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ESTIMATIONS REGARDING CORRELATION BETWEEN HUMIDITY OF IMPERVIOUS CLAY AND THE DIMENSIONS OF ORIFICES ACCIDENTALLY PRODUCED IN THE GEOMEMBRANES OF WASTE DUMPS COVERS

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Abstract. Waste dumps are the result of human activity and evolution; any substance or object that we throw have the intention or the obligation to throw represents waste dump. No matter how you act in the last stage of disintegration of the matter, there will always be a final waste. The waste quantity produced is directly influenced by the community industrialisation degree which determines an increase of the urbanisation degree, therefore the civilisation degree. Wastes can be classified according to their nature and the processing place as follows: domestic waste – those resulted from domestic activities; street waste – wastes specific to circulation lanes; industrial waste – resulted from technological processes in industrial enterprises; resulting from constructions – waste resulted from the demolition or building of civil industrial objectives; commercial waste – resulting from commerce activity; agricultural waste – resulting from agricultural, zootechnical departments; sanitary wastes – resulting from public or private health institutions; special waste – resulting from explosive, radioactive wastes. Wastes problem, no matter of their nature, in the context of polluting the ambient environmental factors, is everywhere in the world and it is a well-known and thoroughly discussed problem, especially in the last decades. It is also known the fact that solving this problem consists in: closing the technological cycle, recycling and dealing with the resulted waste, as much as possible in the source sector; wastes recycling and processing; ecological dumps; corresponding integrated management. Among these, ecological dumps, designed impeccably and executed with good quality materials (geosynthetic materials), do not guarantee an unpolluted ambient environment. In this context, quality control of works completion and tracing out their behaviour in time (monitoring) represent two major elements of maximum importance.

Keywords: waste dumps, impervious barriers, geomembranes.

AIMS AND BACKGROUND

Sealing (sealing barriers), according to the dumps class assigned, can be attained as a simple barrier of mineral materials (clay) or of geosynthetic materials (geomembreane, bentofix), and their combinations, respectively, as a double barrier for radiation and always a double barrier for roofs[1–5]. Geosynthetical materials have been placed in the area of sealing through a series of advantages and quali-

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ties compared to those achieved out of granular materials. Between them the most important are:

– necessary thicknesses incomparable smaller, an advantage which offers the possibility of obtaining an useful space of the waste dump building a lot bigger;

– reduced costs for being operated;

– technological simplicity of being operated, with reduced clearance gauge and high productivity;

– homogeneity of guaranteed proprieties, on their entire surface.

Regardless, as we have already mentioned, in the case of using these materials, quality control especially in the process of being operated, plays an important role and it conditions the consequent desired performances.

As a consequence, the present paper seeks to make a connection between the qualitative and quantitative aspect of the problem, connection which is possible by triggering the analytical model offered by a type relation, established by Giroud and co-workers in 1997.

The faults that can appear when operating the geomembranes, after Manjoie and co-workers (1992) are:

– welding faults, which, according to the experience gathered in the area show that when there is no severe control, the average occurrence of faults is 1 m to 10 m of welded structure, with a fault diameter d = (1–3) mm (Giroud and co-workers, 1989);

– faults in the joining areas of geomembrane with the connecting buildings;

– faults due to granulated elements (gravel) or the tools movement, whose diameter can be between the limits d = (1–10) mm.

These faults relatively frequently found, obviously are (undesirable) accidents, and appear preponderantly during the waste dump execution phase or exploitation, annexed to the partial closing of a body. The severe control during execution and monitoring the sealing efficiency after closing can only be achieved if the geomembrane is equipped with a network of sensors (cables), a network which is placed on the inside and obviously inside the other sealing barriers (clay, bentonite), which could observe (detect) the possible faults. Besides this network there should be some electronic mechanism which would intercept signals from the network, interpret the information received and locate the faults. Among the devices known and already tested, there is LUMBRICUS type mechanism associated with TAUPE calibration system, completed and tested in ‘Karlsruhe Research Center – Techniques and Ambient Environment’, it is able to detect planimetric and the humidity value of the tested sealing barriers, humidity that is variable/influenced and maintained by the meteoritic water seeping through the areas with accidental faults of geomembranes. Humidity cartograms (Fig. 1) established in this way can offer information strictly linked to the humidity value, and by interpreting the planimetric information referring to the fault/faults gun pit and not the information referring its/theirs afferent value (the faults surface, transited volumes/output towards the waste dump body).

