Experience in Plastic Filter Application

L'Application de Filtres en Matière Plastique

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SYNOPSIS Plastic filters (high-polymeric textile materials) can be applied with design, process and economy advantages over conventional earth filters. In selecting the plastic filters, both their specific properties and their interaction with contact soils have to be allowed for. Suitability analyses, engineering to suit the materials, and working methods (placing and covering) are outlined.

INTRODUCTION

Filters in earthwork and hydraulic engineering have to perform the following functions:

(i) to separate soils of different composition and protect them from deformation due to wash-out of fine soil fractions;

(ii) to permit water passage without hydrostatic pressure buildup.

Conventional earth filters are built of one or several layers of classified soil (gravel, chippings). To this end, it is necessary that ample amounts of a suitable filter material be transported to site and placed in the desired location, requiring in part substantial efforts. Instead of earth filters, use can be made of plastic filters giving technical and economical advantages. Plastic filters are roughly defined as industrial textiles of synthetic polymers.

RESEARCH AND DEVELOPMENT

Initial investigations were designed to study various industrial textiles of synthetic materials for their suitability as hydraulic engineering filters. In this respect, applicability tests were carried out for selected civil projects under specific process conditions, while systematic research efforts also included extensive laboratory and field experiments (Markert, 1978).

The problems introduced by the novel material into the design engineering and processes in earthwork and hydraulic construction were analyzed and the engineering and working principles reflected in a works standard specification (SWW 045).

Moreover, joint development work with textile producers yielded synthetic textiles matched to the filter duty in a structure and under field conditions. The efforts were aimed at obtaining the following properties:

- High resistance to aging
- High mechanical strength
- Quantifiable filtering features.

The present range of plastic filters developed (knitted and non-woven materials) can be employed to protect the majority of natural soils from contact erosion.

APPLICATIONS

The plastic filters tested can

- prevent erosion of the basic soil to be protected;
- permit water passage without jeopardizing the stability of the structure.

Therefore, they may be used as spread filters (Fig. 1) to replace the conventional earth filters. This mode of application is approved for

- Small-capacity reservoirs (overflow level not to exceed 5 m)
- Class II dams (overflow level not to exceed 15 m)
- Flood levees
- Canals and water courses
- Structures for site safeguarding (e.g. cofferdams).

Because of their small thickness, such plastic filters cannot rapidly and safely carry off percolating waters occurring. They may be combined with a component (e.g. drain pipe) that serves to drain off the water (Fig. 2). The linear filters so formed are suited for various draining duties (e.g. drainage, structure dewatering).

SELECTION OF PLASTIC FILTERS

In selecting the plastic filters from the range of high-polymeric industrial textiles, the filter properties must be chosen to suit the particular field conditions of the structure, i.e.

- Function and normative useful life of the structure
- Arrangement of filter in the structure
- Materials in contact with the filter.

Properties of plastic filters:

- Resistance to aging

Interaction between plastic filter and contact soil:

- Grain retention and permeability features
- Interfacial shear strength.

FILTRATION PROPERTIES AND ANALYSES

The application analysis of plastic filters and their interaction with contact soils require that the following phenomena be assessed:

- Contact erosion in the joint between basic soil and plastic filter
  The required margin of safety can be evidenced by means of a filter rule

$$D_m \leq n \cdot d_{50} \cdot \frac{1}{\eta}$$

where

D_m is the determinative voids index of the plastic filter, whioh is determined by the hand wet screening method (Batereau & Markert, 1978); (D_m corresponds to the mean grain size of the soil fraction, 90% of which are retained by the plastic filter in the above procedure).

n is a textile engineering coefficient (essentially governed by the type of textile)

d_{50} is the grain diameter of the soil to be protected, at 50% by weight of the grain-size distribution curve

η is a factor to allow for changes in filter structure (for tissues, latch needle and knitted fabrics: η = 1-2; for non-woven materials: η = 1)

- Colmation on the plastic filter
  This phenomenon is assessed from evaluation of suffusion of the basic soil. In most applications, an estimate is the only feasible approach.

