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DESCRIPTIVE AND INDEX PROPERTIES OF A NON-STANDARD GEOMATERIAL

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1. Introduction

Stabilisate is a geomaterial which originates from a prescribed formula from the ash waste of power-producing works. It is deposited at registered landfill of waste (Fig. 1.1).

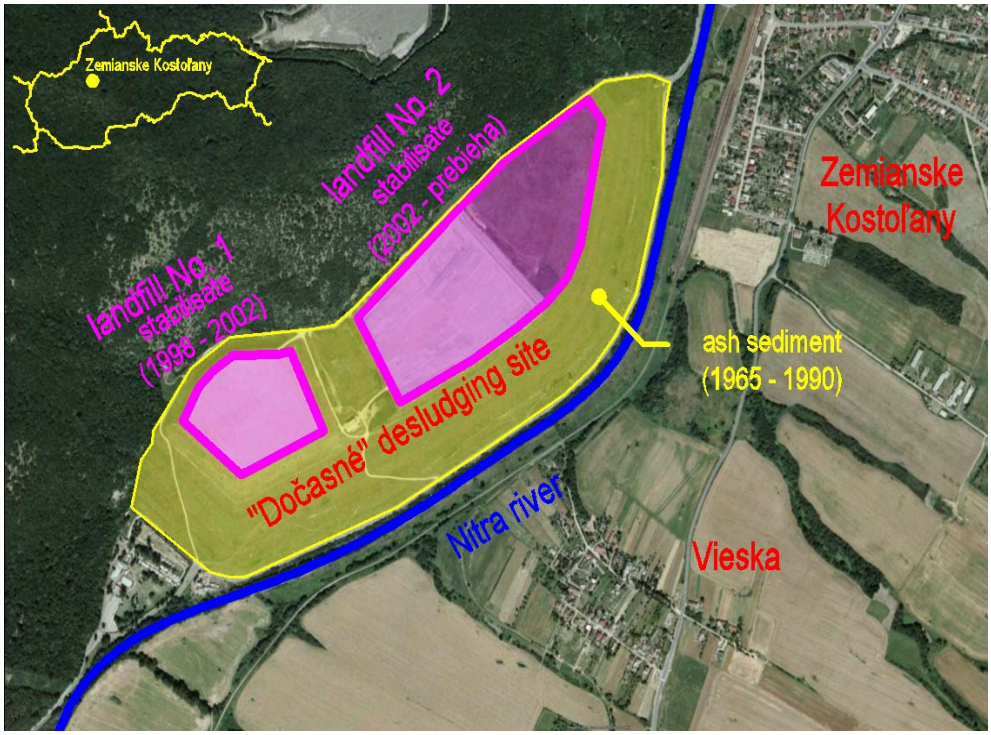

Fig. 1.1 Aerial view of the area of the desludging site ENO, z. (source: GOOGLE Earth)

It is transported from the electric power plant by lorries and in a prescribed way it is spread and rolled in layers at the landfill. At present, on the ash sediment of the desludging site of total thickness of approx. 30 m a stabilisate layer of thickness approx. 8.0 – 10.0 m (landfill

No. 1 and 2) is deposited. In the sense of legislative provision, the producer of waste provides for sampling and determination of properties of the stabilisate being deposited. The laboratory works are being accomplished at high professional standard, in compliance with the valid standards and work methodologies for rock materials. Sampling of stabilisate is performed 4 times a year, always after 90 and 180 days since deposition of geomaterial at the landfill. There are specified its geotechnical parameters, limit concentrations of selected substances (analytic check) and water extract from the stabilisate samples (in compliance with the valid legislation and unified methodologies of waste analytic check, Slovak Environmental Agency (SAŽP) Bratislava). We have evaluated only the results of tests determining the geotechnical parameters of stabilisate. Sampling and laboratory tests of stabilisate samples are performed since the year 1998. The following parameters are monitored: humidity, bulk density, bulk weight, density of solid particles, absorption capacity, porosity, degree of saturation, compactness, simple compression strength, splitting tensile strength, bending tensile strength, cutting strength, shear strength, deformation properties at simple compression, permeability and frost resistance. The results of a part of those tests (index and descriptive properties) evaluated and processed mathematically for the period of 1998 to 2011 provide a realistic idea of the experimentally determined characteristics of the stabilisate. The data of index and descriptive properties of the stabilisate, processed in the tables and graphically, represent their quantitative values in the given period.

