Sealing operations for Valea Ceplea flying ashes deposit, based near Turceni Powerstation

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Abstract: The specialists from the biggest coal operating powerstation in Romania had to face a difficult problem: seepage waters from one compartment of the ashes and slags deposit, known as heaving a high potential risk for human health, were very close to infiltrate in the groundwaters through some permeable layers. As the town of Turceni is supplied with drinking water taken from the groundwaters, the decision factors took immediate measures to prevent the contamination. The designer of the ash deposit was commited to find a suitable sealing solution which had to prevent the seepage water leaks through the permeable layers. The sealing had to be started fast, had to assure a very low k- value and also had to provide a long-term sealing stability. Three possibilities were taken into consideration: the use of a compacted clay sealing, the use of a GCL sealing and , finally , a geomembrane sealing layer. The final choice was made for the GCL solution, this being by far the safest, the fastest, and the cheapest solution for the given situation.

1 INTRODUCTION

Valea Ceplea was built as the main depositing space for slags and flying ashes resulting from the burning of energetic coal at Turceni Powerstation.

The slags and the ashes are transported by hydraulic means to the depositing place, which was built in a valley, at approximately 3 kilometers from the powerstation. The deposit has three compartments, separated by dikes.

A hydrological evaluation was required, than made, to analyze the influence of the growing height of ashes layers against some permeable soil horizons.

The evaluation concluded that there are high risks of infiltrations from the deposit to the underground water, through the permeable soil layers. More than that, it was estimated that as the ashes height is raised, due to the hydraulic transport system, the underground springs get the excess of water and transport it to the nearby valleys, raising both the underground water level and the surface waters level.

As the sewage water is chemically active and hazardous to the human health (load of Mg, Cl^-, SO_4^-) and also taking into consideration the unacceptable risks mentioned above, the responsible factors took the decision to seal the extremities of the permeable layers, on the surface being in contact with the ashes and slags pumped into the deposit.

Photo 1 Total situation of the fly ash deposits

Photo 2 Way of placing the ash by hydraulic means

2 THE GEOLOGICAL ASSESSMENT OF THE AMPLACEMENT

From the geological point of view, the soil in the region is characterized by an alternance of clay with sands and coal horizons. The clayish horizons are mixed with sandy layers, some of them pressed, having thicknesses up to tens of centimeters. These permeable layers can be a preferential way for the infiltrated rainwater and runoff water.

It appeared as necessary to study the possible solutions for the sealing of the permeable horizons and to choose the optimal variant, technically and economically.

3 POSSIBLE SEALING SOLUTIONS

The slags and the ashes can be considered mineral waste. They are organically inert, but chemically active, having water soluble constituents.

There were taken into consideration three sealing possibilities: the classical clay solution and two modern variants, with the use of geocomposite clay liners and geomembranes. The required k-value was established around 10^{-11} meters per second.

The sealing is technically possible in all three cases, but specific characteristics were outlined for every one of them.

Speaking of the installation effort, the geosynthetics are under no doubt more effective, but require qualified personnel and relative complicated operations on large surfaces: preparation of the subgrade, accuracy of the overlaps for GCL-s and high quality weldings for the geomembrane.

On the other hand, even if the clay sealing would be made using the machinery available on site, there is not enough clay available in a nearby quarry. The main difficulties appear due to the necessity to transport the clay from a distant quarry, thus generating important expenses.

4 TECHNICAL ANALYSIS

4.1 The clay sealing solution

<u>Advantages:</u>

- The installation of the clay sealing can be made using the machinery already available on site;
- The clay can be used for the sealing of every permeable layer extremity, with no regard on the embankment slope;
- The clay sealing can be installed without any special preparation of the subgrade, in such a manner that it is not necessary to make an accurate leveling;
- The clay sealing can contribute to the general stability of the embankments;
- The clay sealing can be constructed exclusively for every permeable soil layer, in such a way that the sealing surface is not continuous and thus smaller than in the other variants.

<u>Disadvantages:</u>

- The quantity of clay necessary for sealing is important and not entirely available on site;
- The eventual excavation of the existing clay layers can uncover other permeable layers;
- The installation of the clay is weather dependant. The installation operations (especially compaction) are cancelled if rainy weather or frost occurs.

- The sealing effectiveness is strictly dependant upon the installation quality. It is necessary to respect "by letter" the technical prescriptions and recommendations for clay installation.
- Installation of clay on slopes is not possible.
- The clay liner itself is sensible against frost.

4.2 The gcl sealing variant

The Geosynthetic Clay Liners are composite materials which put together the bentonite and synthetic materials. They act like a barrier against liquids and even gases, they are homogenous, robust and easy to handle.