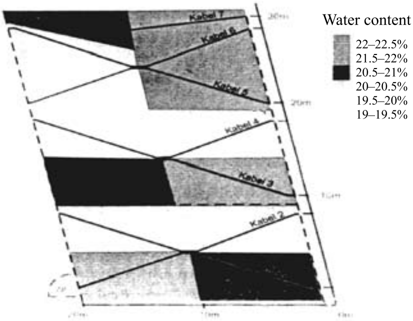

Fig. 1. Humidity cartograms (source: A. Wehry et al., Ecotim 2000 Symposium, 2000, p. 188)

EXPERIMENTAL

PHYSICAL AND ANALYTICAL MODEL

The physical model (Fig. 2) of the problem that we have studied is that of:

– leaking through vents partially obturated (vents with leaks in porous media);

– infiltrations of water in porous mediums partially saturated.

The analytical model is consequently given by:

– the relation of the vents output

$$Q = \mu a\,(2gh)^{1/2}; \tag{1}$$

– the relation of the output infiltrated trough the unsaturated porous media (the Darcy law):

$$Q = \pi R_{\mathrm{h}}^{2} K_{\mathrm{h}} \tag{2}$$

$$q = K_{\mathrm{h}}(\theta)\ \mathrm{grad}\ h \tag{2'}$$

where K_{h} is hydraulic conductivity for unsaturated porous media given by an nonlinear law, dependent on the water retaining capacity (θ) and the hydraulic load (*h*), is opened by the van Genuchten expression (1980) based on the Maulem model (1976):

$$K_{\mathrm{h}} = K_{\mathrm{s}}\,\theta^{\mathrm{k}}\,(1 - (1 - \theta^{1/m})^{m})^{2}; \tag{3}$$

– relation of the Giroud type and co-workers (1997), introduced in specific Romanian literature for the first time by Batali (1999):

$$R_{\mathrm{h}} = 0.26\, a^{0.05}\, h^{0.45}\, K_{\mathrm{h}}^{-0.13}. \tag{4}$$

Notes: (1) the signification of physical dimensions R_h (m), a (m^2), h (m) and K_h (m/s) which make up relation (4) and is explained in Fig. 2;

(2) between the values of the coefficient and the exponents of this relation the only one that has something particular significance is that of hydraulic conductivity K_h of sealing barrier, placed under the geomembrane (bentonitic geocomposite in this case).

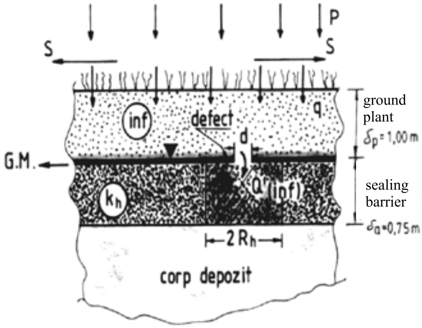

Fig. 2. The physical model (source: A. Wehry et al., Ecotim 2000 Symposium, 2000, p.189)

In accordance with those mentioned at note No 2, if the execution material of sealing barrier from the base of the roof is other than bentonite (bentofix), experimental research is necessary in order to determine the exponent value of hydraulic conductivity (K_h). Often clay is chosen as execution material for the barrier mentioned above and this is done due to economic factors. As clay characteristics are very different from one quarry to the other (local conditions), and the barrier conditions achieved in this way are dependent on the technological performances of execution, in the context of the subject proposed, these researches become highly useful.

The deduction of the calculus fraction of this exponent starts from the continuity equation of the flux determined by the accident produced in the geomembrane ($Q_{inf} = Q_{or}$), i.e.:

$$\pi R_h^2 K_h = \mu a (2gh)^{1/2} \tag{5}$$

resulting:

$$R_h = c\, a^{0.5x} h^{0.25y} K_h^{-0.5z} \tag{6}$$

that is still a relation of the Giroud type, where $c = (\mu/\pi)(2g)^{1/2} = 0.26$ (for $\mu = 0.5$), $x = 0.1$ and $y = 1.80$, by correlation (4).

