSFER STATION

In the wider area of the landfill, geotechnical investigation works were carried out in several occasions, starting in 1998. Investigations were performed for various purposes, but were mainly related to creating the geotechnical maps which were used for Remediation Design or Landfill Closure Design. For the construction of facilities complex within transfer station, the first investigations were carried out in mid 2013. The scope of investigation works was modest, because only three exploration pits were carried out, without taking samples and laboratory geomechanical tests. These investigations have found that in the selected location for the construction of the complex, in the previous period, municipal waste was not disposed i. e. at one part of the site, its thickness is small and can be removed by earthworks. On the basis of this, a technological project was developed within which has defined the layout of the transfer station facilities: facilities for receiving and transshipment, facilities for waste separation as well as facilities within the accompanying contents - reception of waste, vehicle washing, wastewater treatment

(Figure 2).

However, during preparatory earthworks, significant deviations were identified, as the data on the terrain were in contradiction with the presented results in the geotechnical documentation. Therefore, at the beginning of 2014, additional geotechnical investigations (exploration drilling, mapping of existing exploration pitches, geophysical research, laboratory geomechanical testing) were made, which determined the relatively complex construction of the terrain on the part planned for the construction of the transfer station facilities. Namely, in the northern part of the site was established a natural terrain built of quaternary sediments of the fluvial-marsh genetic type, which were deposited through the Neogene complex, which is represented by: marble clays, marls, claystones, sandstones and weakened conglomerates alternating alternately (M_3). It was concluded that this part of the landfill area was not used for waste disposal. However, on the southern part of the site, the surface is built of municipal waste covered with inert earth material (Figure 2).

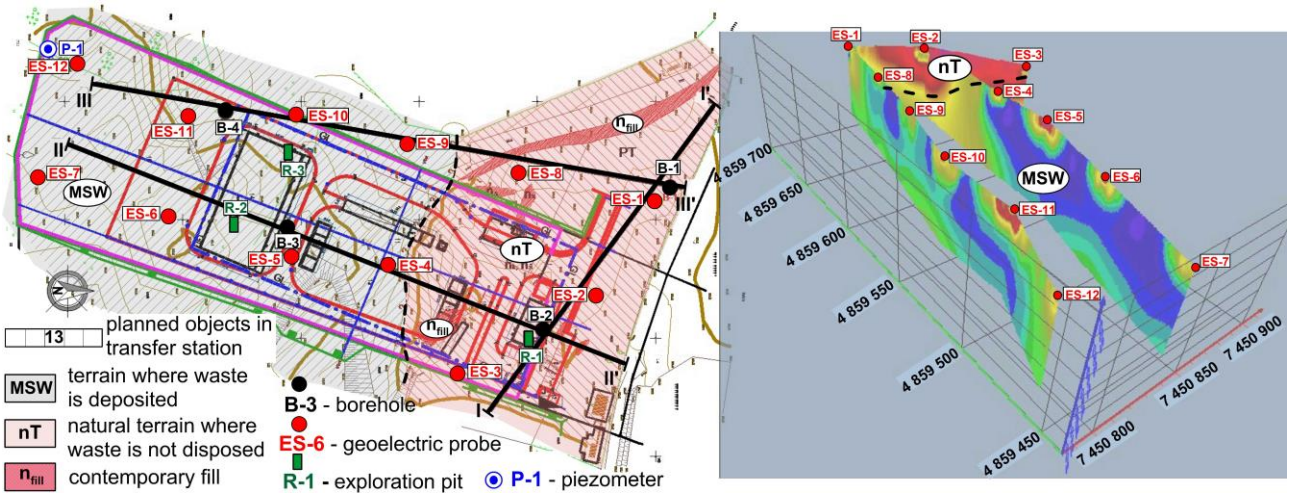

Figure 2. The situation of the terrain with the original schedule of the transfer station facilities

In addition to the significant deviation related to defining the area affected by the disposal of municipal waste at the site (in one larger part of the site, old municipal waste is covered with clay-silty, extremely heterogeneous and poorly compressed soil layer, Figure 2), the deviations also referred to: thickness and separation of natural lithological layers, and especially of modern materials, i.e. the thickness of old municipal waste and its cover (Figure 3). Certain differences related to the definition of groundwater level as well as laboratory geomechanical testing of natural layers (especially parameters of shear strength and compressibility) have been noted.

