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Preliminary investigations on clogging of fabrics
Etude préliminaire sur le colmatage des textiles synthétiques

Par colmatage on entend une diminution de la perméabilité hydraulique du textile par suite de depôts de particules trés fines ou de liaisons chimiques dans les mailles du textile.
Le rapport décrit une étude préliminaire de la sensibilité au colmatage de divers types de textiles synthétiques tels que textiles tissés de monofilaments à mailles de grande dimension, tissés de bandelettes, tissés de bandelettes torsadeés à certaine epaisseur, tissés de multifilaments à petites mailles et textiles non tissés. Durant l'étude, le colmatage a été provoqué en faisant circuler de l'eau claire, de l'eau boueuse et de l'eau de canal dans les textiles. Les resultats montrent que la sensibilité au colmatage augemente lorsque la taille des mailles diminue. Les filtres granulaires avec des ouvertures du même ordre se sont également révélés sensibles au colmatage dans les conditions expérimentales.

1. INTRODUCTION

In various revetment of hydraulic engineering practice filters are used. In addition to guarenteeing the sand tightness of the protection, the filter must be sufficiently permeable to discharge the groundwater quickly in order to prevent the softening of the subsoil and the occurrence of large overperssures. To fulfil this requirement, filters are designed in such a way that in the direction of the flow the permeability of the successive layers does not decrease. Fabrics as a part of the filter structure must also meet this requirement.
When judging the water permeability of fabrics, a distinction has to be made between the water permeability of the fabric with and without influencing surroundings. Starting with the permeability of the fabric itself, without influencing surroundings, this permeability may be reduced by two phenomena:

1. Blocking, which is the partial closure of the fabric's pores by sand grains in the underlaying bed, and
2. clogging, which is the partial or total closure of the fabric's pores due to the deposition of very fine particles or chemical compounds.

Blocking is an immediate effect, while clogging is a time-dependent phenomenon.
It has been shown [1] that blocking causes a rather large reduction of permeability.
Superimposed on this, the clogging effect may reduce the permeability even further.
Numerous factors can influence the clogging of fabrics. As, however their influences, are uncertain, an investigation into this phenomenon is very complex, and so it was decided to start a preliminary investigation

on clogging.
A number of fabrics, such as mesh-nettings, tape fabrics, mats (thick multi-filament fabrics), cloths (thin multi-filament fabrics) and non-wovens were subjected to a permament unidirectional water flow without an influencing sand bed. Different kinds of water and additions were used: tap water, tap water with silt and ditch water.
Moreover, in order to be able to compare the properties of fabrics with respect to clogging with those of granular filters, the test with ditch water was also used with a fine gravel filter. The used characteristic aperture sizes O_{50} and O_{90} were obtained by a sieve analysis [1], the aperture sizes being defined as follows: O_{50} corresponding with the average sand diameter of the sand fraction, of which 50% falls through the fabric under defined conditions, etc.
The investigation was carried out by the Delft Hydraulics Laboratory in commission of the Deltadienst, Rijkswaterstaat.

