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GEOTECHNICAL PROBLEMS OF RAISING THE CAPACITY OF EXPLOITED LANDFILL SITES

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Abstract: Examples of the designs that are applied or created leading to an increase in the capacity of exploited municipal landfill sites located in Lower Silesia are presented. The majority of actually used waste yards were designed and built or modernized in the early 1990's. In terms of contemporary regulations and constructional guidelines, the best solutions are those with a single-stage way of storing. Experience accumulated over last years clearly shows that the municipal landfill sites will achieve soon their full capacity of the waste storage. In majority of cases, there is no possibility of building new objects. The economical condition of the communities and the requirements of a new law make the change of single-stage way of storing to the at least two-stage necessary. The expansion of existing storage sections brings about a sequence of geotechnical problems. New embankments are founded on very atypical subsoil, formed by stored wastes. The analysis of the geotechnical problems and the solutions applied are presented.

1. INTRODUCTION

The beginning of the nineties was marked in Poland by establishing a large number of municipal landfill sites for storing the solid wastes with the comparatively insufficient capacities of the waste depositing. Those structures were mainly founded for local communities. The contemporary regulations and constructional guidelines promoted the single-stage storing and making a soil closure after completion of the landfill site.

A longer time of the landfill site exploitation was usually reached by the construction of the next fill section. Practical experience of the last years clearly shows that the municipal landfill sites will soon achieve their full capacity of the waste storage. In consequence, the local authorities need to solve the problem of the further storing of the municipal solid wastes. As technically appropriate solutions we consider:

- The foundation of a new landfill site that fulfils the current stringent technical and environmental requirements of the law relating to waste (2001) and other regulations being based on EC standards and directives. This way is very limited due to the problems with a proper localization and the unavoidable protests of the local communities.
- Transportation of the wastes to the working landfill sites located in another regions. This way is also limited due to high costs.
- The opening of new storing sections in the area of the existing landfill sites.
- Raising the capacity of exploited storing sections.

Nevertheless, the high cost of all above-mentioned solutions is the main criterion of the choice. Raising the capacity of the exploited storing sections is most preferred by the local authorities. This solution is occasionally combined with creating new storing sections.

Nowadays the expansion of the existing landfill sites causes the sequence of geotechnical problems. New embankments are founded on very atypical subsoil formed by the solid wastes stored earlier. In the paper, the analysis of those geotechnical problems is presented. The examples of raising the capacity of exploited landfill sites located on Lower Silesia are shown.

2. EXAMPLES OF TECHNICAL SOLUTIONS

2.1. LANDFILL SITE OF PRUSICE

The landfill site for the town and municipality of Prusice, the administrative district of Trzebnica, was built in the locality of Krościna Wielka in 1995 according to design [1]. The waste yard has a total area of 1 hectare. It was located in an exploited gravel pit, about 3 meters deep under the ground level. The major part of subsoil is formed by clays, which were recognized as an effective geological barrier for leakage. The permeable part of subsoil was sealed with the PVC foil liner. The sketch and the cross-section of the storage area is shown in figure 1.

The waste layers in the waste yard were formed and compacted by the caterpillar bulldozer under insignificant pressure, which did not cause the necessary compaction of wastes. Moreover, the formed layers of wastes did not cover the whole area. As a result, in the moment of the completion of the fill area (the beginning of 2000), a clear border was created between the wastes very short deposited (“fresh wastes”) and those deposited longer (“young wastes”). The location of this border is shown in figure 1a and 1b.

The local authorities decided to solve the problem of further waste storing on this landfill site by rising of the embankments of the waste yard and to abandon the concept of building a new waste yard in the adjacent excavation. The design of modernization of the exploited landfill site [2] assumed building the embankments from the local sandy soils, whose height was 2.5 m, width of the top 2.0 m and slope inclination of 1 : 2. The internal slopes were sealed with the PEHD geomembrane. This solution assured the storage capacity for the next 3 years.

The embankments designed were founded partially on a natural subsoil and partially on the waste deposits, on both “fresh wastes” and “young wastes”. The localization of the embankments formed was shown in figure 1. Soon after formation of the

embankments the non-uniform subsidence was observed. The cracks appeared on slopes in the places marked with the letters A and B and the embankments inclined to the inside. The failure was removed due to addition of the soil to the embankments designed. The perceptible deformations of embankments were not observed at present.

The breakdown of embankments was unquestionably caused by the lack of stability of the subsoil forming embankments which was due to considerable differences in the deformability of wastes and a natural subsoil.