- The bentonite within these materials is swelling in contact with water or other liquids and this way becomes waterproof;
- The GCL-s are most of them delivered in rolls. Their installation is quit simple: the material is unrolled, than casted in place;
- The GCL-s are homogenous on the whole surface. The eventual human errors which can effect upon the permeability are limited to the overlaps;
- The GCL-s manufactured as combinations between geotextiles and bentonite have self-repairing properties in case of small damages. Due to the bentonite sweeling the small holes or perforations are filled up and then the low permeability is restored without interventions;
- The GCL-s are sensible neither to frozen-thaw cycles, nor to differential settlements;
- The GCL-s can be installed even in bad weather conditions, with low temperatures;
- The connection between adjacent foils is made in a very simple manner, without sewings or weldings: just by overlapping and treatment with bentonite paste.
- GCL have high friction values in contact to soil.

Disadvantages:

- The GCL-s must be installed in "dry conditions" (max. light rain);
- The subgrade must be prepared, machine trimming;
- The GCL-s must be protected with a soil layer;
- If springs are detected behind the sealing through visual examination, they must be drained off to prevent the hydraulic loading of the GCL.

4.3 The geomembrane sealing solution

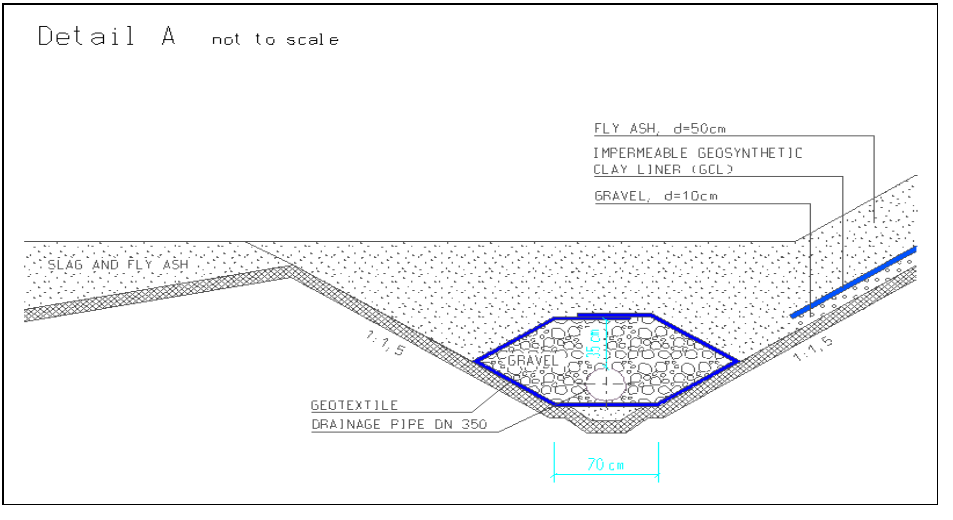
Advantages:

- The geomembranes are practically perfect impermeable for most of the substances; their elongation behaviour is remarkable; their guaranteed service life is higher than in any other of the solutions studied in this project;

- The k value for the geomembranes is lower than the clay and even the GCL-s.

Disadvantages:

- There is no possibility to seal long , steep slopes with geomembranes. If the slope is steeper than 1:3 it is always necessary to make intermediary berms.;
- The connection between adjacent sheets is made by welding. This operation is particularly difficult and requires qualified personnel and suitable weather conditions and positive temperatures (above 5° Celsius);
- The geomembranes must be protected with a geotextile;
- Geomembranes and geotextiles have to be ballasted against wind attack;
- If springs are detected behind the sealing through visual examination, they must be drained off to prevent the hydraulic loading of the geomembrane.



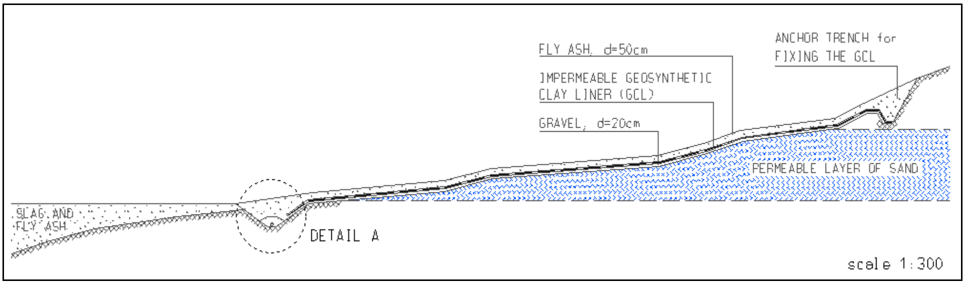


Figure 1 and 2 Cross section of sealing and drainage system

Having in mind all the above mentioned aspects, the following remarks were made:

- The GCL is by far the easiest to install, offering very good performances;
- The clay sealing, although apparently advantageous has two main inconvenients: the transport distance of the clay and the very cautious installation technique;
- The geomembrane sealing is difficult due to the welding operations and the necessity of intermediary berms.

