No Erosion Filter Test for Selection of Geotextiles for Fissured Soils

J. Lafleur, J. Mlynarek & M. Bouthot
Ecole Polytechnique de Montreal, PQ, Canada

ABSTRACT: The current filter criteria do not cover the case of fissured clayey soils. To bridge this gap, an attempt has been made to adapt to geotextiles, the No Erosion Filter (NEF) test, developed by Sherard and Dunnigan (1989) for the selection of granular filters. In this test, a clay sample with a 1 mm preformed hole is placed upstream of a filter and it is submitted to high gradients. The compatibility is assessed from the change in diameter of the hole. Nonwoven geotextiles, stacked in one to four layers, were tested against a clay compacted at different water contents. The results show that the geotextiles did not fulfill the original NEF criterion and this discrepancy can be attributed to the difference in structure between granular and geosynthetic filters at the very interface. However, most of the tests have ended with clear water outflows. This could lead to a relaxation of the original NEF acceptability level when geotextiles are involved.

1 INTRODUCTION

Clays have to be filtered in many instances. For example, in the cores of zoned dams or within chimney drains of homogeneous dams made of clayey material. The work of Sherard et al. (1984) has well evidenced that concentrated leaks can develop within dams made of cohesive soils. Surficial clays also have to be filtered when shallow drainage systems are involved. Lafleur et al. (1987) have shown that fissures and open cracks can develop in surficial clays as a result of the weathering process i.e. the succession of freeze/-thaw-drying/wetting cycles throughout the years. These cracks change the structure and the hydrodynamic processes within the soil mass: the permeability is much larger, being controlled by the presence of the openings and, given the increase in water velocity, the erosion of clays is increased. In the filtration of fissured clays, it is not individual particles that are prone to arrive at the filter interface but rather flocs or agregation of particles. The retention capability of a filter should therefore be established as a function of the size of the flocs that can be eroded along the walls of the fissures.

2 THE NO EROSION FILTER TEST

Sherard and Dunnigan (1989) have developed the NEF test to establish a boundary between successful and unsuccessful **granular** filters. In this test, a clay sample with a 1 mm preformed hole throughout, is placed inside a permeameter upstream of a filter and it is submitted to high hydraulic gradients. A filter is successful if there is no change in diameter of the preformed hole. The filtration mechanism that they have observed is described on Fig. 1. In a relatively short period of time (5 to 10 minutes), the dragging action of the water gradually erodes radially outwards the base particles along the horizontal base-filter interface. With **successful** filters, the eroded clay particles or flocs get trapped at the very entrance of the filter's constrictions and the flow rate progressively decreases. With **unsuccessful**, continuous erosion proceeds and the 1 mm hole is enlarged due to the high water velocity. It was deemed that such a process could apply as well to geotextiles filters, since there are many analogies between granular and geotextile filters (Lafleur et al. 1993).

