Utilization of GCL at recultivation works of burning dump of mine Katerina, Radvanice

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ABSTRACT: This presentation refers to the experience gained in the Slovak and Czech Republic in the studies on the Tatrabent (Tb) geosynthetic mat with a high potential for environmental uses. Two aspects are treated (1) definition of criteria for Tb mat for the choice of the sites for application and (2) design of the engineered barrier in contact with burning dump with an escape of harmful gases from the dump into the atmosphere. The utilization of Tb mat as antiradon barrier belongs among significant properties giving preference to this product at recultivation works of burning dump of the mine Katerina in Radvanice, Czech Republic before other sealing procedures. It is believed that this advantage is given by the zeolite addition having high sorption capacity when entrapping gaseous air pollutants of SO_2, CO, NH_3, CS and NO_x. The coefficient of radon transport through the bentonite - zeolite mineral filler is k_p=2.0x10^{-8} m.s^{-1}. The burning self-ignited spoil material is taken from the dump, dislocated on the new 200x50 m deposition platform (cassette) mixed with a soil, and consequently compacted. The Tb mat overlaps such a composite material. This sandwich system of deposition is repeated for several times until required opening of the next deposition platform. The recultivation works made by Tb mat are conditioned by the necessity of stopping air pollution. Details on non-traditional application of the GCL product as gas-tight barrier are described in the paper from the viewpoint of mineral filler composition, projection documentation and construction procedures.

1 INTRODUCTION

The use of bentonite as environmental sealant has already become a standard practice in construction of landfills (Daniel, D. E. et al. 1993; Jessberger, H. L. et al. 1985). The essence of the geosynthetic clay liner (GCL) is the layer of bentonite, which is held between or on a carrier layers of geotextiles or a geomembrane. In 1994 modified clay liner has been given into practice where bentonite was partially replaced by natural zeolite (Baslík, R. et al. 1994; Baslík, R., Janotka, I. 1996, Janotka, I. et al. 1999).
Zeolite represents a volcanic sedimentary authigenic rock in which clinoptilolite (the main mineral) by the conversion of quartz-rich vitreous ash into the mass of zeolitic rock was created. An alumino-silicate skeleton structure of clinoptilolite enables zeolite its ion exchange capabilities and adsorption of molecules of different sizes on zeolite grains without impairment of their surface. This predetermines zeolite for sorbents, molecular sieves and catalysts (Samajova, E., Kraus, I. 1977; Kraus, I. et al. 1994). Zeolite addition to bentonite contributes to enhancing some special

properties of blended bentonite-zeolite mineral filler relative to that of bentonite such as metal sorption, neutralization ability, dirty air traps (Baslík, R., Janotka, I. 1996, Baslík, R. et al. 1997; Baslik, R. et al. 1997). Zeolite is utilized in blends with ordinary Portland cement in our country (Janotka, I., Števula, L. 1998; Janotka, I., Krajci, L'2000) due to its favourable influence on the increase of chemical resistance of structures made from Portland - zeolite cement, in particular at foundation engineering.

2 BASIC CHARACTERISTICS OF THE MAT

Tatrabent is a geosynthetic mat with blended mineral filler consisting of bentonite and zeolite. The coefficient of filtration k_{fin} is less than $3x10^{-11}$ $m.s^{-1}$. The values of coefficient of permeability k_n in the crude oil and petrol are $2.6x10^{-11}$ $m.s^{-1}$ and $5.4x10^{-11}$ $m.s^{-1}$. In five minutes the pH of the solution is stabilized on values of 8 compared with those of 4.4 at the beginning of tests. Tb mat is suitable for lower and upper sealing of waste deposits, water channel, pond and water basin insulation, and concrete protection against aggressive underwater and controlled drainage of various traffic construction sites. Basic characteristics of this product are given in Table 1.