The final decision was to choose the GCL for the sealing.

5 THE ECONOMICAL ANALYSIS OF THE PROBLEM

This analysis was made with regards to the particularities of the materials and especially to the specific natural conditions on site.

For the clay solution the main factor taken into consideration was the important quantity of raw material required for construction (about 350000 cubic meters), which would have been taken from considerable distances.

For the GCL solution were analyzed the costs for the terrain preparation and arrangement, the cost of the GCL, the drainage system and the methods for the GCL protection layer, consisting in ashes taken from the deposit.

Similarly, for the geomembrane solution, the same factors as in the case of GCL were taken into consideration; more than that, there were also analyzed the welding cost and the geomembrane protection cost.

The result of the analysis was by far in the direction of the GCL. The solution of sealing with a GCL was estimated as being with more than 15-20% cheaper than the other solutions.

6 THE GCL

Given the sealing solution, it was necessary to choose the GCL.

The specific conditions which has to be taken into consideration before choosing the GCL are enumerated like follows:

- The natural slopes inclinations have values between 1:1,8 and 1:5. They are covered with vegetation. The sealing is to be made in more phases, starting with the base of the slope. No changes in the natural geometry of the terrain (slope changes or intermediary berms) are allowed, due to the stability loss risks.
- The subgrade is mainly consisting in sand layers with internal friction angles between 12-18°.
- The cover material for the GCL will be an ash with the following composition:

No.	Chemical combination	Measurement unit	Value
1	Al_2O_3	%	23.98-25.17
2	Fe_2O_3	%	9.83-15.32
3	CaO	%	1.01-2.97
4	MgO	%	0.38-0.45
5	Na_2O	%	0.76-0.95
6	K_2O	%	0.83-0.85
7	SiO_2	%	50.33-56.08

- The main characteristics of the seepage water that will come in contact with the GCL are enumerated below:

No.	Element	Measurement unit	Value
1	PH		7.1-9
2	Free CO_2	Mg/l	17-30
3	Alkalinity "p"	Miliequivalents/l	0
4	Alkalinity "m"	Mg/l	1.4-2
5	HCO_3	Mg/l	80-130
6	Temporary hardness	Mg/l	3.9-6
7	Permanent hardness	^0G	60-80
8	Ca^{2+}	Mg/l	400-460
9	Mg^{2+}	Mg/l	70-115
10	Cl^-	Mg/l	150-190
11	SO_4^{2-}	Mg/l	1100-1500

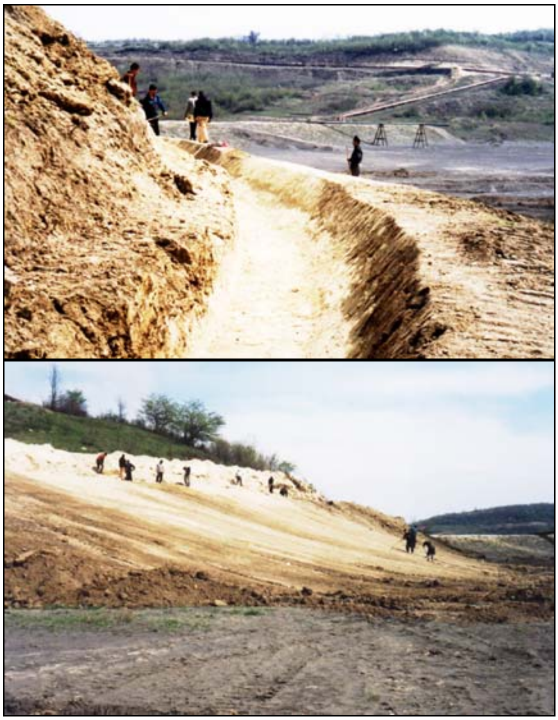
- The cover material to be used is consisting in ashes and slag with an internal friction angle of about 30^0. The cover layer will have a thicknes of 50 cm.
- Due to the scale and urgentness of the work, the installation must be finished in the period between March and June 2000.
- Due to the chemical composition of the seepage water (with the presence of an important Ca^{2+} quantity), with possible influences on bentonite k-value, combined with important hydraulic pressure on the sealing, there were demands for severe hydraulic conditions, in that way that the k-value of the GCL must be measured in the specific site conditions. The normal effort given by the protection layer and the first ashes layers is of about 10 kPa, with a hydraulic load of 1m water head. The normal effort given by the cover layer together with all deposited ashes layers is of about 80 kPa, with a hydraulic load of 20 m water head. The k-value measured under these conditions must be 1x 10^{-9} m/s.