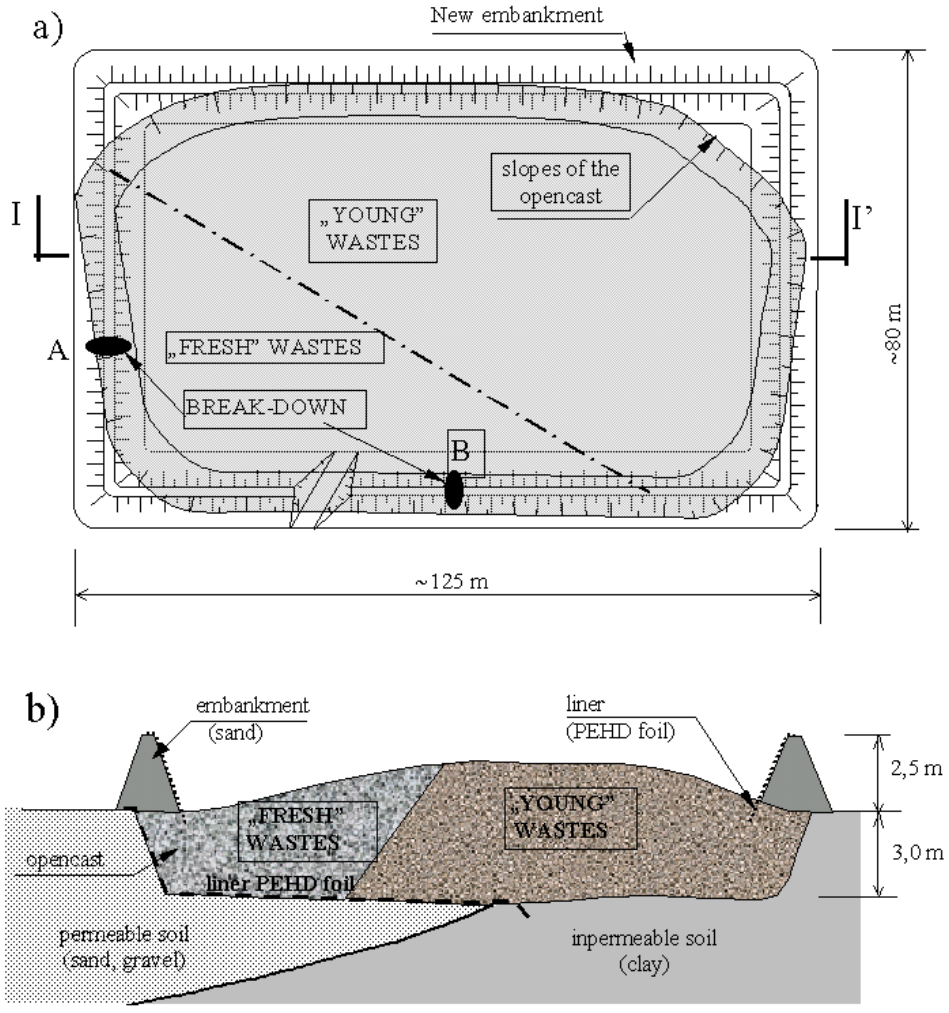

Fig. 1. Landfill site of Prusice (the administrative district of Trzebnica)
a) storage area for the municipal wastes, b) cross-section of the storage area

2.2. LANDFILL SITE OF OBORNIKI ŚLĄSKIE

The landfill site for the town and municipality of Oborniki Śląskie in the locality of Golędzinów is the next municipal waste yard located in a complex of the exploited gravel pits. The oldest part was exploited in 1965–1992 and afterwards was closed.

For a further storage two next pits were chosen with the storage sections no. 2 and no. 3. The storage section no. 2 was completely filled in 1992–1999, the embankments, each 7 m in height, were built in two stages. This section has no artificial liner. A natural geological barrier is created by the pliocenic clay at the depth of 10 m. The local authorities decided to build a new storage section, no. 3, for a subsequent extension of the storage period in this landfill site. The method of the embankment formation is presented in figure 2. According to design [3] the first-stage embankment (the standard dimensions: 3 m in heigh, 2.0 m in the top width, inclination of slopes of 1 : 2) was founded on the surface of drained subsoil. It was made of a local sand and gravel and connected with the embankment of the section no. 2. The internal slopes and locally the bottom were sealed with the PEHD geomembrane because of a shallow deposit of the swelling silty clay.

