Geosynthetic Sealing Products with Bentonite and Zeolite Fillers

R. Baslik, I. Janotka, Z. Cerná & V. Papajová
Civil Engineering Research Institute, Bratislava, Slovak Republic

ABSTRACT: A combination of geotextiles with mineral filler is introduced. The clay component in geosynthetic clay liner (GCL) was partially or totally replaced by the zeolite tuff. The properties of such materials were tested. The geosynthetic bentonite-zeolite liner (GBZL) with optimum of bentonite to zeolite ratio in the mixture composition was verified. The most 50% of bentonite may be partially replaced by the zeolite tuff. On the contrary zeolite tuff increases significantly absorption capability of GBZL against cadmium in comparison with GCL. Zeolite tuff as well as its common mixture with bentonite indicates the reduction in swelling ability. The coefficient of permeability of GBZL is decreased but not to such an extent to eliminate its sealing ability.

1 INTRODUCTION

In recent years, the quality of the life environment in Slovakia is deteriorated to a great extent mainly due to industrial pollution and waste materials production. The leak of waste materials of various type into subgrade and groundwater is possible to expect.

In our case the protection of the subgrade and groundwater against Cd salts was acquired. This method of solution is consonant with the EC Groundwater Directive 80/68/EEC. The cadmium and its compounds should be prevented from being discharged into groundwater (Street, 1994). The effective groundwater protection is provided by means of a combined trapping and sealing layer. For this aim the geosynthetic bentonite-zeolite liner (GBZL) was applied.

2 MATERIALS

The clay component was partially or totally replaced by the zeolite tuff. Commercial bentonite from the North Bohemian deposit situated in the Czech Republic was used. The main mineral montmorillonite was detected by the X-ray diffraction analysis at 1,260, 0,451, 0,322 a 0,257 nm. Bentonite was prepared in Na-modification.

The deposite of the zeolite tuff is situated in the Badenian Mountains, Slovak Republic. The tuff contains clinoptilolite at 0,918, 0,399, 0,802, 0,514, 0,344, 0,334, 0,299 a 0,281 nm, cristobalite at 0,401nm and feldspar at 0,319nm. Partial exchange capacity of the clinoptilolite tuff is 0,75val.kg^{-1} (Varga, 1984). Chemical composition of both materials and bentonite-zeolite mixture used for sorption experiments is given in Table 1.

3. EXPERIMENTAL

Particle size analysis of tested materials was determined by areometric tests in water using also a coagulating agent. Particle size distribution of commercial bentonite, zeolite and their mixtures was divided into three decisive portions: clayish, silty and sandy (Figure 1).

Table 1 Chemical composition of tested materials

Composition (%)	Bentonite	Zeolite	Bentonite-zeolite mixture
Moisture to 100°C	7,82	4,08	4,78
Loss in ignition	15,66	10,99	12,02
SiO_2	43,09	66,72	60,07
CaO	4,53	5,25	4,57
MgO	2,58	-	1,37
Al_2O_3	17,70	13,97	15,59
Fe_2O_3	15,32	1,69	5,44
SO_3	0,55	-	0,19

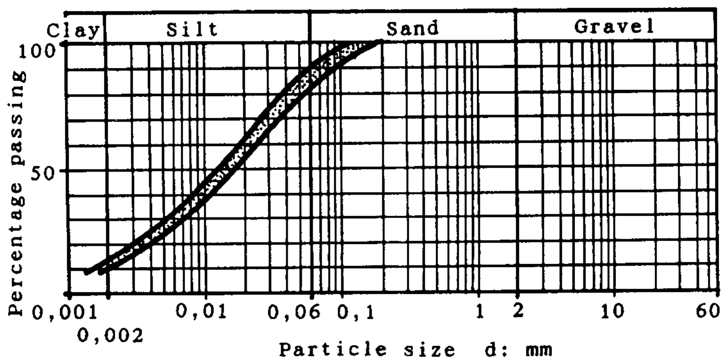

Fig. 1 The range of grain-size distribution of material used

As seen from the above illustration it may be pointed out that particle size distribution of such different materials is very similar. The substantial amount of the particles falls into fraction "silt" for all materials.

