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Soil-geotextile interaction in filter systems

L'interaction sol-géotextile dans les systèmes de filtre

C.B.ABADJIEV, Professor, Higher Institute of Architecture and Civil Engineering, Sofia, Bulgaria

I.S.KALTCHEV, Engineer, Higher Institute of Architecture and Civil Engineering, Sofia, Bulgaria

SYNOPSIS: Laboratory tests of soil-geotextile are carried out to prove the possibility to use the geotextile as a filter in large dams where the stress, strains and hydraulic gradients are high. Filter apparatus for testing soil-geotextile under high stress and high hydraulic gradients are constructed and long term tests are performed.

INTRODUCTION

Geotextile has been tested for clogging by many authors. The change in permeability of soil-geotextile system within long periods of time has been traced for different soils and geotextiles. Clogging has to be checked by long term tests on each soil and geotextile. If the geotextile shall be used in places with high loading and high hydraulic gradients, it has to be tested under such conditions too.

In high hydraulic structures, where stress, strain and hydraulic gradients are high, the geotextile clogging problem is still not settled. Therefore there is restraint from the use of geotextile as a filter in higher earth- and rock-fill dams.

The present tests aim to check the possibility of using geotextile as a filter in a high rock-fill dam with clay core. Since the danger of geotextile clogging by clay is greater, we chose here the possibility of using geotextile only as a second filter layer. This is valid if a layer of sand is kept as a first filter after the clay core, and after that we lay geotextile as a second filter layer. In some of the following tests we shall investigate the clay-geotextile interaction. Geotextile shall be used as a filter immediately next to the clay core, and shall replace all filter layers of natural materials: sand, gravel and coarse gravel.

First of all, apparatus has to be constructed for higher loading and higher hydraulic gradients.

APPARATUS

In the Higher Institute of Architecture and Civil Engineering, Sofia, 20 steel cylinders have been constructed, with 0.45 m height and 0.120 m internal diameter, for determining permeability, erosion and clogging of soil samples or of soil-geotextile systems (Fig. 1).

Possibilities have been created for normal loading up to 3000 kPa and head of 0.10 - 40 m (hydraulic gradient up to 400). Under the geotextile it is possible to put a highly permeable material or soil, which is going to be used in reality. Water is fed to the apparatus from the upper side downwards, and the downstream water level may be lower or higher than the geotextile level. Low loadings (up to 2 kPa) are realized by weights, and high loadings - by oil jacks.



Fig. 1 - Apparatus for testing soil-geotextile interaction under high stress and high hydraulic gradients

EXPERIMENTAL PROCEDURE

Due to the high stresses and strains in a high rock-fill dam, the chosen geotextile is of polyester non-woven needle-punched one, type "Bidim", resisting highest relative elongation. The mass of the chosen geotextile is 830 g/m² due to the same reasons.

The granulometry of the tested river sand is shown on Fig. 2. The rate of discharge through the sand layer with a thickness of 0.10 m over the geotextile was measured daily. Tests have been carried out in 3 stages: =2 kPa, 200 kPa and 2000 kPa. The stresses due to the weight of the soil massive laying over, in our case, were up to 200 kPa. In