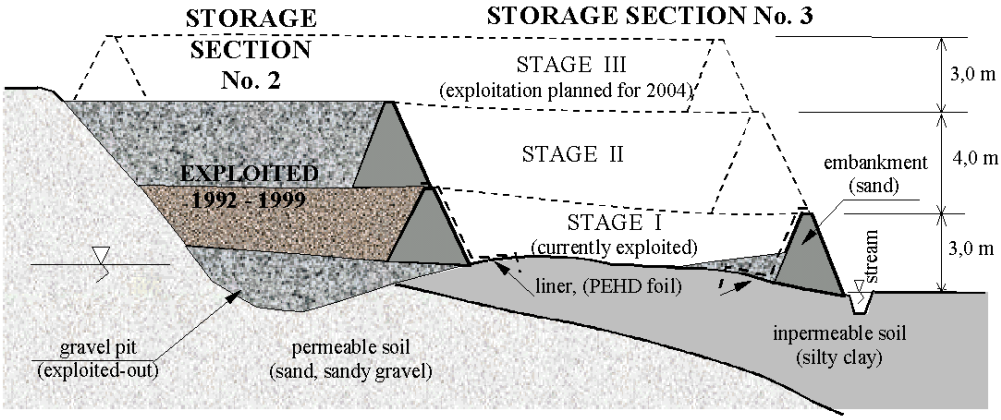

Fig. 2. Landfill site of Oborniki Śląskie – cross-section, the state for February 2001

The construction was completed in March 1999 and this month the storage of the wastes started. The storing period was planned for 5 years. The conception of a further storing (after 2004) assumed construction of next embankments raising the storage level in the section no. 3 in the second stage and over both sections in the third stage. This conception is presented in figure 2.

The example of the landfill site of Oborniki Śląskie motivates us to analyse thoroughly the embankment stability. The final height of embankments in that site will be 4 times as great as that in the landfill of Prusice.

2.3. LANDFILL SITE OF TWARDOGÓRA

The municipal and industrial landfill site for the town and municipality of Twardogóra was built in the locality of Grabowno Wielkie. It was located in a complex of the shallow open casts of brick loam exploited in 1896–1974 by the local brickyard. A total area of the open casts is 14 hectares. At present the area of the waste dump is 3 hectare in two fill areas, separately for the municipal and industrial wastes. The fill areas were built in 1994–1995. The sketch and the cross-section of the municipal waste fill area is shown in figure 3. A permeable subsoil of the fill area and the retention pond were sealed with the PVC foil liner.