- Water permeability of the plastic filter
  The resistance of the filter to infiltration, which is essentially governed by the contact soil, can be determined experimentally (Batereau & Rehfeld, 1979):

$$w = \frac{\Delta h}{V_f}$$

where

w - Resistance to infiltration

Δh - Hydraulic pressure loss across the filter

V_f - Filtration velocity.

Using this parameter (w)

a) the percolating water flow pressure occurring on the filter, and

b) the position as might be altered, of the phreatic line

can be calculated and, thus, the stability of the structure evidenced while allowing for placed plastic filters (Batereau & Rehfeld, 1979).

STABILITY PROBLEM

When plastic filters are placed in an earthwork structure in an inclined arrangement, then the stability in the contact joints between filter and adjoining materials must be analyzed and evidenced, for which purpose coefficients of interfacial shear strength are required. Such friction data are influenced by the interaction of several factors:

- Surface structure and fibre material of the plastic filter;
- Mean grain size and grain-size distribution of the soil;
- Compactness of soil, or normal stress.

Moreover, they are subject to a large variation scatter.

For the engineering of slopes, the coefficients of friction were determined by project-related shear tests using a translation shear tester, an angle-of-slope tester, and also in situ.

ENGINEERING PRINCIPLES

General Notes

The specific properties of synthetic textiles call for engineering to be tailored to the materials.
Plastic filters must not be subjected to long-term tensile stresses or abrasion load.
Plastic filters must be placed on level subgrade, which is free from stones, branches or other matter that might cause damage to

the filter.

Joining

In order to join plastic filters to obtain larger areas, the following methods were developed and tested:

- Cementing (preferably by CHEMISOL)
- Welding (by blow lamp or propane torch)
- Sewing by synthetic yarn.

These depend on weather conditions and are suited for pre-fabrication in confined spaces.

Overlapping (not less than 20 cm wide) gave most satisfactory results under field conditions. This is a simple and fast method that can be employed without technical auxiliaries.

Covering

Plastic filters in a structure must be secured in position to protect them from wind and wave action. Moreover, they may not be exposed to weather and U.V. radiation for an unlimited period. Rather, covering within few days is essential. Usually, the coverings used consist of soil (crushed rock, rubble) or prefabricated concrete units.

PROBLEMS IN CONSTRUCTION

Mechanical Load Capacity of Plastic Filters

Application of the covering material imposes a high load on plastic filters. However, their serviceability and reliability must not be impaired.

Loading and its effects are influenced by the following factors:

- Covering material (grain size, condition, height of drop, angle of impact)
- Plastic filter (strength, extensibility)
- Basic soil (resistance or elasticity, grain sizes and grain roughness).

Numerous site experiments as well as experience gathered in the application of more than 100 000 sq. m. of plastic filters in various earthwork and hydraulic engineering projects (Markert, 1978) have led to the following conclusion:

The process of placing the covering material must be tailored to both the plastic filter and the covering material, since such materials are preferably selected while allowing for functional aspects.

Placing Processes

Fully satisfactory field results have been obtained by using the following methods:

- Dump the covering material in front of the plastic filter or onto a cover layer already present, and shove the material by a bulldozer to spread it over the filter. The minimum thickness of covering material layer required under the caterpillar tracks is 20 cm.
- Spread covering material on the plastic filter by loader or grab, and level by bulldozer. Hand levelling is required on steep slopes or subsoil of low load-carrying capacity.

When, during trial application of the above methods, the plastic filter is damaged or unduly deformed a protective layer approx. 10 cm thick of pit run gravel sand can be initially applied to the filter, and on top the actual covering material.