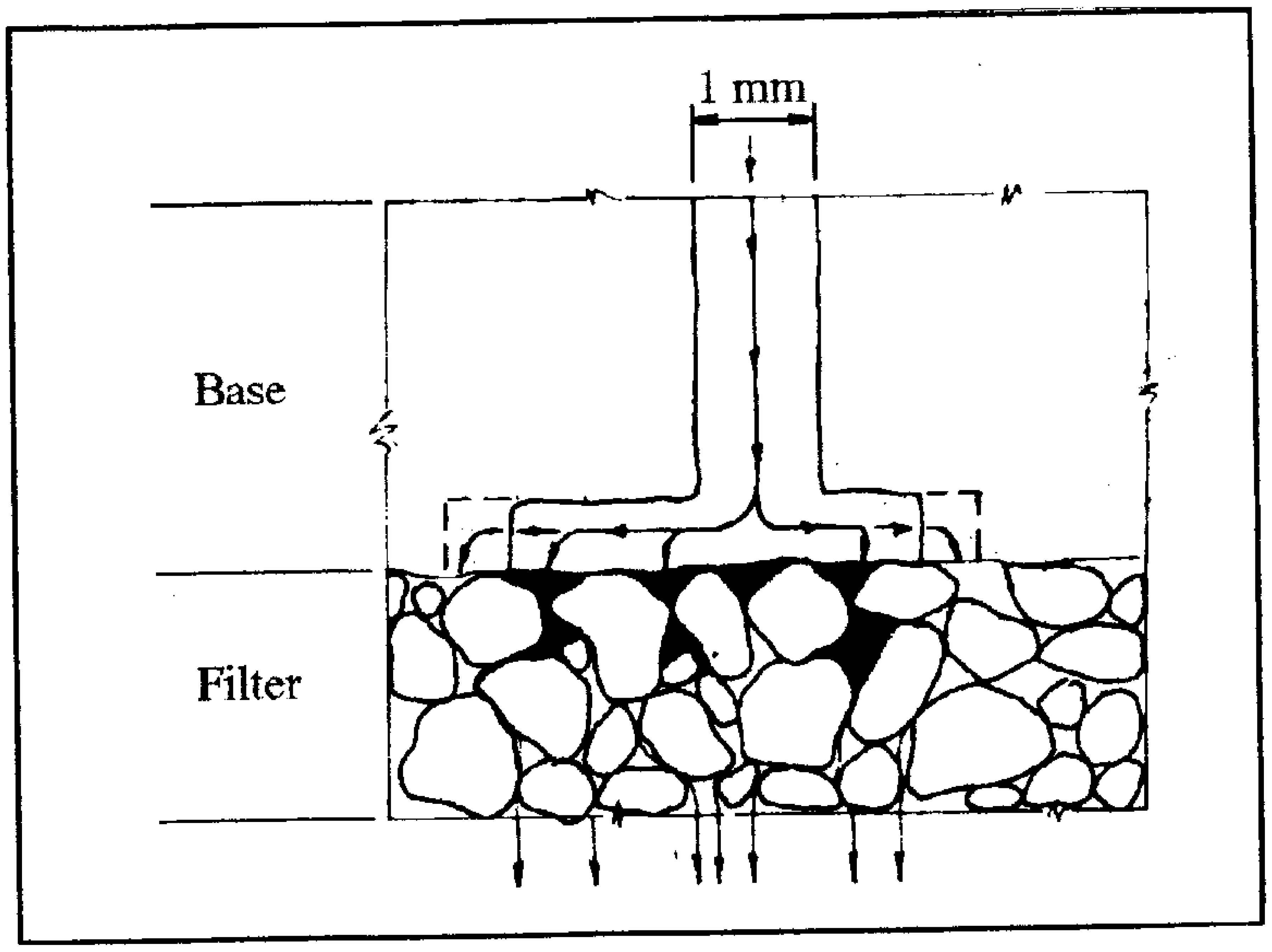

Fig. 1 Filtration mechanism observed by Sherard and Dunnigan (1989)

3 TEST PROGRAM

Apart from evaluating the applicability of the NEF test to geotextiles, the program was designed to verify the influence of the properties of the base (compaction water content) and of the geotextile (thickness).

3.1 Apparatus and procedure

The Fig. 2 gives the cross section of the permeameter. It should be noted that the dimensions of the compacted base (40 x 38 dia.) were somewhat different from those of Sherard and Dunnigan (1989) (25 x 100 dia.). The geotextile was fixed immediately downstream of the base in the center of which a 1 mm hole was bored. The 400 kPa pressure head measured by the transducer, was applied to the system. A porous stone or rubber ring was placed under the filter in order to prevent the water from flowing between the soil-filter complex and the permeameter wall. The procedure was as follows: compaction by impact inside the mould, boring of the 1 mm hole, pressure head application. The behaviour of the combinations was observed until equilibrium in flow rate was reached. At the end of the test, the diameter of the hole was measured and the clay sample weighted to evaluate the percent of eroded material.