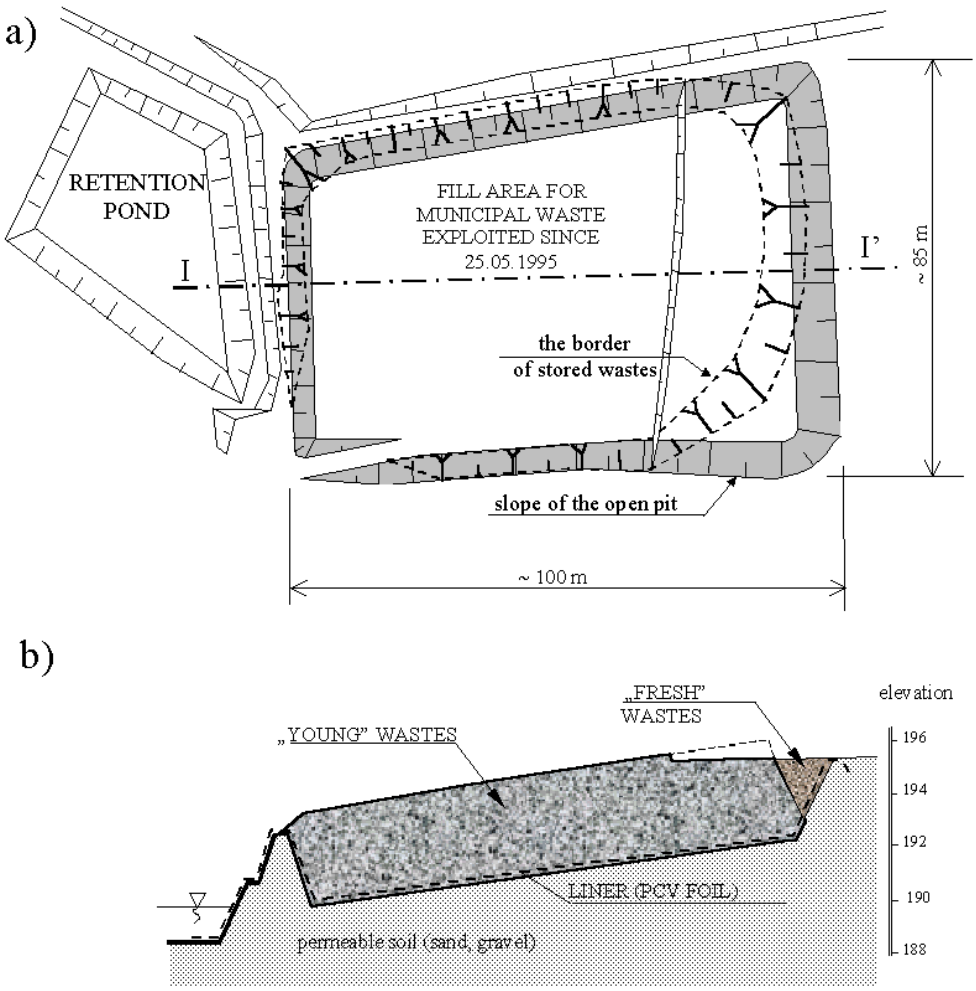

Fig. 3. Municipal and industrial landfill site for the town and municipality of Twardogóra: a) sketch, b) cross-section of the municipal waste fill area

When the storage capacity of the fill area had been exhausted, the local authorities took an immediate decision to raise the waste storing level in the municipal waste fill area. Building of a new fill area was also planned in the immediate vicinity.

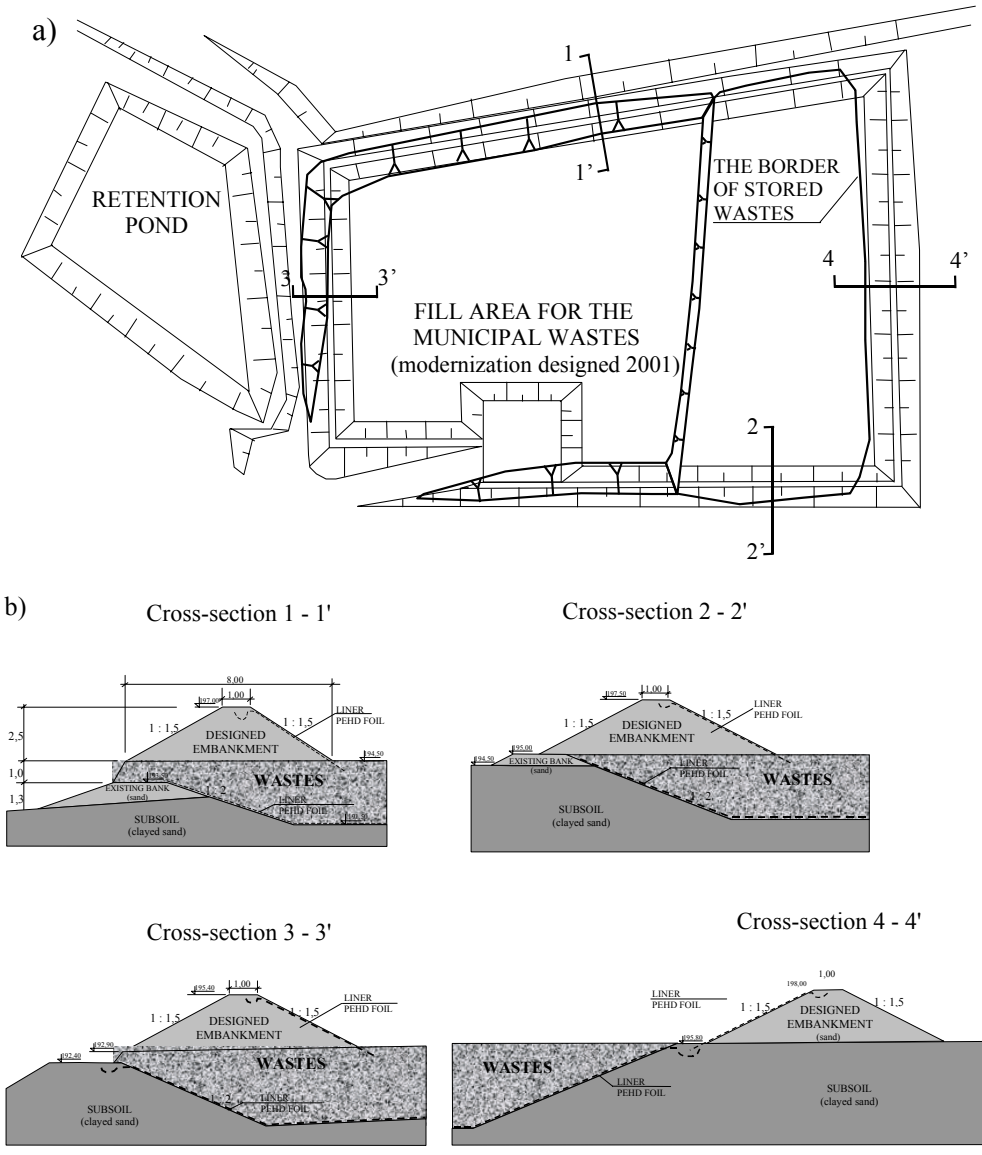

Fig. 4. Municipal and industrial landfill site for the town and municipality of Twardogóra:
a) sketch of the embankments designed for increasing the storing capacity,
b) representative cross-sections of the embankments designed