Liquid and plasticity limits as well as plasticity index are given in Table 2.

The ability to entrap cadmium (ionic radius of 0,097nm) and for comparison cesium (ionic radius of 0,167nm) was provided by the sorption experiments. As Figure 2 and 3 show cesium with the larger ionic radius is arrested by bentonite and zeolite tuff comparatively. At this point it must be found that zeolite tuff as well as bentonite-zeolite mixture pronouncedly enhance its absorption capability against cadmium-smaller in ionic radius.

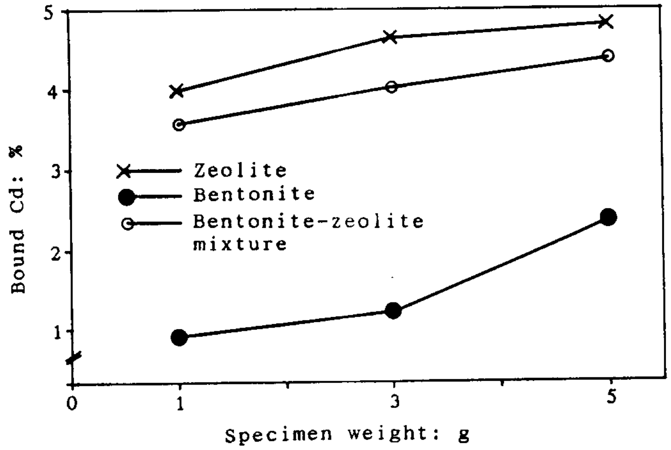

Fig. 2 Cadmium bound in tested materials stored 14 days in 0,01 mol.dm^{-3} $CdCl_2$ solution

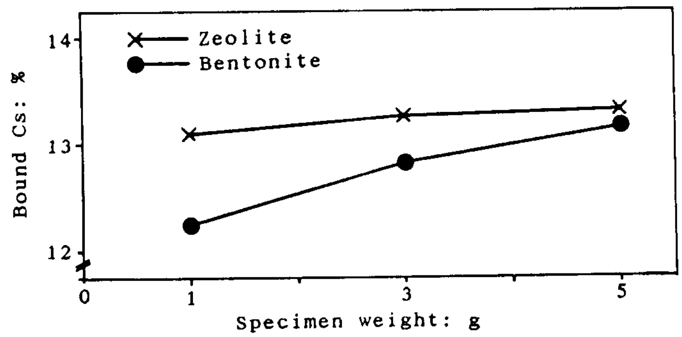

Fig.3 Cesium bound in tested materials stored 14 days in 0,01 mol.dm^{-3} CsCl solution

4 GEOTECHNICAL EVALUATION OF THE BENTONITE-ZEOLITE MIXTURE

The mixture should posses primary requirement - it may prevent Cd salts discharging from the landfill into subgrade and then into groundwater.The extraordinary properties of the each mixture component are exploited; zeolite traps Cd salts into its structure and bentonite create a sealing layer owning to its swelling behaviour. In consideration of both dissimilar properties and different exertion of the each mixture component laboratory tests were carried out.

According to the required multi-functional performance of the product it is important geotechnical evaluation of the mixture.

Classification tests were used to determine index properties of all three materials: bentonite, zeolite, bentonite-zeolite mixture. Tests results are shown in the Casagrande´s graph (Figure 4).