ECONOMY

Compared to conventional soil filters, the economy of plastic filter application is as follows:

- Reduced structural weights
- Disentanglement of processes
- Shorter completion periods by 35 - 80%
- Savings in materials and transport expenses by 30 - 50%.

REFERENCES

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Batereau, C. & Rehfeld, E. (1979). Hochpolymere textile Stoffe im Erd- und Wasserbau. Bericht des VEB Baugrund zum Vertragsforschungsthema (unpublished).

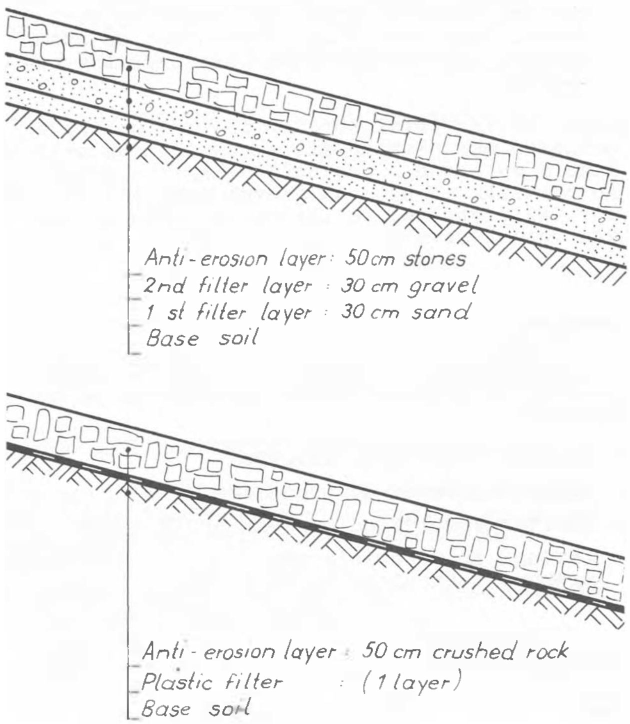
Anti - erosion layer: 50cm stones
2nd filter layer : 30 cm gravel
1 st filter layer : 30 cm sand
Base soil
Anti - erosion layer : 50 cm crushed rock
Plastic filter : (1 layer)
Base soil

FIG. 1

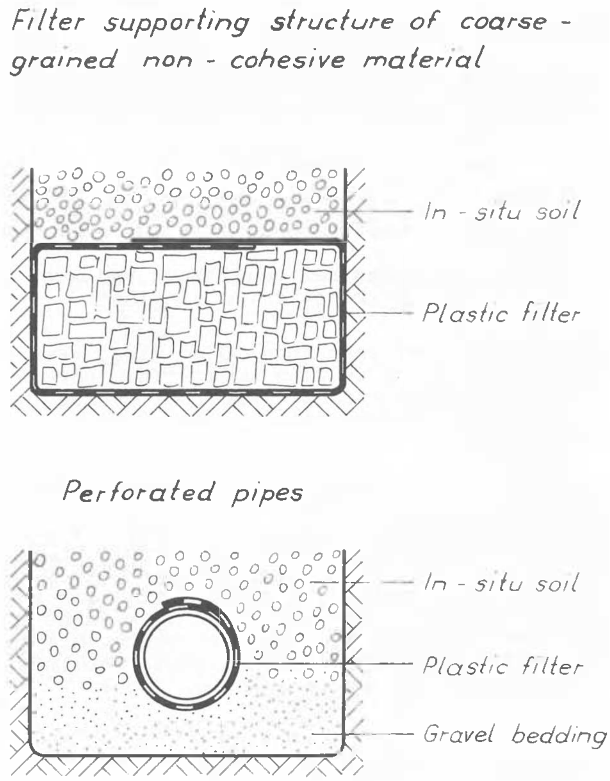
Filter supporting structure of coarse - grained non - cohesive material
In - situ soil
Plastic filter
Perforated pipes
In - situ soil
Plastic filter
Gravel bedding

FIG. 2