2. Definition of the stabilisate properties being specified

The anthropogenic geomaterial is, just like natural rock, a three-phase environment formed by a solid phase (skeleton), liquid phase (water) and gaseous phase (pores). In laboratory research we work with samples of geomaterial. It is therefore obvious that the test results will not be absolutely identical with the results we would achieve by determining the properties of the anthropogenic waste at the place of deposit (in situ). However, the laboratory tests are unsubstitutable, because they provide the basic values for valuation of the material characteristics and behaviour of the geomaterial in various application tasks.

Humidity of the stabilisate is the ratio of mass of water in the stabilisate and of the mass at specified standard temperature 105 – 110 °C of the dried stabilisate. **Bulk density** of the stabilisate is the mass of bulk unit of the stabilisate. It is specified in immediate state (wet, natural) and after drying (105 – 110 °C). **Density of solid particles** (in older literature called specific or mass density, apparent density of solid particles) is a ratio of mass of the solid particles after drying at the temperature of 105 – 110 °C to their volume. Water, firmly bound to the surface of particles even after drying by the specified standard temperature, is considered to be a part of the solid phase. **Absorption capacity** is the ability of the stabilisate dried at 105 – 110 °C to accommodate a certain amount of water at defined conditions. **Porosity** is defined as the ratio of the volume of pores in a certain amount of the stabilisate to its total volume. It is specified by calculation from the apparent density and bulk density of the geomaterial. **Degree of saturation** of the stabilisate expresses how large part of its pores is filled by water. **Compactness** of the stabilisate is a ratio of the bulk density and of the density of solid particles. It represents the portion of the solid phase to the total volume and it complements the value of porosity up to 100%.

3. Processing of the results of the laboratory tests of stabilisate

All results of the laboratory tests are processed by a unified methodology for individual quantities according to years and to the time of deposition of the geomaterial at the landfill at the time of sampling (90 and 180 days) and after unification of files (Tab. 3.1). The tables contain basic statistic data (the basis for further analyses and testing). The same procedure is used for evaluation of the test results in each year of the monitored period, and the resulting values of the stabilisate properties for the whole period are summarized. The dispersion of the values of selected stabilisate properties in dependence on time is shown in Figs. 3.1 to 3.6.

Tab. 3.1 Properties of stabilisate samples fort he period 1998 - 2011

Geotechnical characteristics of the stabilisate for the period 1998 - 2011 (90 and 180 days)								
quantity	**humidity**	**bulk density of dry sample**	**bulk density of damp sample**	**density of solid particles**	**absorption capacity**	**compactness**	**porosity**	**degree of saturation**
	w	**ρ_d**	**ρ**	**ρ_s**	**NV**	**S_H**	**n**	**S_r**
dimension	[%]	[g.cm^{-3}]	[g.cm^{-3}]	[g.cm^{-3}]	[%]	[%]	[%]	[%]
diameter	40.73	1.10	1.54	2.643	46.88	41.58	58.41	75.96
minimum	19.77	0.85	1.18	2.188	26.17	31.25	47.57	44.01
maximum	63.50	1.35	1.71	2.783	66.56	52.43	68.75	97.14
median	40.85	1.10	1.55	2.644	46.91	41.55	58.45	78.04
std. dev.	7.27	0.08	0.09	0.073	6.46	3.02	3.02	9.53
sample qty	298	298	288	298	293	298	298	293