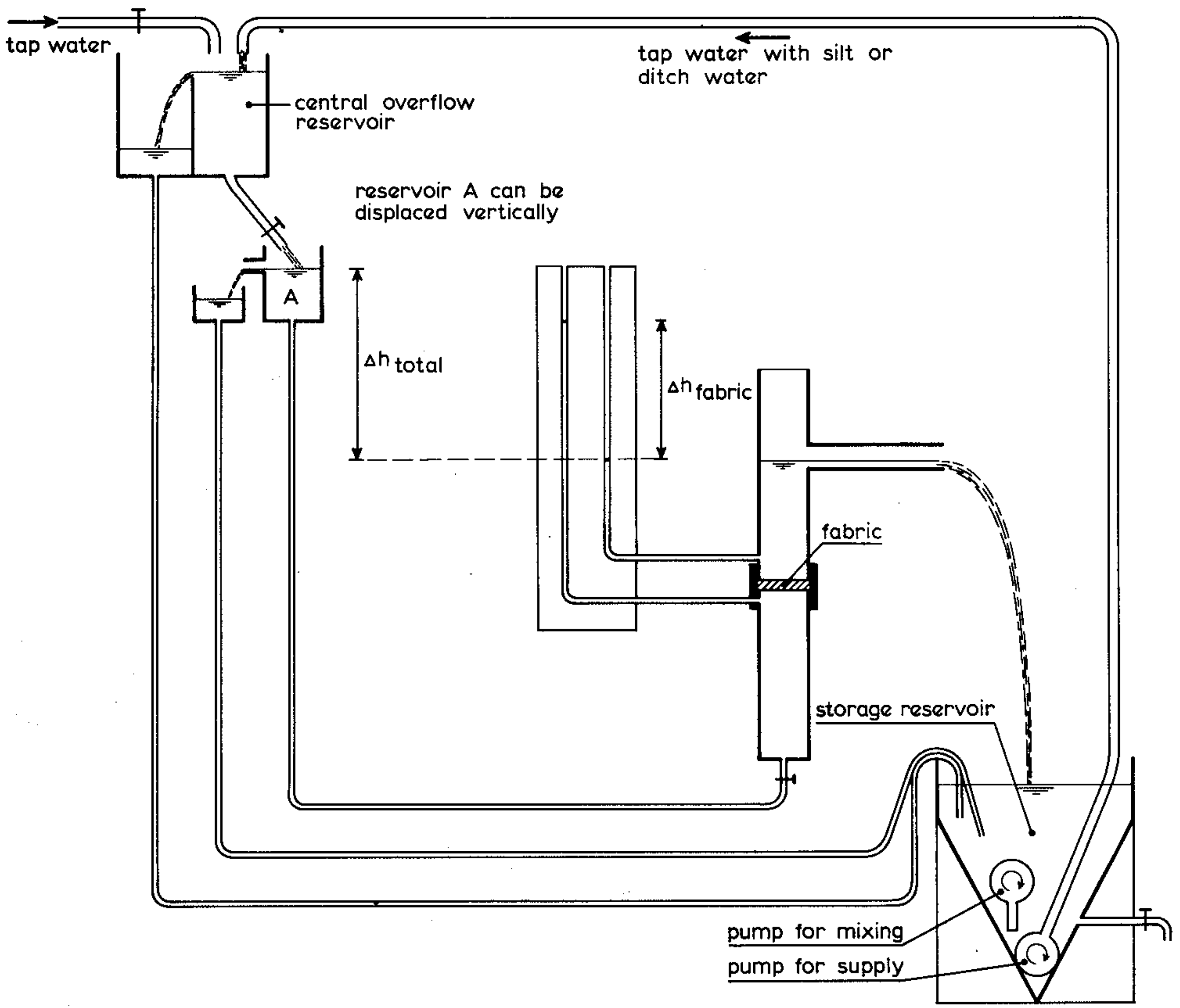

Figure 1 Test equipment

2. TEST EQUIPMENT AND SET-UP OF MEASUREMENTS

To investigate the clogging a test sample of a fabric (diameter of conveying cross-section Ø 0.05m) was fixed in a tube as shown in Figure 1. From the storage reservoir water with additions was supplied to the central overflow reservoir, which may provide the supply of five filter tubes. The water circuit was closed by conducting back to the storage reservoir the discharge through the fabric and the superfluous water in the overflow reservoir of each filter tube. To prevent sedimentation of the additions, the water in the reservoir was stirred by a pump. At the start of a test a certain filter velocity in the fabric was adjusted, and the corresponding head difference over the whole system was not changed during a test. This meant an increase of the head difference over the fabric due to the increase of the hydraulic resistance caused by the cloggging of the fabric. The discharge in the system, however, and also the filter velocity in the fabric, was decreasing.
During a test the discharge from the filter tube and the head difference over the fabric were measured at regular time intervals. The rate of clogging is expressed in the time needed for a reduction of the original filter velocity: t_{50} is the time needed for a reduction upto 50% and t_{25} is the time needed for a reduction upto 25% of the original filter velocity.