The design of raising the storage capacity of landfill was given in [4]. New embankments were designed in such a way that they could be built on very various subsoils: the eastern bank on natural subsoil, the western bank on the waste strata of variable thickness and the northern and southern banks on both sands and wastes. The shape of the embankments designed and their representative cross-sections are shown in figure 4. The analysis of this design shows that the critical problems of the interaction between the new embankments and the subsoil are very likely to occur.

In order to estimate deformations of the embankments designed, the settlement calculations for the representative cross-sections (figure 4b) were done. The values of the geotechnical parameters were determined based on the data published [5] and the Polish Norm PN-81/B-03020.

The calculated results (figure 5) show that the final settlement of the top of embankment could reach the value of several tens centimeters on southern, northern and western banks with some inclination to the inside of the fill area. The top of eastern embankment is not practically deformed. A significant deformation of the slopes should be expected. Particularly dangerous are significant differences in the settlement of a short section of embankment, where the conditions in a subsoil are differentiated. That could lead to the breakdown of the embankment in the transitory zones.

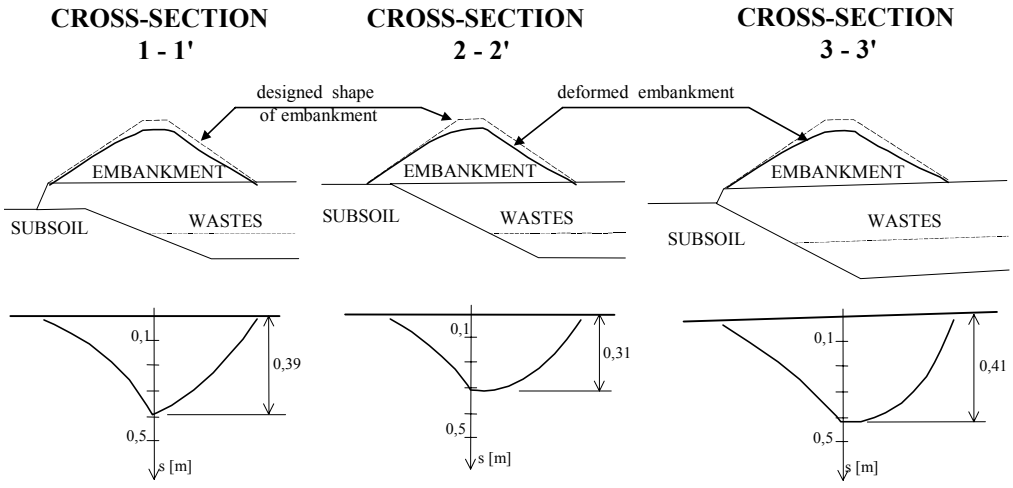

Fig. 5. Municipal and industrial landfill site for the town and municipality of Twardogóra. Prognosis of the settlement for the raised embankments

In the case of implementation of the design [4], a purposeful action allowing reduction of the settlements should be undertaken, e.g. by reinforcing the subsoil with geogrids or geotextiles. An adequate time should be allowed in an initial consolidation of the

subsoil under the embankments built, which make the geometry corrections for the final embankment forming with the liners on their internal slopes possible.

3. SUMMARY

Some examples of the designs being created or implemented in order to increase the capacity of exploited municipal landfill sites were shown. Practical experience has proved that the interactions between an earthen structure and its subsoil in many cases is not analyzed. In consequence, the safety of exploitation of landfill sites is endangered. Considering specific geotechnical properties of the municipal wastes, the authors suggest that designing and forming the earthen structures on the wastes stored should be based on tried and tested methods of building road embankments on a weak soil at determined values of safety coefficients. In such a case, the following technical actions minimizing the risk of breakdown should be considered:

- improving the subsoil properties by planned and systematic thickening of the stored wastes;
- diminishing the pressure exerted on the subsoil by making the embankments from lightweight aggregates or by reducing the size of embankments;
- limiting the deformation of earthen structures by means of geosynthetic reinforcement stabilizing the subsoil.

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