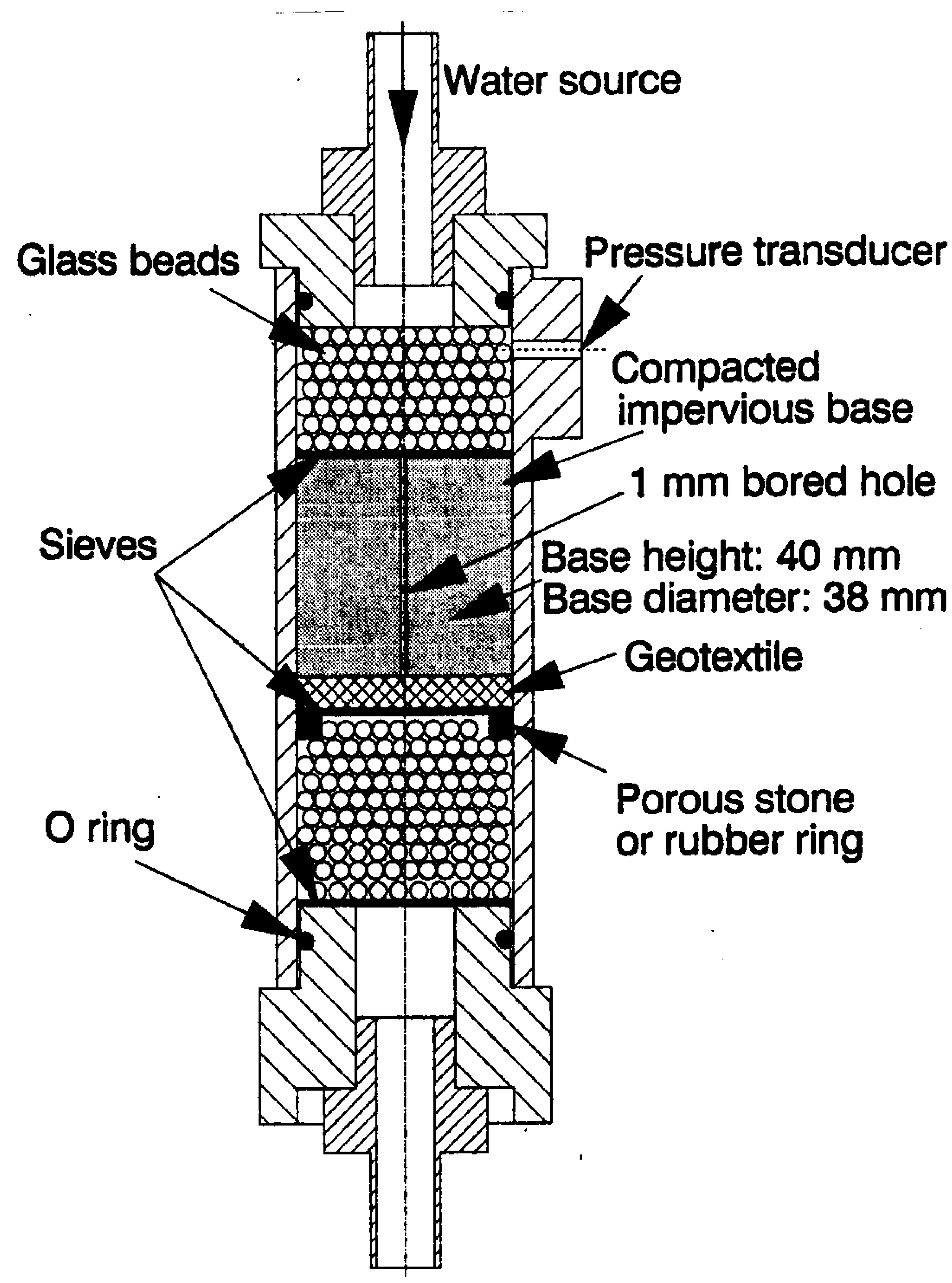

Fig. 2 Permeameter for the NEF test on geotextiles

3.2 Tested materials

The tests were made on the plastic Saint-Hilaire clay (75% of particles finer than 2 μm, w_L=65% and w_P =26%), compacted at water contents varying between 23 and 30%. The Fig. 3 gives the Standard Proctor curve and the compaction water content and dry density corresponding to each test. Two series of tests have been made: a) near the optimum and b) at 5% wet of optimum.