3. TESTS WITH TAP WATER

The tests with tap water without any further addition were carried out because it was thought that clogging might occur due to the chemical compounds in the tap water. An analysis of the tap water is given in Table 1. The tap water was not recirculated in the system; after passing the fabric, the used water was discharged from the system.

The results expressed in the values of t_{50} and t_{25} have been compiled in Table 2. Even after 400 hours no clogging was observed in the mesh-netting. The deposition in the fabrics was analysed and appeared to consist mainly of ferro-compounds.
Due to the very long duration of the tests, only a limited number of fabrics was tested and no attempt was made for a more systematic approach to this series.
On the basis of the results, it is clear that clogging due to the chemical compounds in the used tap water is not essential in comparison with the clogging due to the tap water with the added silt.

Neg.ions	mg/l	Pos.ions	mg/l	Gases	mg/l
Cl^-	45	Fe^{++}	0.08	CO_2	10
NO_3^-	5	Mn^{++}	0.03	O_2	11.5
SO_4^{--}	22	Ca^{++}	73		
HCO_3^-	220	Mg^{++}	6.5		
PO_4^{---}	0.03	NH_4^+	0.04		
		Na^+	19		
pH			7.5		
hardness (DIN)			11.5		

Table 1 Analysis of tap water

type	O_{90} µm	t_{50} hours	t_{25} hours
non-woven	< 60	45	75
cloth	110	15	35
mat	210	70	230
tape fabric	255	155	350
mesh-netting	375	> 400	> 400
original filter velocity: 10 mm/s			

Table 2 Values of t_{50} and t_{25} for tap water

4. TESTS WITH TAP WATER WITH SILT

In this series 12 different fabrics, grouped in three classes, were investigated. The classification had been based on the

characteristic aperture size O_{90} (see Table 4). An attempt was made to get the five different types of fabrics in each class, but this was not possible with the available samples. The division into classes eliminates the influence of the magnitude of O_{90} and facilitates making a comparison of the sensitivity to clogging of the different types of fabrics. This is important, because by selecting a fabric for a filter structure the magnitude of O_{90} plays an important rôle. The grain size distribution of the added silt is given in Table 3, the concentration of the silt being 1 gram per litre.
For all tests the original filter velocity was about 5 mm/s.

The results of this series have been compiled in Table 4, the fabrics per class being mentioned according to the increasing magnitude of the ratio O_{50}/O_{90}. Also in this series there is a tendency that the clogging proces is quicker with smaller O_{90} values.

grain size in μm	weight in percentage
< 25	89.8
< 16	88.5
< 8	83.4
< 9	76.6
< 2	71.4

Table 3 Grain size distribution of silt

				tap water with silt		ditch water	
type	O_{90} μm	O_{50} μm	O_{50}/O_{90}	t_{50} hours	t_{25} hours	t_{50} hours	t_{25} hours
classe 1	ca. 200						
mat	200	< 60	0.33	0.17	0.68	0.03	0.13
non-woven	195	157	0.81	– [1]	– [1]	0.23	0.40
tape fabric	210	170	0.81	0.75	1.58	0.23	0.70
cloth	182	165	0.91	0.91	1.83	0.33	1.00
class 2	ca. 300						
tape fabric	350	238	0.68	0.75	1.50	0.82	1.75
mat	295	215	0.73	1.33	4.75	0.12	0.70
cloth	280	215	0.77	0.91	4.75	0.10	0.35
non-woven	315	275	0.87	– [1]	– [1]	1.32	2.36
mesh-netting	305	270	0.89	– [2]	– [2]	0.88	1.33
class 3	ca. 400						
mat	420	250	0.60	1.00	15.00	0.13	0.60
mesh-netting	400	330	0.82	– [2]	– [2]	1.50	3.68
tape fabric	380	320	0.84	– [2]	– [2]	1.18	2.42