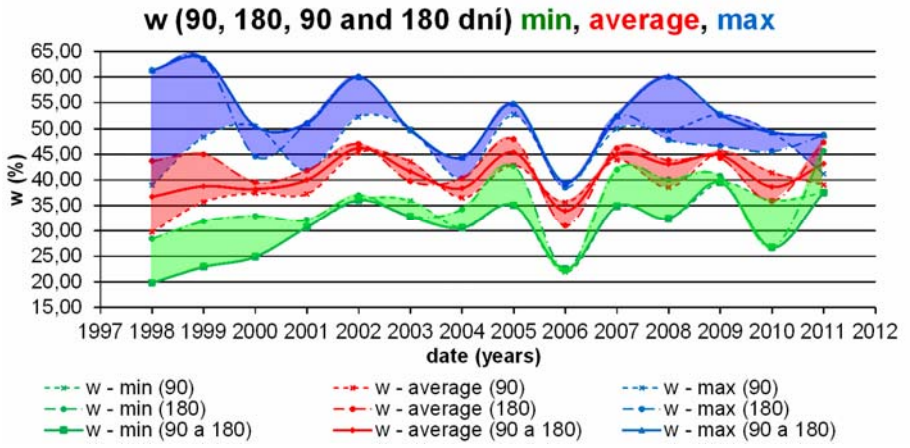

Fig. 3.1 Dispersion of the humidity values of the stabilisate samples

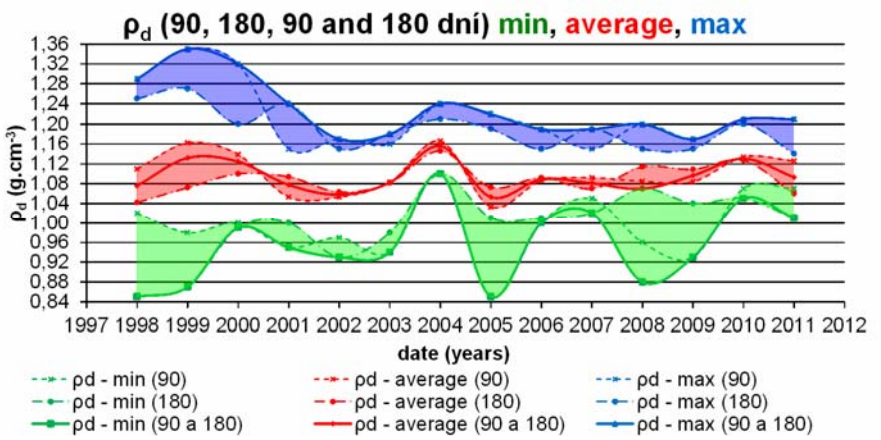

Fig. 3.2 Dispersion of the bulk density values of the stabilisate (ρ_d)

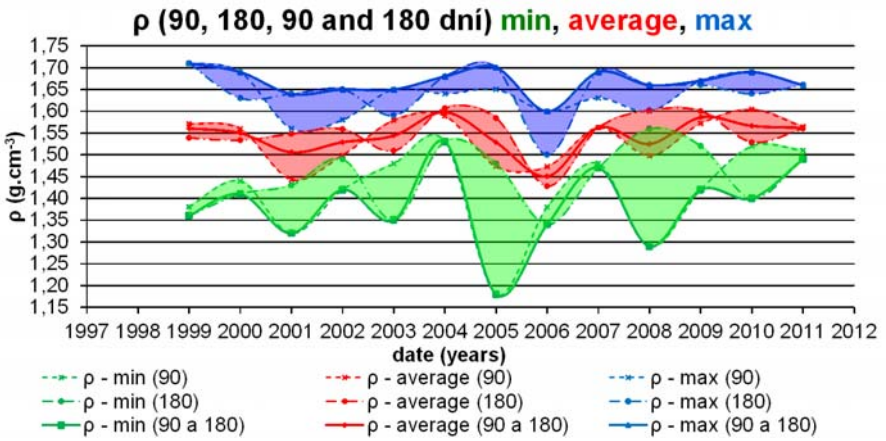

Fig. 3.3 Dispersion of the bulk density values of the stabilisate (ρ)

