Special Applications

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COMPARATIVE STUDY OF THE GEOVALVES
VERGLEICHENDE STUDIE ÜBER GEOVENTILE
ETUDE COMPARATIVE DES GEOVALVES

Geovalves are semi-waterproofing systems constitued of a geotextile support and a waterproofing soil in order to insure impermeability in the direction up to downstream and permeability in the reverse direction.

This technic has been described in previous papers.

This study presents results of comparative tests realised on cakes of different constitutions. Admixtures of various natures have been added in the referencc soil (clay and line of sugarworks).
On the other hand, different pratical dispositions have been analysed to improve the obtained results.

1. INTRODUCTION

The sealing of the water retention works proceeds especially now from the use of thin membranes of some millimeters thick.
These membranes have so some feeble points :

- the weldings are too numerous;
- they present an important sensibility to the perforations;
- they are "impervious" in the two senses (upstream to dowstream and downstream to upstream) to the liquids and the gazes.

These different imponderables produce important losses of efficacy and important constructive devices :

- rigorous preparation of the support;
- laying and welding of the bands;
- checking of the weldings;
- ballasting of the membrane.

These different devices increase substancially the cost of construction and the risks of the membrane's damage.

We don't want to give a solution for these diverse problems but the concept of "geovalve" gives a certain number of answer elements.
J.P. GIROUD {1} had defined the perfect membrane as being perfectly impervious from upstream to downstream and perfectly permeable from downstream to upstream.
Basing him on this principle, J.M. RIGO, at the University of Liège, had the idea of the conception of a semi-permeable membrane (named "geovalve") by colmating voluntarily a geotextile with fine particles of soil.
The geotextile is put on a permeable soil to seal.
By mechanival putting of embaking, we constitute, on the geotextile, a semi-permeable bed.
When the downstream pressure becomes greater than the upstream pressure (emptying of the bassin or the channel, inflow of the water table, gaz pocket), the cake rises lightly and cracks appear; upstream water or gaz goes into the retention work until we have an equilibrium between the pressures. When everything becomes normal the cake reforms, either directly by closing of the cracks or by seepage of the waters in the geotextile.

For these works, we have insisted on the sealing of the decantors in a sugar-refinery. Indeed, for these applications, we must fear simultaniously water under-pressures but also and especially gaz under-pressures, provided from the transformation in CH_4 of the organic materials contained in the waters of the unavoidable flights.

2. THE GEOVALVE WITH REGARD TO ACTUAL IMPOSITIONS

D. FAYOUX {2} has collected the actual impositions for the sealing of retention works.

These fore studies {3}, {4} have permitted to conclude that it was possible to make "geovalves". Tests in laboratory have permitted to verify that :

- the use of banalised materials (soil of decantor) permits to obtain permittivities in the neighbouring of the impositions;
- the geovalve can play the role a a clack to dissipate the several consecutive under-pressures without perturbation of the function of imperviousness;
- about the putting, the geovalve permits the quick constitution of a puddle without any necessity of constituting intermediate beds of filtration;

TABLE 1

Type of work	k/e (sec^{-1})	Values considered by : ·
Natural tanks	10^{-7} to 10^{-8}	Ministry of Agriculture (France)
System of irrigation	10^{-8}	Agricultural Prof. Com.
Basin of sugar-refinery	10^{-8}	Service of Mines
Great dams	10^{-8}	Particular studies
Neutral chemical waste-products	10^{-7}	Ministry of Environment
Household fiths	10^{-7} to 10^{-8}	Circular of
Toxical products	10^{-10}	the 22.01.80
Urban and industrial waste-products	10^{-8}	Italy

- the rusticity of this technic satisfies itself with summary earthworks, doesn't impose particular connections between the different nappes of geotextile;
- this technic is essentially applicable for the plane parts of the sealing;
- the geotextile plays the roles of a separator screen between the cake's fine particles and the permeable support, and of a filter during the constitution of the cake after the application of an under-pressure;
- the geotextile influences very secondarly the level of imperviousness of the geovalve.

Seeing these results, it seems to be logical to make such a research about the constitution of the cake to improve the imperviousness'level.