[1] test not executed

[2] no clogging observed

Table 4 Values of t_{50} and t_{25}, tapwater with silt and ditch water

Mesh-nettings seem to be less sensitive to clogging than the other types of fabrics, which do not differ much with the exception of fabrics with small values of O_{50}/O_{90} (see also Figure 2). The explanation for this is that small values of O_{50}/O_{90} imply the presence of a relatively large number of very small apertures in the fabric and it are these apertures which are most sensitive to clogging

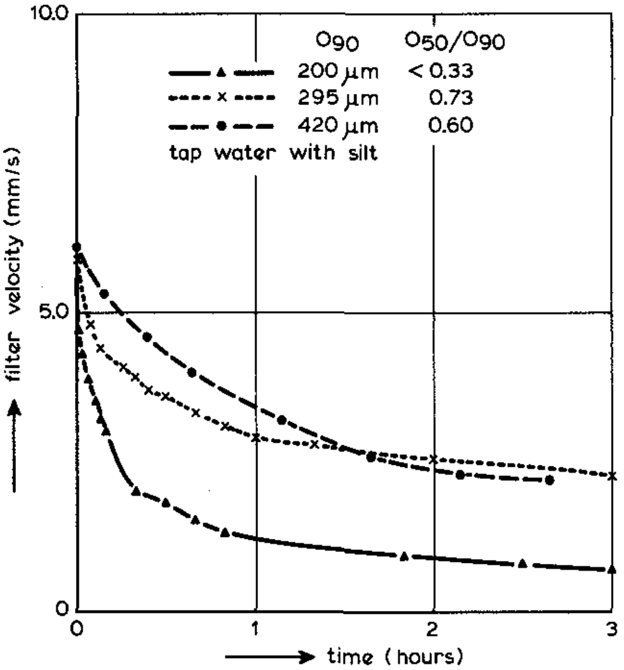

Figure 2 Clogging of mats

5. TESTS WITH DITCH WATER

For this series the same fabrics were used as for the series with tap water and silt.
An analysis of the ditch water is given in Table 5, the organic material consisting of silt and algae.
The original filter velocity was about 5 mm/s.
The results expressed in t_{50} and t_{25} have been compiled in Table 4.
The clogging process was mostly quicker than with tap water and silt in spite of the smaller concentration of the additions. The cause of this was undoubtedly the presence of algae with a threadlike shape. Due to the irregular pollution of the algae, the results showed a large spreading when the tests were repeated (see Figure 3). The results mentioned in Table 4 are average values of two or more tests.

compounds	content per litre
chloride-	196 mg Cl
nitrite-, nitrate-	0.7 mg N
nitrogen-	4.2 mg N
phosphate-	0.3 mg P
ammonium-	0.7 mg N
B.O.D.	13 mg O_2
organic material (algae)	20 mg