Table 1. Basic characteristics of the mat used for sealing in Radvanice

Montmorillonite content (methylene blue test)	min. 65 %
Swelling ability (2g/100 ml /2 hours)	min. 16 %
Water sorption (Enslin/24 hours)	min. 500 %
Plasticity limit	max. 50 %
Liquidity limit	min. 330 %
Metal sorption	min. 95 %

Blended mineral filler of Tb mat is more effective sorbent of nitrogen dioxide vapour than comparative silicagel. The efficiency of the nitrogen dioxide sorption is approximately 2.6 times larger than that found in comparative silicagel. Similar results were observed for water vapour sorption. The coefficient of radon transport through the bentonite-zeolite filler is $k_p=2.0x10^{-8}$ $m.s^{-1}$.

3 QUANTITATIVE ASSESSMENT OF LOCAL SEALING CLAY MINERAL

Three local clayey materials were verified bearing in mind the principal qualitative criterion - coefficient of filtration required on levels $k_{fn}=n \times 10^{-10}$ $m.s^{-1}$ in construction plans. Properties of clayey materials are given in Table 2.

Table 2. Main geotechnical characteristics of local materials

Material index		Jaromer	Pulice	Katerina
Grains < 0.063 mm,	%	79.9	87.5	73.4
grains < 0.002 mm,	%	21.3	16.2	10.0
Liquidity limit,	%	40	39	28
Plasticity limit,	%	19	19	18
Natural humidity,	%	19	18	19
Coeff.of filtration	$m.s^{-1}$	$3x10^{-11}$	$6x10^{-10}$	$3x10^{-8}$

The above clayey materials do not meet given demands on the sealing quality. Moreover a high degree of their heterogeneity has been found. Modification of their properties by powder bentonite addition has been rejected due to small cubatures confirmed by geological quest. Costs for clay importation of high quality from distant localities are so high that it has been coming up to the alternative of a combination of natural materials with artificial sealing elements. This idea was inserted into the layout of deposition platforms (cassettes) construction scheme. Clay mineral sealing from local available raw materials is suitable only for conditioned crop base of lower cassettes. For the sealing of embankments slopes and closing of cassette surface geosynthetic mat was applied.

4 RECULTIVATION OF BURNING DUMP PILE OF THE MINE KATEŘINA, RADVANICE

4.1 *History of coal deposit*

The beginning of mining is dated between 1840-1850. In 1940 100 kt of coal was mined annually. Maximum was reached in 1978 with 321 kt. At the beginning of the 8th decade of the 20th century the mining has been not economically profitable. Concurrently consequences of oxidation processes inside the dump gained such intensity that surrounding country started to be negatively influenced. At the same time until now any attempt to extinguish burning dump pile was unsuccessful.

4.2 *Characterization* of the dump pile

The area of former Mine Katerina is situated into nearness of the village Katerina (Czech Republic). An average above sea level of the area is 530 m, dimensions 650x350 m, volume of burning dump pile is approximately 2.5 mil. m^3. The dump pile consists of 3 basic parts: dump pile I - north-west part, dump pile II - middle part so-called the basic cone ("old dump pile"), and dump pile III - south -east part ("new dump pile"). The amount of burnable substances in the dump is up to 65 %; the total mass of dump pile contains 20-25 % combustible. It represents at least 500 000 t of coal with calorific value approximately 31 MJ/kg. Total amount of heat capable to release by self-ignition and firing of spoil is estimated on more than 10 000 t of sulphur dioxide. Burning zone is situated 5-15 m under the surface of dump pile. Temperatures in the core reach values of about 1000 °C. One third of the surface mass has temperature below 50 °C, 1/3 between 50-80 °C, and the rest over 100 ^{o}C. Next characteristics of dump pile are increased radiation as well as metal content (Fe, Cu, Pb, Zn, Mo, As, Ti, Se, Ge).

4.3 *Proposed way of dump pile recultivation*

In September 1995 Energie Kladno Ltd., Czech Republic elaborated the project dealing with the liquidation of burning dump pile of the Mine Katerina, main principles of which concern following procedures: a.) liquidation of long-term source of deleterious gaseous emission, b.) liquidation of consequences of mining activity in the country, c.) high standards of cleanliness of surrounding water courses on required level of water quality.
The actual procedure of recultivation works lies in three principal steps: a.) the mining of burning dump pile, b.) the cooling of the mass of dump pile on safe temperatures from the viewpoint of self-ignition of coal spoil ($t \leq 35$ °C), c.) the storage of cooled mass into new built dump pile on the basis of guided construction of cassette systems. Geosynthetic mat has been making useful just here.