With this object, two types of study have been realized:

1) study of the cake's constitution;
2) study of a device of reduction of section of the cake, exposed to the water of the retention works, without deterioration of the clack's effect.

3. DISPOSITION OF THE CAKE

The first step of this study was an analysis of the composition of the cake, with the aim of improving the results we have obtained before. We must note here about that the fore studies had been conducted on a soil coming from a decantor of sugar-refinery, with a addition of 15 % of sand 000 RILEM (1500 - 500 µm).
The used geotextiles were a woven with bands, a non-woven composit spunbonded and a non-woven homogen spunbonded.

For the reasons evocated at chapter 2 hereabove, and to continue these works, we have chosen the non-woven homogen spunbonded. We purpose to compare diverse compositions of cake between themselves.

3.1. Disposition and test proceedings

For this part of the study, simple cells have been made. They are cylindric receivers (10 cm diameter and 12 cm high), whom bottom is permeable. A bed of 4 cm of fine gravel (Ø means 4 cm) is laid on the bottom of the receiver. The geotextile is laid on this gravel-bed.
The sealing along the wall is assured with a silicon grease.
The addition of water to be investigated soil is in the rapport of 1/1 in mass. That represents a thickness of cake of 4 mm.
After putting the cake on the geotextile, the receivers are filled at constant level and the permeability of the cake is measured.

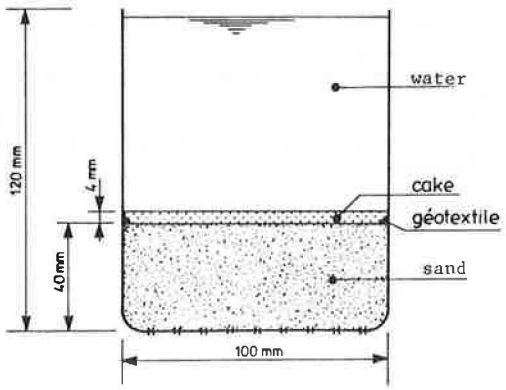

Figure 1 : device used for the comparaison of the effect of the additions to the soil of reference

3.2. Obtained results

The composition of references is the same one that used for the fore studies : 85 % of soil of decantor and 15 % of sand RILEM 000.
The additions are respectively, the bentonite and 4 types of bituminen emulsions.

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The different percentages of the components of the cake are so :
- soil of decantor : 74 %;
- sand RILEM 000 : 13 %;
- addition : 13 %.

TABLE 2

Nature of the cake (thickness 4 mm)	Permeability (mean on 3 measures) (m/sec)
Reference (Ref)	$4,6\ 10^{-5}$
Ref + bentonite	$2,3\ 10^{-7}$
Ref + emulsion A	$3,2\ 10^{-6}$
Ref + emulsion B	$4,4\ 10^{-5}$
Ref + emulsion C	$6,6\ 10^{-5}$
Ref + emulsion D	$4,8\ 10^{-5}$

The relatively feebleness of the results is explained especially by the feeble thickness of the cake.
Moreover, we think that the comparative value of the results is more important. It seams that only the bentonite and the emulsion A improve the behaviour of the blending of reference.
These two additions have been so incorporated with diverse proportions, the percentage soil of decantor on sand 000 being constant (= 5,7).

TABLE 3

Nature of the cake (thickness 4 mm)	Permeability (mean on 3 measures) (m/sec)
Ref	$4,6\ 10^{-5}$
Ref + 2,2 % bentonite	$7,6\ 10^{-6}$
Ref + 6,6 % bentonite	$4,7\ 10^{-7}$
Ref + 13 % bentonite	$2,3\ 10^{-7}$
Ref + 22 % bentonite	$3,4\ 10^{-8}$
Ref + 2,2 % emulsion A	$3,75\ 10^{-5}$
Ref + 6,6 % emulsion A	$1,0\ 10^{-5}$
Ref + 13 % emulsion A	$3,2\ 10^{-6}$
Ref + 22 % emulsion A	$8,5\ 10^{-7}$