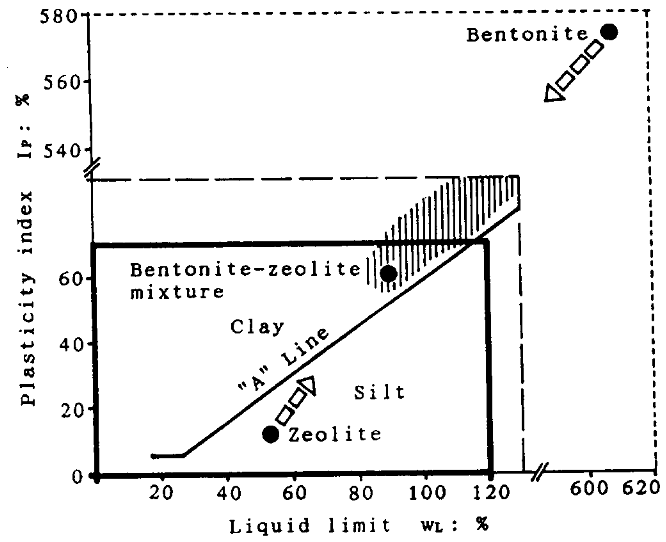

Fig. 4 Casagrande´s graph

Activity index I_A after Skempton was determined: $I_A \approx 0,8$ for zeolite and $I_A \approx 5,9$ for bentonite-zeolite mixture.

The important data are presented in Table 2. On their basis the classification of tested materials was performed. Zeolite is classified as inorganic silt of high plasticity and bentonite as clay of extremely high plasticity.

Table 2 Characteristics and classification of the tested materials

Characterictics	Bentonite	Zeolite	Bentonite -zeolite mixture
Particles amount > 0,06mm, (%)	12	10	18
Particles amount < 0,06mm, (%)	88	90	82
Particles amount < 0,002mm, (%)	≈ 12	≈ 15	≈ 10
Liquid limit w_L, (%)	618	53	91
Plasticity limit w_P, (%)	45	41	32
Plasticity index I_P	573	12	59
Position compares with "A" line	above	below	above
Class	F8	F7	F8
Group symbol	CE	MH	CV - CE
Name	Extremely high plastic clay	High plastic silt	Very high plastic clay

The bentonite characteristics are expressively changed by adding of zeolite. Values of w_L and I_P decrease, the reduction of the plasticity index is important.

Mixture mechanical characteristics, shear strength and compressibility, are directly related to the plasticity index. Significant forces act on the GBZLs due to the weight of overlying layers.

GBZLs must be capable of withstanding high loads without reduction of its sealing and absorbing function. In this case the mixture shear strength is very important and we assume that added zeolite increase the mixture shear strength. Changes depend primarily on the bentonite to zeolite ratio.

5 GBZL - DESCRIPTION AND MANUFACTURE

This geosynthetic clay-zeolite liner consists of a layer of special packing mixture encapsulated between two geotextile layers connected by a proven method of mechanical binding - needlepunching technology.

The textile layer is a nonwoven polypropylene spunbonded geotextile material. The fibres from the nonwoven polypropylene geotextile are needlepunched through the packing mixture and through the other nonwoven layer forming a bond between these two layers of geotextile. The special packing mixture is fixed by means of a mechanical binding.

It is possible to apply also other known technologies of mechanical binding beside the technology of needlepunching, e.g. stitch-bonding, stitching etc.

The product is available in rolls with 10 m length and 3,5 m width wrapped in PE-foil.

6 GBZL AND GCL - PERMEABILITY COEFFICIENTS

Two types of geosynthetic mineral liners were used in this research. One geosynthetic clay liner - GCL with bentonite filler and the other a geosynthetic clay-zeolite liner - GCZL with bentonite-zeolite filler. The products have mass per unit area 3.700 g/m^2.

The specimens were inserted in a triaxial cell as well as in a constant head permeameters in order to measure the permeability (Fiala, 1993). The tests were continued until the change in the flow of water through the system was constant. The laboratory test results are illustrated in Figure 5.