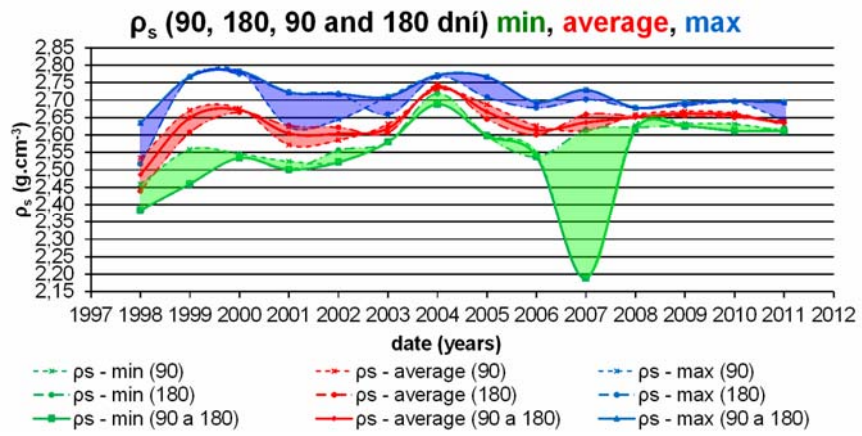

Fig. 3.4 Dispersion of the solid particles density values of the stabilisate

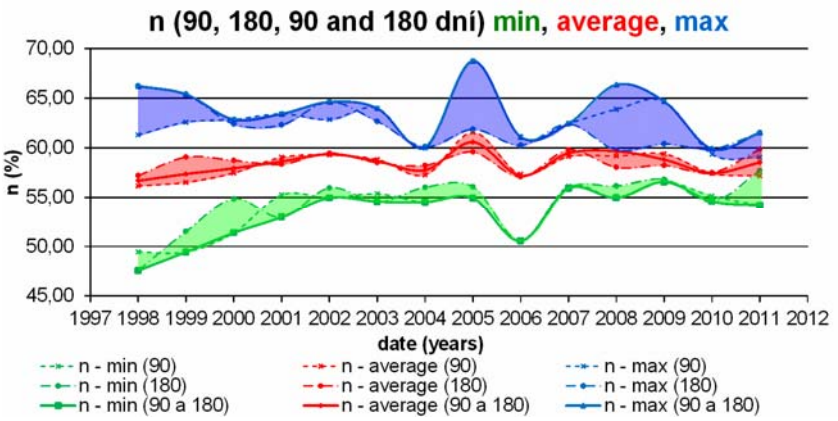

Fig. 3.5 Dispersion of the porosity values of the stabilisate

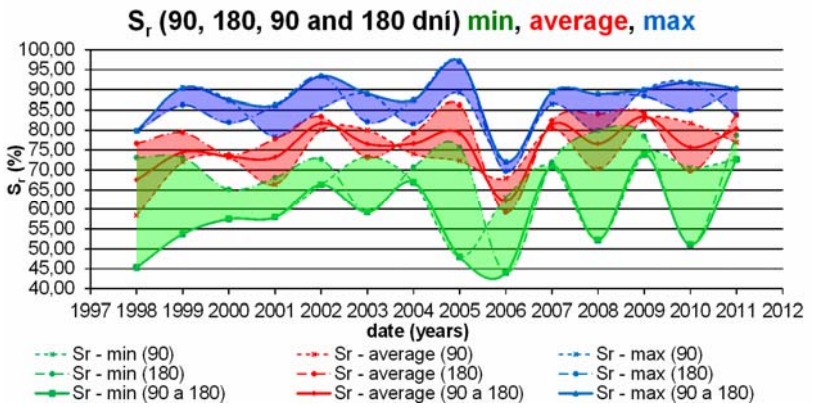

Fig. 3.6 Dispersion of the degree of saturation values of the stabilisate

4. Conclusion

Processing of the extensive set of results of the laboratory tests of the stabilisate samples represents a complex evaluation of carefully performed tests of this geomaterial in dependence on time (1998 to 2011), site of sampling (landfill No. 1 and 2) and the duration of deposit (90 and 180 days). The selected geotechnical characteristics of the stabilisate exert in measurements only small differences. Exceptionally there occur also lower or smaller values; however, the average values and medians are without extremes. At some measured characteristics of the stabilisate, the interval has a broader span, which may be caused by a local nonuniformity of the stabilisate, not exactly identical way of sampling and transportation of samples, laboratory conditions etc. Since the test results are recorded without a more detailed commentary, it is not possible to identify and categorize those influences. After comparison of the evaluated files for the individual years, from the landfills No. 1 and 2 and after depositing for 90 and 180 days after sampling, the test results are unified into a common file and they give a plausible notion of the quantitative span of the selected geotechnical characteristics of the stabilisate, which represent the foreground part of the inputs into interactive geotechnical calculations.

