TECHNICAL REPORT

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Design using geosynthetics —

Part 1: **General**

Conception utilisant des géosynthétiques —

Partie 1: Généralités

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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 10 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.

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.

For each of the design considerations, 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 1:
General

1 Scope

This document provides general considerations to support the guidance to geotechnical and civil engineers for design using geosynthetics provided in the subsequent parts of the ISO/TR 18228 series.

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 and symbols

3.1 Terms and definitions

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

For the purposes of this document, the symbols are taken from ISO 10318-2. Table 1, Table 2 and Table 3 provide lists of the lowercase, uppercase and Greek symbols that are typically used throughout the ISO/TR 18228 series. Additional useful symbols may be found in the relevant parts of the series.

Table 1 — Lowercase symbols

Symbol	Meaning
f	Partial factor (with subscripts as noted)
h	Hydraulic head
i	Hydraulic gradient
pH	Value of acidity of an aqueous solution
m	Mass of an element
q	Flow quantity (with subscripts as noted)
r_{u}	Pore pressure ratio
t	Thickness of a geosynthetic
t_{d}	Design life
t_{t}	Test duration

Table 1 *(continued)*

Symbol	Meaning
u	Pore water pressure

Table 2 — Uppercase symbols

Symbol	Meaning
A	Area
C	Hazen empirical coefficient for permeability
C_{u}	Coefficient of uniformity (D60/D10)
D	Particle grain size, subscript defines percentile
E	Elastic modulus
F_{d}	Factored design load
F_{k}	Unfactored characteristic load
H_{t}	Total height
K	Hydraulic conductivity or coefficient of permeability of the soil
K_{a}	Coefficient of active earth pressure
K_{o}	Coefficient of earth pressure at rest
K_{p}	Coefficient of passive earth pressure
L	Length
N	Normal force
O_{90}	Effective or characteristic opening size in a geotextile, (where 90 % of openings finer than the value)
POA	Percentage open area
Q	Applied pressure
Q_{m}	Average pressure
R	Reaction
T_{CR}	Extrapolated compressive creep rupture strength at the end of the design life
Z	Section modulus

Table 3 — Greek letter symbols

Symbol	Meaning
α	Inclination of a slope to the horizontal
γ	Unit mass density of soil (with subscripts as noted)
μ	Apparent coefficient of friction
φ	Friction angle of the soil (degree)
σ	Normal stress
σ_{h}	Horizontal stress on an element of soil
σ_{v}	Vertical stress on an element of soil
σ'_{v}	Applied vertical effective stress
Θ	Transmissivity of a geosynthetic
T	Shear stress

4 General design considerations

4.1 Fundamentals

Designs using geosynthetics normally take into account the nature of the soils in contact with the geosynthetic materials. The characteristic properties of the soils can be measured using in situ tests as described in ISO 14688-1, ISO 14688-2, ISO 22476 (all parts) and ISO 22282 (all parts), or with associated laboratory tests from ISO 17892 (all parts) as appropriate for the information required for the designs being made.

Geosynthetics have characteristics which might be suited to specific functions or applications but might be unsuitable for some functions or applications. The individual parts of the ISO/TR 18228 series provide guidance as to which types are suited to each function or application, but the final choice of product for any situation will be the choice of the designer or the project approval authority.

All geosynthetic products delivered to a construction site would normally be clearly marked and labelled as described in ISO 10320.

4.2 Short-term properties

4.2.1 Survivability

4.2.1.1 Mechanical damage

Geosynthetics are predominantly sheet materials which are supplied in rolls or as large folded units. Geosynthetics can be damaged during transport to the construction site, between initial storage on site and the point of laying and during the construction process. To minimize the damage that can arise due to transportation and handling, some geosynthetics might need to be wrapped and pads might be required where appropriate to reduce contact stresses and any resultant damage.

The incorporation of geosynthetics in the construction works involves rolling out or laying the material. Special handling equipment would normally be used when the material units are too heavy for manual handling.

The assessment of survivability would normally consider the nature of the soils and materials in contact with the geosynthetic, and whether construction equipment, wheeled or tracked, will be allowed to run over the geosynthetic.

Any resulting damage from placing fill material (i.e. soil, rock or asphalt) on a geosynthetic would normally be considered in the design by the application of a damage factor. Product specific advice may be obtained from the manufacturer of the geosynthetic as to the damage factor(s) to be used in the particular situation.

4.2.1.2 Weathering

All geosynthetic materials are susceptible to the effects of weathering during periods of exposure; the effects of weathering can be assessed following EN 12224 and EN 12226.

Weathering can be defined as exposure to one or more of the following:

— sunlight (UV radiation/oxidation) (see ISO 13438);

— water (see EN 12447);

— extremes of temperature;

— wind.

Weathering resistance can be built into the geosynthetic or can be inherent as part of the manufacturing process.