4.3.1 *Disassembling of warm parts of origin dump pile*

Disassembling of origin dump was realized on the basis of "Technological rule for disassembling of warm parts of the dump into cassettes No. 3 and 4". No detailed attention is devoted herein to it.

4.3.2 *Model scheme of construction solution of cassettes*

In spite of the conception "Recultivation of burning dump pile of the Mine Katerina, Radvanice" it has been coming up to the construction of cassette sealing dumping into which primary reclaim waste material cooled on temperatures below 35 °C has been deposited.

Main principles of cassette construction are following:

- processing of the subgrade utilizing local available materials (soils, clays)

- drainage of dumping subgrade (retaining drainage ditch over upper border of cassette, basal square drainage in the subgrade of a cassette). To avoid mutual linkage of waters between systems the square drainage on the upper border of cassette was sealed off by impermeable clay plug with the power of 85 cm compacted gradually in 4 layers with width of 4 m
- mineral clay sealing of bottom parts of the dumping
- cassettes are built without embankments, the maximal power of stored spoil material is 7 m
- artificial sealing by geosynthetic mat
- drainage of cassettes (inner and bottom drainage)
- protection against erosion
- closing of dumping (clay sealing 45 cm, upper protective layer 20 cm, drainage layer 30 cm, cover layer from inert material 35 cm). The 25-cm thick vegetation layer is situated on the top of dumping.

5 APPLICATION OF GEOSYNTHETIC MAT

Application of geosynthetic mat is explained in a more detail on example of the construction of cassettes No. 5, 6 and 7. The cassette No. 6 is situated over the cassette No. 5. (inclination of slopes 1:3) and is provided with closing layer. The cassette No. 7 is tied just onto this slope, which is sealed by the mat. The overlap of the mat is 2 m at the heel of a slope, and 3 m at upper border. Each cassette (volume over than 1000 m^3) is divided into blocks, which are again sealed by the mat. Cassettes No. 6 and 7 serve as closing ones. Therefore they are also sealed by mineral clay sealing and covered by final closing layer. Volumes of individual structural elements are reported in Table 3. Geosynthetic mat is put 1.) on inner walls dividing cassettes into blocks, 2.) on the cover of a cassette. Before putting the first 3-m wide layer, the excavation around the perimeter of a cassette till on the clean top layer of mineral clay subgrade is carried out. The excavation is then by fraction of 0-30 mm of processed spoil material filled up and is again compacted. Next horizontal strip is put by similar way step by step. The excavation carries out the join of mat between previous and new cassette at slope and square connection.

Table 3. Volumes of individual structural elements at the construction of cassettes No. 5, 6 and 7

Cassette	Structural elements				
		No. 5	No. 6	No. 7	Total
Protective layers	m^3	8250	-	-	8250
Geosynthetic mat	m^2	25600	-	-	25600
of blocks					
Protective layers	m^3	-	1110	1040	2150
Geosynthetic mat	m^2	-	3440	3200	6640
Total					
Protective layers	m^3	8250	1110	1040	10400
Geosynthetic mat	m^2	10150	3440	3200	16790
Filling material	m^3	63950	166390	154760	385100
Antierosive layer	m^3	2350	-	-	2350
Spoil from dump	m^3	84650	180140	155800	420590
Mining of spoil	m^3	88883	189147	163590	441620

6 CONCLUSIONS

1. Geosynthetic mat is inseparable component of the whole systematic course of sealing of burning spoil using the construction of cassettes for this aim.
2. The advantage of blended bentonite-zeolite filler bound in the mat lies in stopping of air pollution of surrounding country. No self-ignition of spoil stored in cassettes and no release of harmful gases into the atmosphere has been found up today.
3. The use of geosynthetic mat means a pronounced simplification of sealing procedure.

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