References

[1] ATKINSON, J.: *The mechanics of soils and foundations*, Taylor and Francis, Abingdon, ISBN 978 – 0 – 415 – 36256 – 6, 2007, 442pp.

[2] BREZNICKÝ, J. et al.: *Dočasné odkalisko, SE a.s. – ENEL, ENO, závod Zemianske Kostoľany, Zisťovanie vlastností stabilizátu skládkovaného na skládke č.1 po 90 dňoch od uloženia*, Hydroconsult Bratislava š.p., 08/1998 – 03/2002, 464pp., 49A4 drw.

[3] BREZNICKÝ, J. et al.: *Dočasné odkalisko, SE a.s. – ENEL, ENO, závod Zemianske Kostoľany, Zisťovanie vlastností stabilizátu skládkovaného na skládke č.1 po 180 dňoch od uloženia*, Hydroconsult Bratislava š.p., 12/1998 – 11/2002, 401pp., 49A4 drw.

[4] BREZNICKÝ, J. et al.: *Dočasné odkalisko, SE a.s. – ENEL, ENO, závod Zemianske Kostoľany, Zisťovanie vlastností stabilizátu skládkovaného na skládke č.2 po 90 dňoch od uloženia*, H.E.E. CONSULT, s.r.o. Trenčín, 03/2003 – 11/2011, 406pp., 84A4 drw.

[5] BREZNICKÝ, J. et al.: *Dočasné odkalisko, SE a.s. – ENEL, ENO, závod Zemianske Kostoľany, Zisťovanie vlastností stabilizátu skládkovaného na skládke č.2 po 180 dňoch od uloženia*, H.E.E. CONSULT, s.r.o. Trenčín, 05/2003 – 02/2011, 350pp., 70A4 drw.

[6] BREZNICKÝ, J.: *Dočasné odkalisko, SE a.s. – ENEL, ENO, závod Zemianske Kostoľany, Zisťovanie vlastností stabilizátu skládkovaného na skládke č.1 po 6 rokoch od uloženia*, H.E.E. CONSULT, s.r.o. Trenčín, Arch. No.: 2208, Cust. No.: 35829052 – 51 – 2208, 08/2008, 28pp., 5A4 drw.

[7] BREZNICKÝ, J.: *Dočasné odkalisko, SE a.s. – ENEL, ENO, závod Zemianske Kostoľany, Zisťovanie vlastností stabilizátu skládkovaného na skládke č.1 a č.2 po 180 dňoch, 8 a 10 rokoch od uloženia*, H.E.E. CONSULT, s.r.o. Trenčín, Arch. No.: 3010, Cust. No.: 35829052 – 51 – 3010, 08/2010, 28pp., 5A4 drw.

[8] MASAROVIČOVÁ, M., SLÁVIK, I., DVOŘÁKOVÁ, S.: *Dočasné odkalisko, SE a.s. – ENEL, ENO, závod Zemianske Kostoľany, Aktualizácia geotechnických informácií pre stabilitnú analýzu odkaliska*, STU – SvF – Katedra geotechniky, Bratislava, PE53, 09/2010, 49pp., 51A4 Annexes.

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OPISNÉ A INDEXOVÉ VLASTNOSTI NEŠTANDARDNÉHO GEOMATERIÁLU

Anotácia

Neštandardné geomateriály sú antropogénne odpady vznikajúce priemyselnou činnosťou človeka. Sú to elektrárenské a teplárenské popoly, banské odpady a flotačné kaly a tiež priemyselné kaly (najmä z chemického priemyslu). V súčasnosti ich ukladáme na odkaliská alebo na špeciálne zložiská. Tieto inžinierske stavby, ktorých návrh, bezpečná prevádzka a existencia, t.j. celý ich životný cyklus, sú výrazne ovplyvnené interakciou s horninovým (a všeobecne životným) prostredím. Všetky prognózy ich správania sa závisia od vstupných dát do interaktívnych geotechnických výpočtov. Dominantnú úlohu medzi vstupnými dátami majú geotechnické vlastnosti týchto neštandardných geomateriálov.