Polymers and natural materials used in the manufacture of geosynthetics have varying susceptibility to UV damage. The base polymers can be mixed with additives to enhance the UV resistance. If a geosynthetic is supplied in a protective wrapping, it would normally be kept wrapped or stored as recommended by the manufacturer until needed.

The weathering assessment would normally also consider other processes that can affect geosynthetic performance. Some geosynthetics might be more resistant to the actions of wind and/or flowing water. Selection of a particular geosynthetic would normally consider the method of manufacture and the site conditions.

4.2.1.3 Chemical resistance

Polymer geosynthetics degrade principally due to chemical reactions with the environment. The rate at which this occurs depends significantly on temperature and other conditions. Some key points are:

— Many reactions occur at the polymer surface therefore thicker materials are normally more resistant than thinner materials.

— A change in temperature can lead to a change in the rate of the chemical reaction at the polymer surface.

— Chemical reactions between particles in a solid state are generally slow in comparison to reactions between those involving fluid states.

— The high surface area of fine fibres, as used in the manufacture of geotextiles, will increase the rate of chemical surface attack.

— Chemical reactions can take place in the main chain of the polymer or in the side chains. Rupture of the main chain is more critical because it will directly reduce the strength of the polymer.

4.2.2 Mechanical properties

4.2.2.1 Tensile behaviour

As a short-term property tensile strength is one of the measures used to determine the resistance of the geosynthetic to damage during the construction process. Tensile test method is given in ISO 10319.

4.2.2.2 Impact or penetration damage resistance

Impact or penetration damage can occur when fill or other materials are dropped or placed onto geosynthetics during construction. The laboratory tests described in EN 14574, ISO 12236, ISO 10722 and ISO 13433 measure how easily holes can be made in the product. In some circumstances, full scale site tests might be required when laboratory tests are unable to model the site conditions, including full scale rock dropping tests.

4.2.2.3 Compressive behaviour

Compressive behaviour as measured in ISO 25619-1 and ISO 25619-2, or the ability of three-dimensional products to support loads applied normal to the surface of the material, is usually assessed when the geosynthetic is required to transmit fluids in the plane of the product. Applications such as drains in sports fields, transportation works, structural drainage, landfill drains and gas vents require a three-dimensional core combined with a geotextile filter to ensure that the core remains clear.

4.2.2.4 Abrasion resistance

Abrasion resistance as measured by ISO 13427 is used to check that the geosynthetic does not suffer from damage during construction when subjected to compaction forces on the surface of the product.

4.2.3 Hydraulic properties

4.2.3.1 Filtration and permeability

Filtration is the ability of a geotextile to filter soils so that fine materials do not clog any of the drainage layers, natural sands/gravels or three-dimensional geosynthetic products. The effective opening size, O_{90}, of the geotextile as measured by ISO 12956, is a measure of the pore sizes in the geotextile.

Permeability is a measure of the ability of the geotextile to allow water or other fluids to pass through the product into a drain. The permeability of barriers is measured using tests in EN 14150, EN 16416, ISO 10776, ISO 10772 and ISO 11058.

4.2.3.2 Drainage or flow capacity

Short-term drainage will normally not be critical as any geosynthetic acting as a drain will have its maximum capacity during construction. If the geosynthetic is required to carry additional flows during construction the capacity of the drainage layer would normally be checked. The flow capacity is measured using test in ISO 18325.

4.2.4 Friction properties

4.2.4.1 Direct shear and inclined plane

Friction as measured in either the direct shear (ISO 12957-1) or the inclined plane test (ISO 12957-2) would normally be considered to ensure that fill materials do not slip over the geosynthetic or that the geosynthetic does not slip over the substrata. In some circumstances, interfaces in the construction may be designed to slip to minimize tensile forces in the geosynthetic layers.

4.2.4.2 Pullout resistance

Pullout resistance as measured in a large pull-out test (EN 13738) might need to be considered when anchor lengths of geosynthetics are provided for anchor reinforcement, particularly when the overburden or vertical pressures are less than the permanent loadings.

4.3 Long term properties

4.3.1 Durability

Guidelines for assessing the long-term durability of geosynthetics can be found in ISO/TS 13434:2008.

Assessment of the durability of structures using geosynthetics normally requires a study of the effects of time on the functional properties. The physical structure of the geosynthetic, the nature of the polymer used, the manufacturing process, the physical and chemical environment, the conditions of storage and installation, and the load supported by the geosynthetic are all parameters which govern the durability. A main task of the designer is to understand and assess the evolution of the functional properties over the entire design life. This problem is quite complex due to the combination and interaction of numerous parameters present in the soil environment, and the lack of well-documented experience.

4.3.2 Mechanical damage

The design would normally consider the effects in service of mechanical damage due to dynamic loading. Examples of where dynamic loading results in damage include:

— railways – geosynthetics used in track construction;

— coastal protection – geotextile filters under revetments;