Municipal solid waste (MSW), is separated into material of old municipal waste (MSW-kO), which was created by the former active waste disposal on the whole southern part of the site and into material made by remediation measures of this landfill area, i. e. its covering of inert material (MSW-prk). Both of these landfill material layers are extremely heterogeneous. Old municipal waste (MSW-kO) is in the advanced stage of biochemical decomposition, so that mainly organic materials are dominant. Besides them, various materials that are difficult to decompose, such as plastics, metal, glass, etc., are also found. They are partly located below the groundwater level, and basically waste is muddy, expressive black to dark gray colour. It is most likely randomly deposited without compaction, so it is very loose, unconsolidated and with great chances of local rupture occurring in the body due to uneven decomposition of certain components of waste. Its thickness is uneven. In the eastern and southeastern part of the site, toward a part of the uncovered landfill, thickness is about 6 m, while the thickness decreases to the west of the site and the fence of the landfill, and ranges from 2.2 to 4.0 m (Figure 3). The inert earth material, which represents old waste cover (MSW-prk), is a clay-silty composition, black to dark brown, insufficiently compact and loose. It is mainly a construction material with rare fragments of brick and concrete, but gravel fragments and industrial slag are also found. At some thin intervals, municipal waste zones were also observed, most likely occurring during the spreading of the surface cover part with construction

machinery. In the bottom part, the waste is saturated with liquid waste materials and eulath (caused by the infiltration of the flowing waters in the terrain), as well as by the occasional rise in the groundwater level.