For exponent z, after processing for c, x and y having the values mentioned before, we obtain the relation:

$$z = \frac{\lg \dfrac{R_h}{0.26 a^{0.05\, h^{0.45}}}}{\lg \sqrt{\dfrac{1}{K_h}}} \tag{7}$$

It should be noted that the values of the vent area (a), pressures (h) and conductivity (K_h) are determined within the experimental research from the stand, or even *in situ*, in the waste dump.

LABORATORY STAND, RESULTS OF EXPERIMENTAL DETERMINATIONS

The experimental program afferent to determining exponent z value of hydraulic conductivity, an exponent dependent from value point of view on clay local features (quarry conditions) and the execution technology of sealing barrier has called for the need of building a laboratory stand shown in Fig. 3.

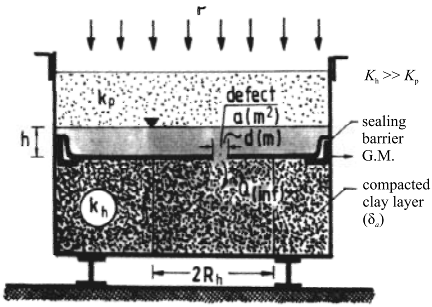

Fig. 3. Laboratory stand (source: A. Wehry et al., Ecotim 2000 Symposium, 2000, p.190)

This program needed the following:

(1) the execution of a sealing barrier ($\delta_a = 0.40$ m) inside the tub (1) by manual compaction of four intermediary layers maintained at optimum humidity, collecting proofs for determining the value of K_h and restoring the surface; assembling and sealing around the tub the superior sealing barrier (geomembrane), in which a vent was used (with diameter (d)/area (a) desired), a vent which simulates a fault;

(2) simulation of the infiltration layer fed by rainfall through the waste dump roof (insuring the load of the accidental vent, $h = (0.02–0.05)$);

(3) measuring the diameter ($2R_h$) of the moistening cylinder/bulb from the clay barrier, after closing the infiltration process.

The results of the measurements done are shown synthetically in Fig. 4. By processing these and by using relation (7), for exponent z was obtained the average mean $z = 0.222$. Therefore, for the analysed clay from Oradea, the relation of the Giroud type has the following form:

$$R_h = 0.26\, a^{0.05}\, h^{0.45}\, K_h^{-0.111}. \tag{8}$$

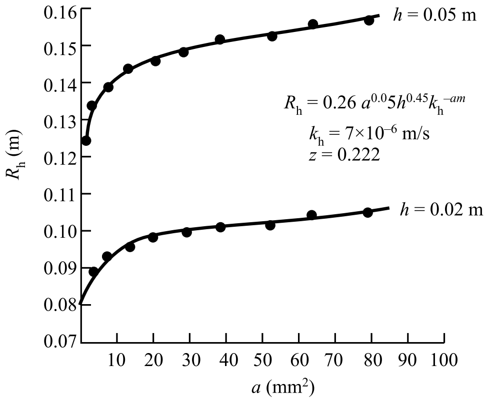

Fig. 4. Results of measurements (source: A. Wehry et al., Ecotim 2000 Symposium, 2000, p. 191)

CONCLUSIONS

By synthesising the facts presented in the previous paragraphs and from the researches experience undertaken so far, we can draw the following conclusions:

1. The researches undertaken and the results obtained highlight the undeniable role of laboratory and *in situ* experimental research, as the single method available which offers complete and correct information regarding the characteristics of the materials used, characteristics determined by the local features of clay quarries; only in this way an efficient monitoring can be achieved towards an effective protection of the ambient environment.

2. Correlation of the data offered by electronic monitoring devices (Lumbricus – Taupe) with the analytical results of the Giroud type relation, can offer the staff specialised in maintaining the waste dump, both qualitative and quantitative information (location, flux intensity of infiltrations towards the waste dump body, dimensional proportions of the fault occurred); this kind of information is offered, related to the emergency degree and the amplitude of the works necessary for afferent repairs.

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