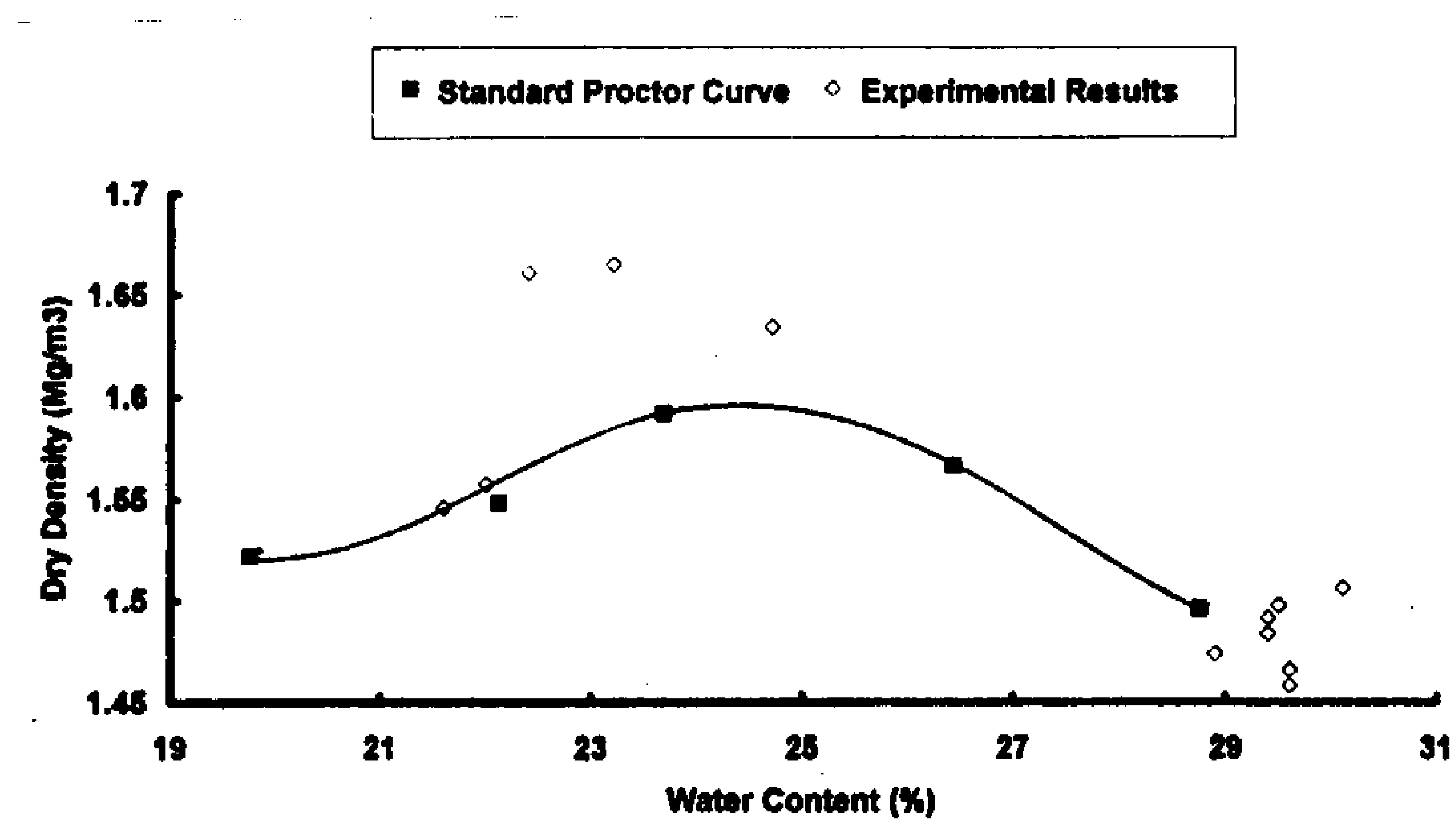

Fig. 3 Compaction curve for the Saint-Hilaire clay

The geotextile was nonwoven needlepunched, with a mass per unit area of 175 g/m^2, a thickness of 1.0 mm and a filtration opening size (as determined by hydrodynamic sieving) of 78 μm. The geotextile has been stacked in one, two, three and four layers.

3.3 Test results

The Table I shows that only test no. 28 (with 3 layers) was successful, according to Sherard and Dunnigan (1989).

Table I Testing conditions and results

Test no.	comp. water cont. %	no. of layers	% of eroded mat.	final average diam. (mm)
24	23.2	1	8	8
33	29.4	1	55	*
34	29.6	1	14	10
29	21.6	2	16	4
30	29.6	2	66	*
35	29.6	2	NM	4
28	22.0	3	4	1
22	24.7	3	3	3
31	30.1	3	4	3
36	29.5	3	5	3
26	22.4	4	4	5
37	28.9	4	6	4
38	29.4	4	4	3
32	30.5	4	NM	5

note: *: base specimen totally destroyed
NM: not measured

From those results however, some trends can be observed:

- the thinner filters (1 and 2 layers) had the higher percent eroded material and the larger final hole diameters; they had lower retention capacity;

Typical flow rate and turbidity versus time curves are given on Figs 4 and 5 for 1 and 3 layers respectively. The turbidity is defined on an arbitrary scale between 1 and 5 as a function of the opacity of the outflowing water, 1 being clear water; all the tests were carried out by the same person. The curves show that the erosion stabilized within a relatively short period of time: flow rates, within 15 minutes and turbidity, within 35 minutes, the lower values being associated with the drier clays. Except for the successful test no. 28 (3 layers, clay compacted at optimum -3%), the flow rate curves follow the pattern of the unsuccessful tests of Sherard and Dunnigan (1989), i.e. initial increase not followed by a decrease. The turbidity curves show that the outflowing water becomes clear after a period varying between 5 and 35 minutes, the shorter period being for the drier clays.