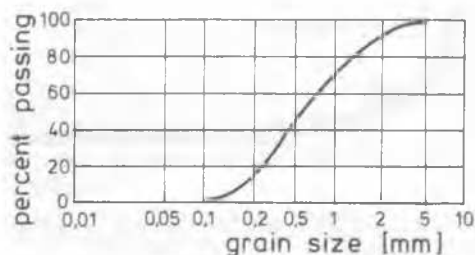


Fig. 2 - Granulometry of the tested sand

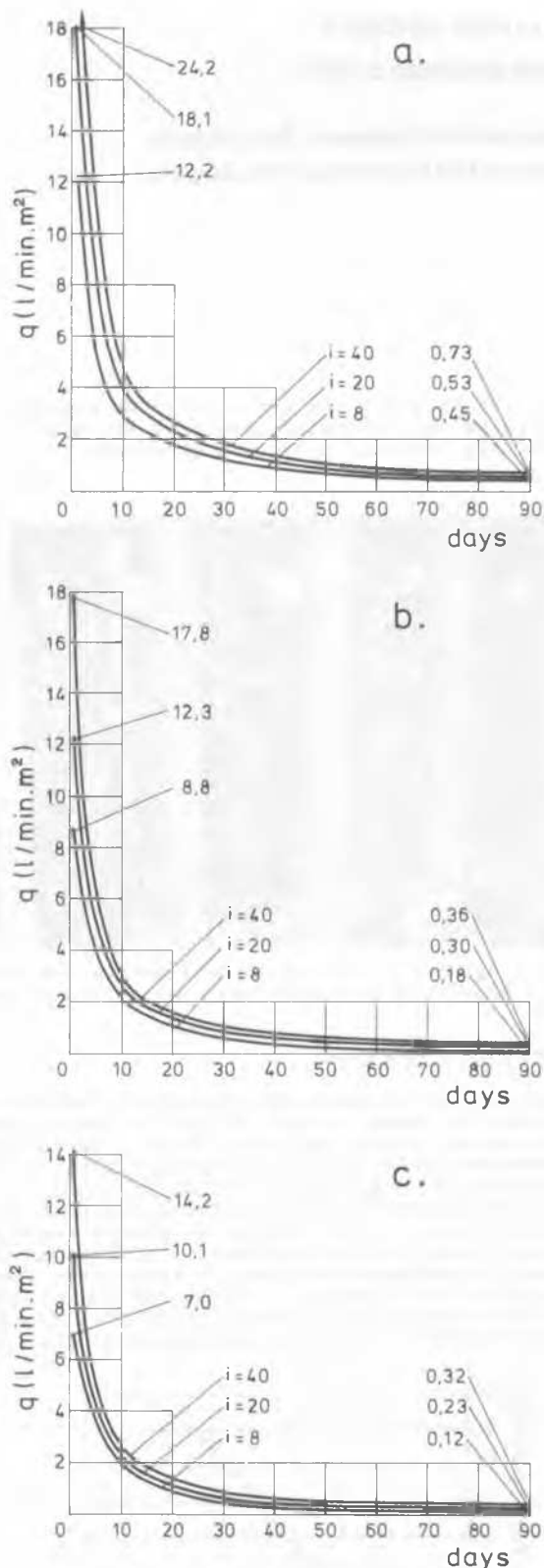


Fig. 3 - Discharge in l/min.m² versus time at hydraulic gradients $i = 8, 20$ and 40 .

a). = 2 kPa; b). = 200 kPa; c). = 2000 kPa

order to record more intensive distribution of the stresses and to be on the safe side we made tests with = 2000 kPa too.

The maximum expected hydraulic gradient shall be about $i=8$ in reality. In order to record an eventual clogging and to shorten the time of testing, we tested the soil-geotextile system also with $i=20$ and $i=40$.

Although the rate of discharge was stabilized after 30 days, the tests proceeded 90 days, so as to be on the safe side.

Due to the long duration of each test, testing was carried out in separate cylinders. Therefore, there is no proportionality in the different gradients.

Parallel to this, soil samples alone, without geotextile, were tested for permeability under the same conditions. For comparison, the rate of discharge of the geotextile was tested at head 0.10 m, once on new clean samples and then on partially clogged geotextile taken from the above tested soil-geotextile samples.

TEST RESULTS

The test results of the soil-geotextile interaction are shown on Fig. 3. a, b, c.

The longterm tests show that no erosion occurs in the tested soil and geotextile. The rate of discharge is decreasing in the different tests versus time by 27-58 times, but it is never annulated. Always some low permeability is preserved. This decrease is due to the following 3 reasons: compaction of the soil by loading, contraction of the geotextile by loading, and clogging of the geotextile. The clogging of the geotextile is decreasing when the load over it is increasing.

The parallel tests only with sand showed rates of discharge $q=57.6$ l/min.m² at $i=8$ and =0, and $q=6.72$ l/min.m² at $i=8$ and =2000 kPa, or a decrease of 8.57 times. The discharge through soil and geotextile after clogging on the 90th day is $q=0.12$ l/min.m², or the decrease of discharge is 480 times. If we accept that the decrease of about 8.57 times is due to the compaction of the sand by loading, then 56 times of it is due to the contraction of geotextile from loading and to its clogging.

SUMMARY AND CONCLUSIONS

The first tests carried out with the new apparatus at high stress and hydraulic gradients are not numerous, but yet they permit the following conclusions to be drawn:

1. Erosion never takes place in the tested here soil and geotextile in spite of the high gradients.
2. At higher loading the rate of discharge is stabilized earlier than at low loading.
3. The clogging of the geotextile is decreasing when the load over it is increased.
4. At high loading, e.g. in high dams, the permeability of a soil-geotextile system is considerably decreased with time.
5. Permeability of geotextile is decreasing at high loading considerably with time, but always some part of it is preserved.
6. Under these conditions the permeability of geotextile may become lower than that of the protected by it soil. The permeability criterion of the filters cannot be observed. In spite of this, geotextile could be used in cases of large dams, if the safety of the structure is still sufficient.