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Design using geosynthetics —

Part 3: **Filtration**

Design pour géosynthétiques —

Partie 3: Filtration

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 221, *Geosynthetics*.

A list of all parts in the ISO/TR 18228 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The ISO/TR 18228 series provides guidance for designs using geosynthetics for soils and below ground structures in contact with natural soils, fills and asphalt. The series contains parts which cover designs using geosynthetics, including guidance for characterization of the materials to be used and other factors affecting the design and performance of the systems which are particular to each part, with ISO/TR 18228-1 providing general guidance relevant to the subsequent parts of the series.

The series is generally written in a limit state format and guidelines are provided in terms of partial material factors and load factors for various applications and design lives, where appropriate.

This document includes information relating to the filtration function. Details of design methodology adopted in a number of regions are provided. The characteristics of the geosynthetics and the test methods normally used to quantify the properties of the geosynthetics are described. Some regional specific rules and regulations that normally apply to designs using geosynthetics in these regions are also provided.

Design using geosynthetics —

Part 3:
Filtration

1 Scope

This document provides general considerations to support the design guidance to geotechnical and civil engineers involved in the design of structures in which a geotextile is used as a filter. The key potential failure mechanisms are described, and guidance is proposed to select engineering properties.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 10318-1, *Geosynthetics — Part 1: Terms and definitions*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10318-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.2 Symbols

B, B_1, B_2	factors function of the application, soil properties and hydraulic conditions, used for the verification of the retention criteria of the soil skeleton
C	constant, used for the verification of the non-retention criteria of fines in suspension
C_u	coefficient of uniformity of the soil, defined as $C_\mathrm{u} = d_{60} / d_{10}$
d_{85}, d_{60}, d_{50}, d_{30} or d_{10}	diameters of particles for which 85 %, 60 %, 50 %, 30 % or 10 % of all soil particles are smaller (e.g. d_{85} = 200 µm means that 85 % of the soil particles are smaller than 200 µm)
d_I	indicative diameter of the soil, for retention criteria
d_J	indicative diameter of the soil, for non-retention criteria of fines in suspension
ΔH	water head used to measure the indicative velocity in the laboratory test, i.e. ΔH = 0,05 m

E constant, used for the verification of the permeability criteria

i_G hydraulic gradient prevailing immediately upstream of the geotextile (0 to 0,025 m away from the geotextile as in ASTM D5101)

i_s hydraulic gradient prevailing in the soil, in the vicinity of the geotextile filter

k_s permeability of the soil

m number of constrictions

V_F is the indicative velocity of the water passing through the filter, which is the flow rate divided by the total area of passage (apparent area) at a water head of ΔH = 0,05 m

Ψ permittivity, represents the volumetric flow rate of water per unit cross sectional area per unit head under laminar flow conditions, in the normal direction through a geotextile

3.3 Abbreviated terms

BOD biological oxygen demand

COD chemical oxygen demand

COS characteristic opening size of a geotextile

PI plasticity index

POA percent open area

PVD prefabricated vertical drain

UV ultra-violet

4 Concepts and fundamental principles

4.1 General

Soils are porous media containing 20 % to 40 % voids in between soil particles, which are typically filled with gas such as air, liquid such as water, or both. Displacement of water within the voids of the soil generates a dragging force on each of the grains of the soil. When the grains are supported, e.g. by other grains, they stay in place and the water moves without disturbing the soil structure. However, if the grains of soil are not in contact with a solid that can offer a resisting force, internal erosion can develop: soil particles are dragged by the water until they reach an obstacle, or until they exit the soil structure.

Soil structures often include configurations where the water has to flow away from the soil, e.g. into a drain. To prevent internal erosion, a filter media can be installed, in order to offer a resisting force to the largest particles of the soil, called the soil skeleton, and to prevent it from being dragged away by the water. However, this filter media should not restrain the flow of water, in particular to avoid pore pressure build-up, which could also adversely affect the stability of the soil structure.

In geosynthetics, the filtration function is to stabilize the soil by maintaining in place the soil skeleton in contact with the geotextile surface and restrain uncontrolled passage of soil, while allowing the passage of water or other fluids and some of the finest particles transported in suspension across the filter. The geotextile filter can be thought of as a catalyst to create a natural granular filter in the thin soil layer in contact.

Filters may be installed at the interface with a water-transport media, e.g. soil with high permeability, drainage pipe, edge drain, drainboard, PVDs. They may also be installed between soil and rip-rap, gabions or product with the same function, for example for coastal protection, banks protections, in dams.

When the geotextiles are not covered with soil and laid alone, e.g. as silt fences, etc., the filtration behaviour is different: there is no soil skeleton to stabilize, the geotextile is intended to trap or screen all moving particles.

The performance of a filter may be qualified by its ability to fulfil the two contradictory functions required for filtration:

— prevent damages caused by the transport of an excessive quantity of particles from one side of the filter to the other (piping), such as internal erosion of the soil being filtered which could modify in its engineering properties, formation of cavities on the upstream side of the filter. Such damages also include excessive contamination of the structure located downstream by particles piped through the filter, e.g. blocking of a drainage pipe;

— minimize restriction to the flow of water passing through the filter, to avoid pore pressure build-up on the upstream side of the filter.

4.2 The filtration function of geotextiles

Long term performance of geotextile filters can be endangered by the blocking of the surface (blinding) or of the pores (clogging) of a soil or geotextile filter. These mechanisms can be caused by the accumulation of fine particles and development of a “cake” on the surface of the geotextile (blinding), or inside the geotextile structure (clogging), resulting in a drastic reduction of the permittivity of the filter.