The bentonite gives so mean results which are more probative than emulsion A. Moreover, when we add an important quantity of emulsion, the cake becomes very inflexible. That produces a delicate running of the clack.
We have so decided to give up the emulsions of bitumen as addition to the composition of reference.
We have moreover tested a certain number of cake's compositions, with especially :

- sand RILEM 0000 (85 %) + bentonite (15 %)
  ($k = 1.10^{-7}$ m/sec);
- sand RILEM 000 (42,5 %)
  sand RILEM 0000 (42,5 %)
  bentonite (15 %)
  ($k = 1,3.10^{-7}$ m/sec)
- pure clay
  ($k = 3,4.10^{-9}$ m/sec)
- pure clay (50 %)
  silt (50 %)
  ($k = 3,5.10^{-9}$ m/sec).

These diverse compositions, although they give relatively probative results, are less interessant in the case of a sealing of the decantors because they draw the almost integral bringing of the materials which form the cake. We prefer a treatment, as limited as possible, of the available soil, found in situ.

4. DEVICE OF REDUCTION OF SECTION

The fore study has permitted to compare between themselves diverse solutions of improvement of the soil of reference. The second part of this study have permitted to control the best compositions in a greater permeameter and to being up a device of protection of the cake and of reduction of its section exposed to the upstream.

4.1. Reduction of section of the cake and protection

The permeameter is constructed with two cylindric parts, having the same useful diameter (Ø 25 mm) (fig. 2).
The low part is filled with gravel. This gravel is surmounted by the geotextile - mechanical support of the cake.
The geotextile is fixed along its border with a metallic ring.
The cake (thickness = 2,5 cm) is laid on the geotextile. This device constitues the geovalve.
To assure the protection of the cake against a too important dessication, at the time of a drying up of the water retention work, and to reduce maximally the crossing section fo water (upstream to downstream) a sheet of P.E., perforated with holes of Ø 4 mm, radialy cross-shaped (distance 20 mm), is laid on the cake.
This sheet of P.E. is lested with 2,5 cm of gravel (mean grain size 25 mm).
The device permits the application of an under-pressure of water or air.

The campaign of measures has permitted to insure ourself that the "protected" cake is permeable to the down liquid and gaz, and presents a very acceptable imperviousness against the upstream waters.

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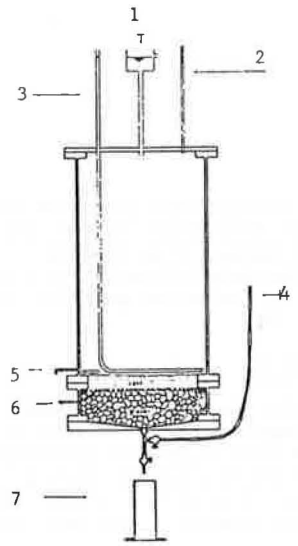

1. constant level container
2. piezometric tube
3. filling up of the reservoir
4. loading (downstream)
5. emptying
6. air evacuation
7. water and particles

Figure 2 : device of caracterization of the protected cake

4.2. Obtained results

The table hereafter presents the results (k/e sec^{-1}) obtained during these experiences.
The permittivities are related to two dispositions : with or without a perfored plastic sheet on the cake.
These results are expressed in function of the percentage of bentonite into the reference mixture.

TABLE 4

% bentonite	Permittivity k/e (sec^{-1}) without perfored sheet	with perfored sheet
0 %	2,9 10^{-5}	1,26 10^{-5}
2,2 %	9,4 10^{-6}	3,62 10^{-6}
6,0 %	8,0 10^{-7}	3,39 10^{-7}
13,0 %	2,7 10^{-7}	1,25 10^{-7}
22,0 %	1,0 10^{-7}	5,65 10^{-8}

4.3. Analysis of the results

The placement of a perfored plastic sheet on the cake improve the results. The section offered to the up to downstream is reduced. On the other hand, the system always presents a very good permeability to the dow to upstream.
Other practical dispositions are actually tested. These are presenting better results.

5. CONCLUSIONS

The above analysis is based on a simple and daring concept.
The results obtained until now show continious improvement in the results. On the other hand, the actual obtained results are compatible with the standards.

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