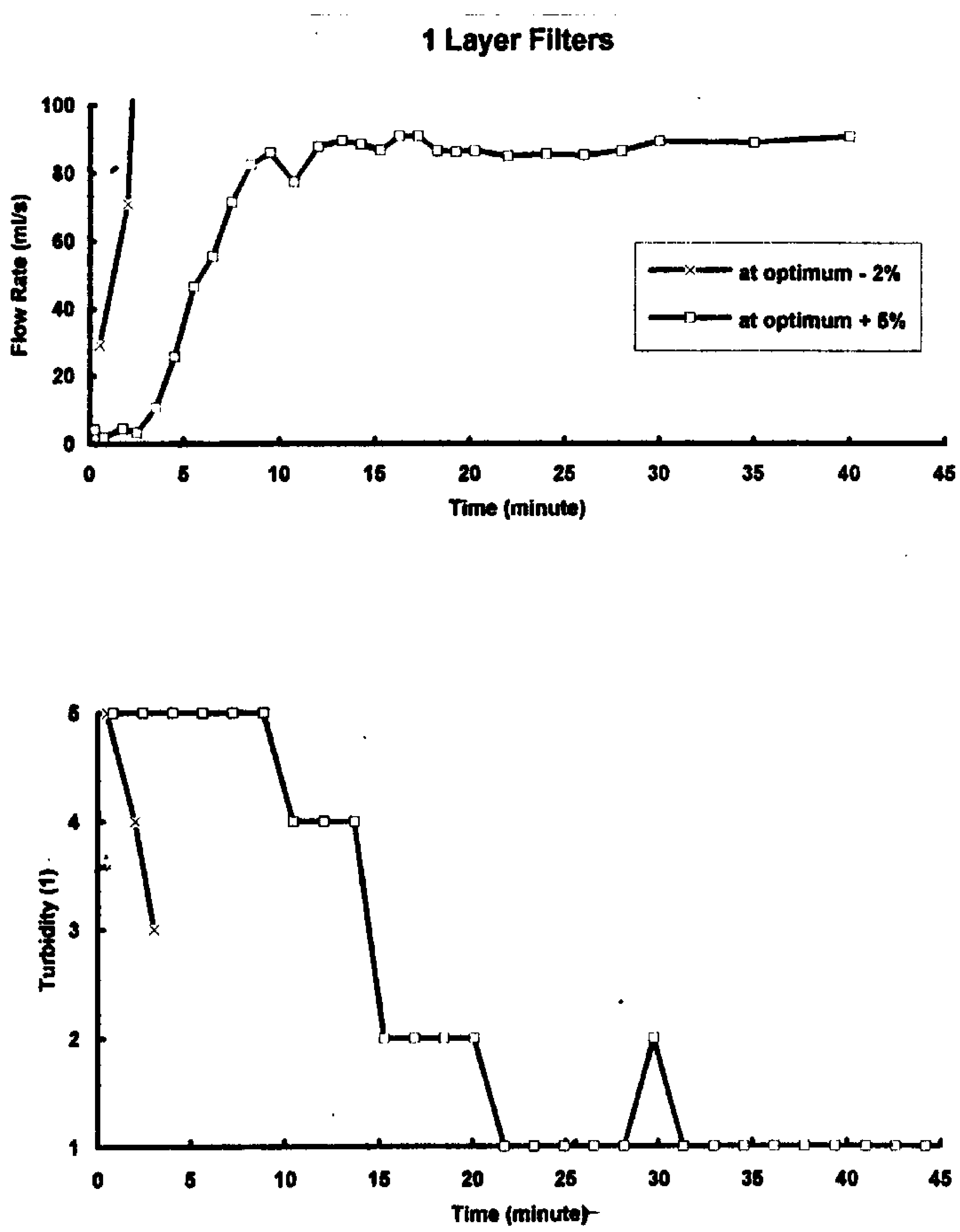

Fig. 4 Flow rate and turbidity vs time for 1 layer

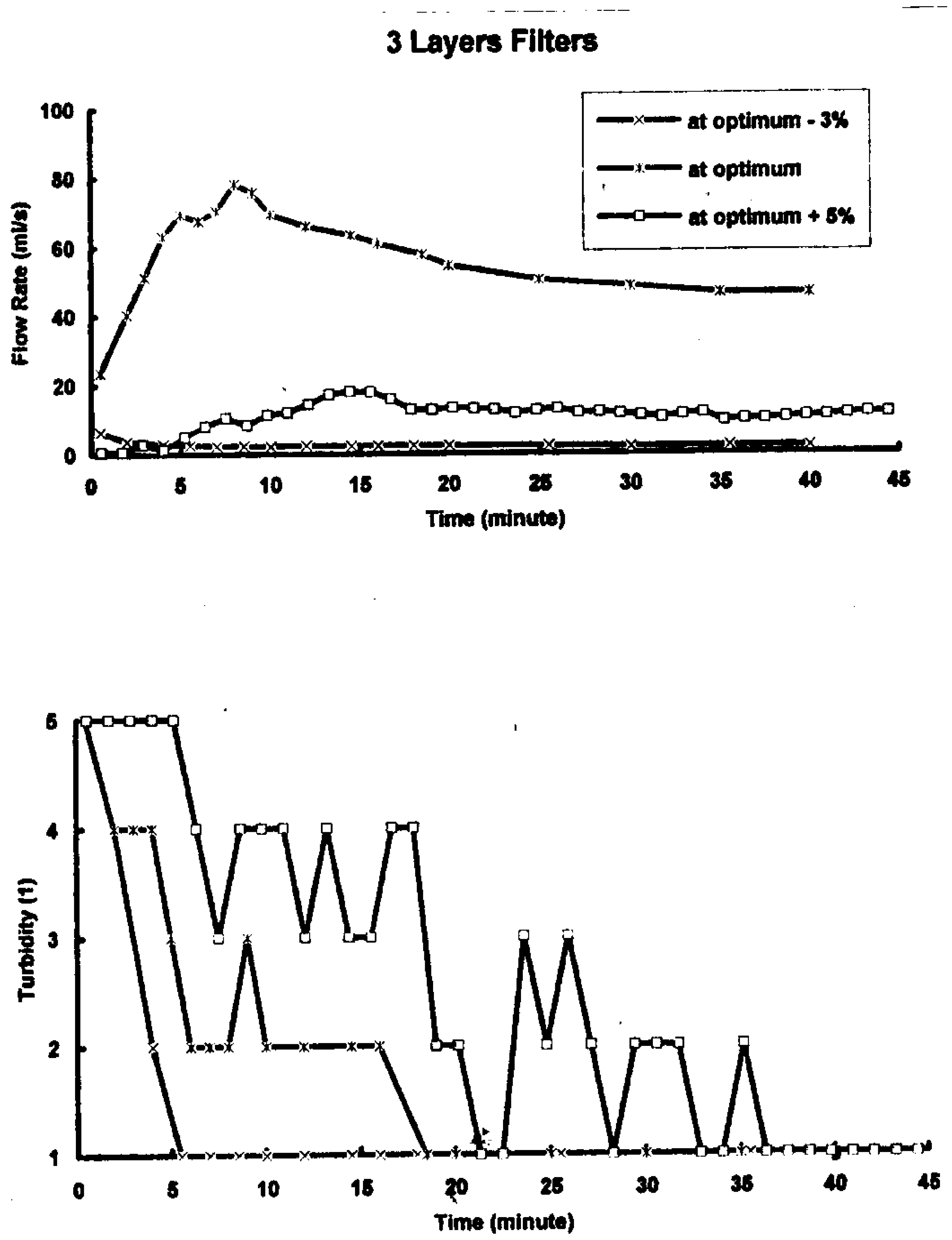

Fig. 5 Flow rate and turbidity vs time for 3 layers

4 CONCLUDING REMARKS

From limited experimental evidence, the NEF test did not give significant results on geotextiles when compared to the previous works of Sherard and Dunnigan (1989) on granular filters. This discrepancy can be attributed to the structure of the constrictions of the filter at the very interface: for a given constriction size, the larger porosity of the geotextiles may not favor the entrapment of clay flocs at the entrance of the constrictions when compared to the porosity of a granular filter. This latter has a "tighter" structure i.e., larger surfaces where clay flocs can set to form the arches shown on Fig. 1.

Originally, the NEF test was intended to simulate the most severe conditions that could develop in a dam from a concentrated leak through the core. In our opinion, the very large applied hydraulic gradients do not conform to reality. This condition can be abusive when considering geotextiles in shallow drainage, for example. Further investigations will eventually assess the relevance of such large gradients.

The NEF test has shown some promising trends in defining the compatibility of geotextile filters since the compaction water content and the filter thickness were found to influence the filtration process. The size of the eroded flocs should logically be related to the compaction water content: larger flocs with drier clays. As regards thickness, it was observed that thicker filters have increased retention capabilities. Finally, most of the tests have ended with clear water outflows. This is in accordance with the objective of a successful filtration and could lead to a relaxation of the original NEF acceptability level when geotextiles are involved.

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