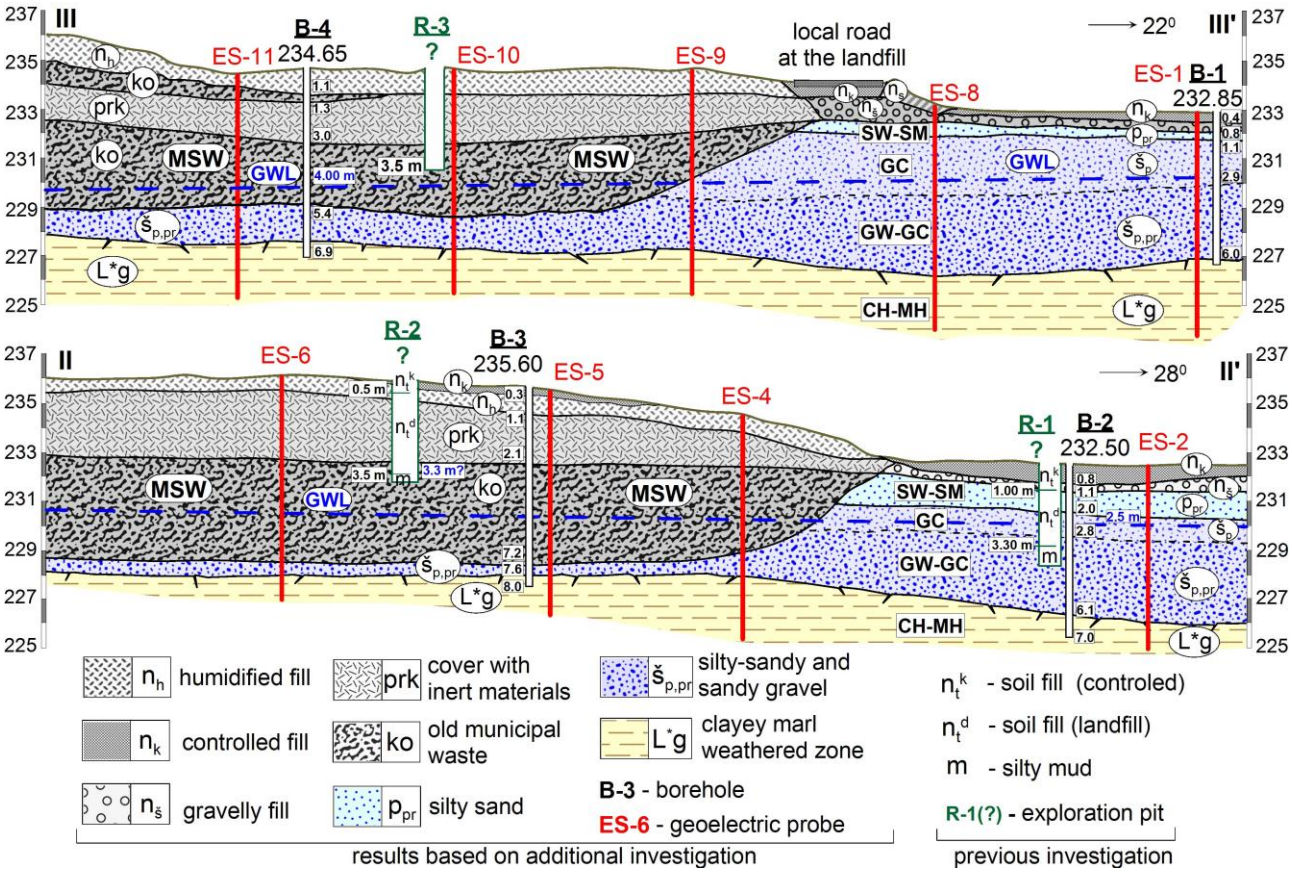

Figure 3. Characteristic geotechnical cross sections of the terrain at the location of the transfer station

In the central part of the landfill itself, which is outside the planned construction zone of the transfer station facilities, the waste is fresh, very loose and with uneven surface. In this part, the slopes of the landfill are of average height of 3.5-5.0 m, and they have observed local dives that are not of major importance because they happen in the area where the construction of a transfer station is not planned.

From the geotechnical point of view, the construction of some of the transfer station facilities (transporter ramp, railway track for press-containers, most of the manipulative plateau, part of the waste disposal boxes, the waste selection hall, the whole recycling yard) are directly dependent on the characteristics of waste in this part of the landfill. It is well known, however, that waste is a very poor quality primarily due to: heterogeneous composition (both by the participation of individual materials and by their size), insufficient compaction and consolidation. Due to this specific porous structure, the physical and mechanical characteristics of the waste are extremely variable at a relatively small distance. Therefore, any engineering intervention on the deposited material is a special problem and requires the use of special stabilizing methods (complete replacement of materials below the planned foundations, application of geosynthetic nets for soil reinforcement under foundations, stabilization of the terrain by the application of the so-called georaft system using "honeycomb" geosynthetic systems, and it is possible and the application of a deep compaction system, or a deep vibrational compression). Considering that subsequent geotechnical research found the existence of municipal waste thickness up to 6.0 m at the part where the construction of facilities was planned (area of about 1.6 ha), it was proposed to relocate objects in the northern part of the site. This new situation led to the development of a new technological project, and an economically justified solution was adopted with the relocation and redistribution of planned transfer station facilities.

5. CONCLUSIONS

The advantages of the presented technical solution for the treatment of municipal waste are multiple. From the point of view of achieving national goals, the level of recycling increases and obtains the necessary raw material for the work of the recycling industry. The mass and volume of the final disposed municipal waste are reduced, and therefore the operating costs. From the aspect of local self-government, the way of waste treatment is being improved, a certain number of workers of lower social status are employed and a positive economic effect is achieved. From a citizen's perspective, the introduction of a quality organization into the waste management system, with the exception of a stimulating effect (feeling of quality living) can lead to a reduction in the costs of waste collection.

On the example of this landfill in Cacak, it has been shown that a very important role in the arrangement of facilities with accompanying equipment has the results of geotechnical investigations. These results are essential in assessing geotechnical risks, whether it comes to the deformability of the substrate, the possibility of mechanical deformation in the landfill body or deformability and stability of the cover systems. Additional research has shown that the northern part of the site is a natural terrain that has not been used for waste disposal, while in the southern part of the site municipal waste thickness exceeding 6 m has been found. This conditioned the partial alteration of the technological project, primarily the relocation of originally planned facilities, and the main reason was the basic geotechnical conditions (long-term settlement of municipal waste and the possibility of breaking the substrate below the foundation, which would certainly have negative consequences on the transfer station facilities).

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