In some cases, reduction of the capacity of the geotextile filter to let water pass across its plane might also be caused by the precipitation of chemicals, e.g. iron ochre, calcium, or the development of a biological activity. Evidences of clogging caused by the presence of air pockets trapped into, or in the vicinity of, the filter have also been observed.

These mechanisms suggest that the best performance for a filter is obtained when using a material which openings are small enough to stabilize the largest particles in contact (soil skeleton) but large enough to let pass the finest particles in suspension and to avoid internal erosion of the soil, and piping.

For both piping and clogging mechanisms, the parameter controlling the performance of a filter is the size of the voids through which particles of the soil are likely to travel at the surface or inside the geotextile. The filtration characteristics of a geotextile filter, such as opening size or permeability, are therefore crucial to its design. These properties need to be selected with consideration to the properties of the soil to be filtered and hydraulic conditions prevailing on a particular site.

Other parameters characterizing the structure of a geotextile have also been investigated, such as the pore size distribution (determined using ASTM D6767) or the number of constriction (determined using ASTM D7138). However, although there is a consensus regarding the fact these parameters can influence the filtration performance of a filter, they are still being investigated by the research community. Design guidance was still not available at the time this document was prepared.

Depending on their structure, some geotextiles can be compressed under load. Consequently, their permeability might decrease when compared to the property measured without load. This phenomenon was investigated. Some reliability issues were identified with the testing techniques and the impact of normal load found to be difficult to quantify. There is no consensus at the time this document was prepared regarding the need, nor the value, that should be used as a safety factor to be applied on the values of permeability without load to address this issue.

In some cases, account also needs to be taken of potential loading mechanisms, presence of iron ochre, potential biological activity, and mineralogy of the soil, which can all affect the long-term performance of the filter. For extreme situations, it might be necessary to use alternatives to geotextiles.

4.3 Filter selection fundamentals

A geotextile filter should be selected considering the following parameters:

— filtration performance: ability to retain the soil skeleton and to let the water pass perpendicularly to its plane, depending on the soil properties, i.e. grain size distribution, cohesion and permeability of the adjacent soils, and taking into account the type of pore water flow (turbulent, laminar);

— suspended solids concentration of the water to be filtered, property of the suspended particles when applicable;

— survivability, or capacity to resist the stress caused by installation and subsequent construction works;

— capacity to resist mechanical stresses encountered during its service, when applicable;

— durability, which includes resistance to the chemical environment in which it is installed; resistance to UV oxidation during construction or in service when applicable; and long-term durability;

— penetration of roots, anchorage of an overlying structure, or any other alien material likely to affect its continuity or its properties;

— location of the geotextile filter within the soil structure.

Most applications involve the seepage of water in a single direction, typically perpendicular to the plane of the geotextile filter. However, some applications involve bi-directional flow, cyclic flows, which involve significantly different hydraulic and/or mechanical stresses which are likely to affect the filtration performance of a geotextile.

Mechanical stress prevailing on the soil/geotextile interface might vary from one application to another. While many drainage and filtration applications involve static, constant loads, others such as bank protection can experience dynamic loading, which can affect the stability of the filter. For many roadway applications, the repetitive passage of trucks on a road generates dynamic stresses which are likely to affect the stability of the soil structure in the vicinity of the filter.

Geotextile filters are typically used to drain water but may also be used with leachate or other liquids from adjacent soils, waste, or other solid porous media, such as in landfill leachate collection systems. They are occasionally used to filter gases in soils, e.g. gas collection layers in landfills, or gas drainage layers installed beneath building basements.

5 Typical applications

5.1 General considerations

There are two key types of application of geotextile filters, which involve different filtration mechanisms, thus different approaches to design:

— filtration of soils, where the geotextile is in intimate contact with the soil. The water then moves within the soil matrix, and might drag the finest particles away depending on the equilibrium of each particle in contact at the geotextile surface;

— filtration of slurries or suspended particles, where each particle reaching the geotextile (or soil accumulated on the geotextile) is suspended in water.

Designing using one or the other approach might lead to the recommendation of different properties for the geotextile filter. Consequently, the long-term performance of the geotextile filter is first determined by the correct identification of the filtration mechanism actually involved. One impact might be the recommendation of preventive measures to ensure that a geotextile designed for soil filtration is not exposed to slurry filtration (i.e. include a requirement to backfill immediately after installation).

5.2 Soil filtration

Soil filtration typically involves the filtration/retention of compacted soils exposed to a flow of water, where an intimate contact between the soil and the geotextile is assumed. Examples of such situations include:

— drainage systems (buildings, agriculture, etc.);

— dams;

— PVDs;

— roadways;

— rail track bed;

— waterways/canals;

— coastal protection;

— landfills – leachate collection systems.

Soil filtration can also involve the separation/retention of soils exposed to the flow of gases, for example:

— protection against the intrusion in buildings of radon and other subsurface gases;

— gases collection layers in landfills.

5.3 Slurry filtration

Typical applications where the geotextile is designed to separate water from solid particles, where there is little or no particle-to-particle contact, include:

— filtration of slurries and dewatering applications;

— geocontainers;

— silt fences.

6 Materials

Geotextiles intended to perform as a filter for permanent applications are usually manufactured with polypropylene, polyester or polyethylene fibres. They may be woven, non-woven or knitted. Typical ranges of properties are given in this Clause, however, there are products on the market offering characteristics beyond the proposed limits, intended for use in specific applications. Manufacturers should be contacted for further details on their products.

Woven geotextiles may be either slit-films (Figure 1), monofilaments, multi-filaments or a combination thereof (Figure 2). They offer opening sizes varying between 0,05 mm and 2,0 mm, POA from 0,5 % and 40 %, and velocity index from 0,001 m/s to 1 m/s. Their construction may include multifilament polyester yarns, polypropylene or polyethylene tapes or strands.