As a result of the analysis of the different GCL-s available on the Romanian market paying attention to the technical suitability for the given purpose and the price, the specialist chose the Bentofix® NSP 4900-3 , produced by Naue Fasertechnik GmbH & Co KG.

Bentofix® was considered the optimal material because of the following reasons:

- it is a needle-punched GCL, thus having the advantage of a superior inter-layer connection strength;

- it fulfills both the hydraulic conditions and installation conditions. Its k-value, measured by an independent German laboratory in contact with the seepage water from Ceplea Valley site, was around 10^{-12} m/s, ten times smaller than the required;
- the needle punching technique allows the material to adapt itself to differential settlements keeping the same low k-value;
- the needle-punching guarantees the stability of the bentonite layer between the geotextiles.



Photos 3 and 4 Preparation of the subsoil prior to the installation of the GCL

7 THE GCL INSTALLATION

The main operations required for the installation of the Bentofix® GCL are enumerated below:

1. the laying of Bentofix® sheets on the slope, positioned to cover the permeable layers;
2. the construction of a drainage system (metal pipe in a geotextile protected mineral filling).

The drainage is made to download the hydrostatic pressure created by the water immersed ashes and slag and to intercept the eventual coastal springs coming

through the permeable layers towards the sealing. The drainage system will be buried in the ashes , at the base of the Bentofix® sealing structure.
The drainage system also takes the responsibility to drain off the water which will eventually penetrate from the deposit behind the sealing system.

The sealing work will be made in the same time with the drainage work, on phases and working fronts. For every working front there will be made: the subgrade preparation, the Bentofix® installation, the drainage system construction, the cover with ashes. After that, a new working front will be opened, and so on.

The Bentofix® sealing operations need an initial preparation of the terrain before the laying:
-the clearing of the vegetation growing on the soil;
-the excavation of the vegetal layer;
-the construction of the Bentofix® entrenchment system;
-the drain off of the eventual coastal springs;
-the laying on the subgrade of a small-sized granular material (maximum diameter small than 20 mm), if in the section there are some small impermeable layers inside the permeable soil;
-the excavation of the trehch for the drain.

After this preparation, the proper installation of Bentofix® can be started: the material is anchored, then unrolled, overlapped. The overlaps are treated with bentonite paste. The Bentofix® is unrolled on the slope from the top to the bottom, paying attention to the overlapping distance for the adjacent rolls. On the top of the slope, the Bentofix® is anchored in the trench, which is then filled with soil.

The last step is the covering of Bentofix® with 50 cm of ashes and slag, as a ballast and protection layer. The covering is to be berformed with bulldozers, from the bottom to the top. In the areas where the slope is very steep, 1:1,8, there are allowed small modelations of the terrain, in such a way that the inclination is brought to a value of 1:2,5.

As a prevention measure, small trenches will be excavated in the covering material, to take care of the eventual high flow run-off waters possible to appear after a heavy rain.

The installation works were not started yet. They will probably begin in the first week of April. Until the date when symposium is to take place, more information will be available.

Uszczelnianie składowiska popiołu Valea Ceplea, usytuowanego w pobliżu elektrowni Turceni

Revenco V. & Tronac B.

Streszczenie: Specjaliści z największej działającej w Rumunii elektrowni węglowej musieli zmierzyć się z trudnym problemem ekologicznym: wody filtracyjne z jednej części składowiska popiołu i żużlu, o którym wiedziano, że

jest potencjalnie szkodliwy dla zdrowia, były bliskie przeniknięcia do wód gruntowych. Ponieważ miasto Turceni jest zaopatrywane w wodę pitną pozyskiwaną z wód podziemnych należało podjąć natychmiastowe kroki aby zapobiec zanieczyszczeniu. Konieczne było znalezienie odpowiednich środków zaradczych, które uniemożliwiłyby infiltrację wody przez przepuszczalną strefę aeracji. Uszczelnienie należało zastosować natychmiast; winno ono zapewnić bardzo niską wartość współczynnika filtracji k oraz długotrwałą stabilność uszczelnienia. Rozważano trzy warianty: zastosowanie uszczelnienia ze zwartej gliny, uszczelnienia gliną geosyntetyczną (GCL) lub wykorzystywanie jako warstwy uszczelniającej geomembrany. Ostatecznie wybrano drugie rozwiązanie, jak dotąd najbezpieczniejsze, najszybsze i najtańsze.