Table 5 Analysis of ditch water

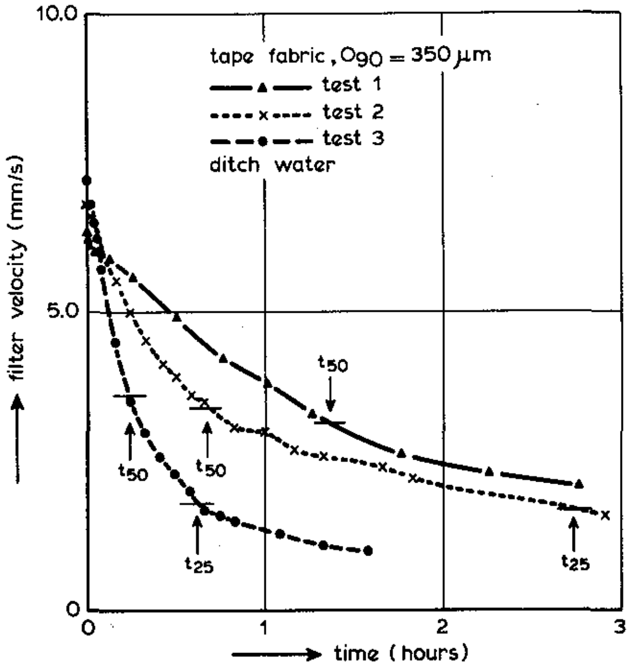

Figure 3 Reproduction of tests

Conspicuous is again the strong sensitivity to clogging of mats with small values of O_{50}/O_{90}. In order to get a comparison between fabrics and granular filters concerning the sensitivity to clogging, a granular filter with a thickness of 0.20 m was subjected to the test with ditch water. On the basis of the grain size distribution the aperture size of this filter was estimated at about 400 µm. The result of the test is shown in Figure 4, from which it appears that also granular filters are sensitive to clogging, although to a less extent than fabrics under the test conditions used.

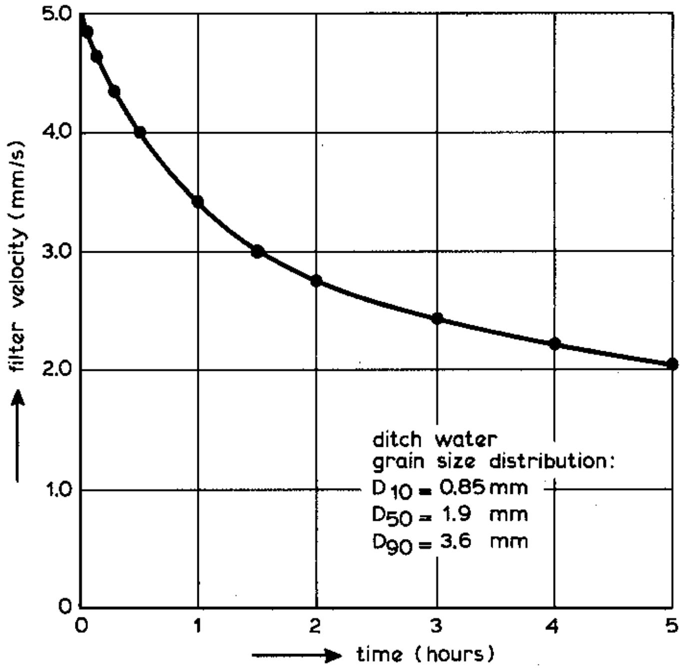

Figure 4 Clogging of granular filter

6. CONCLUSIONS

In spite of the relatively small number of fabrics used in the preliminary investigation, the following conclusions may be drawn:

- Dependent on the nature of the transported particles, all the investigated fabrics are more or less sensitive to clogging under the test conditions used.
- The rate of clogging increases for decreasing values of the characteristic aperture size O_{90}.
- Small values of the ratio O_{50}/O_{90} increase the sensitivity to clogging.
- Granular filters are also sensitive to clogging under the test conditions used.

7. FUTHER RESEARCH

In the next phase of the investigation on the clogging of fabrics more attention will be paid to obtaining a more balanced distribution of the several types of fabrics in the different classes of the test samples. Besides unidirectional flow, reversible flow will also be used in the test equipment. Also different filter velocities will be applied in the experiments in order to determine a possible influence on the clogging process. This further research must give indications for investigations in the field where at characterestic places the clogging process can be studied. The field investigations are indispensable for the interpretation of the laboratory tests.

8. LITERATURE

1 OGINK, H.J.M.,
Investigations on the hydraulic charateristics of synthetic fabrics.
Delft Hydraulics Laboratory, publication No. 146, 1975.