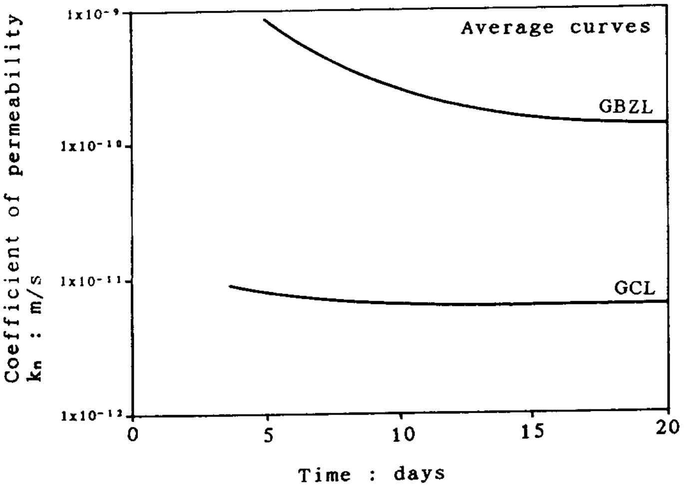

Fig.5 The evolution of the permeability coefficient for tested products

The course of the permeability curves is very similar. However, curves inclination in the initial period of the tests show a slightly different behaviour of the each product. The initial permeability of the system decreases gradualy, stabilizing after approximately 17 days to a value of $k_n = 2.10^{-10}$ m/s for GBZL, resp. of $k_n = 7.10^{-12}$ m/s for GCL.

7 GBZL - USING IN LANDFILLS

GCLs are used in a wide range of sealing applications in civil and hydraulic engineering. GBZL was developed for the construction of landfills and can be installed as component within base layers of the composite sealing systems (Figure 6).

8 CONCLUSIONS

The effective groundwater protection against cadmium salts and similar compounds with the size equivalent of their ionic radius by the geosynthetic bentonite-zeolite liner was suggested. The commercial bentonite and zeolite tuff of Czecho-slovak origin was applied for tests. Bentonite was partially replaced by zeolite tuff to improve the absorption capability of the mixture. Classification tests of materials as well as permeability tests were estimated and properties of

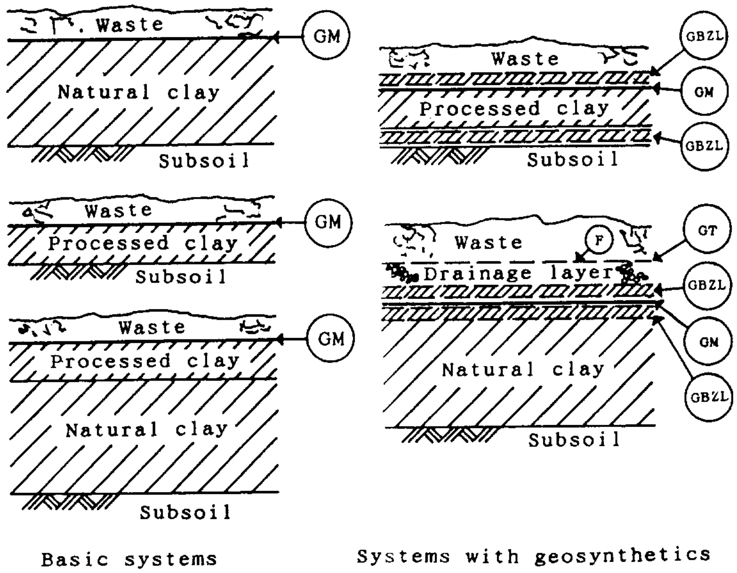

Fig. 7 Composite sealing systems

all materials were compared.

It was found out that partial replacement of bentonite by zeolite tuff increase significantly absorption capability of the mixtures with the optimum of bentonite to zeolite ratio.

The cadmium ion with the smalle radius is decisively entrapped by zeolite tuff. Bentonite creates a cesium-tight barrier, so this clay is suitable to trap only metals with the larger ionic radius.

With respect to its impermeability GCZL can be suitable component of the composite sealing systems.

It can be concluded that the partial replacement of bentonite by zeolite tuff in the geosynthetic liner may introduce the new way of sealing of lanfills against selected aggresive media. The effect of the zeolite tuff addition on the modification of the bentonite mat properties has to be investigated in more detail.

REFERENCES

Varga, I. (1984) The first zeolite deposit in Czechoslovakia: results of geological exploration of the clinoptilolite tuff in Nižný Hrabovec, (in Slovak), *Mineralia Slovaca*, 4:371-376.

Fiala, Z. (1993) GBZLs and GCLs permeability tests. *Test report* - Civ. Engng. Research Institute Brno.

Street, A. (1994) Landfilling: the difference between Continental European and British practice, *Proc. Instn Civ. Engrs Geotech. Engng*, 107:41-46.