TECHNICAL REPORT

# ISO/TR 13434

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# Geotextiles and geotextile-related products — Guidelines on durability

*Géotextiles et produits apparentés — Lignes directrices concernant la durabilité*



Reference number
ISO/TR 13434:1998(E)

## Foreword

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The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until data they provide are considered to be no longer valid or useful.

Technical Reports are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.



Attention is drawn to the possibility that some of the elements of this Technical Report may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TR 13434, which is a Technical Report of type 3, was prepared by the European Committee for Standardization (CEN) in collaboration with ISO Technical Committee TC 38, *Textiles*, Subcommittee SC 21, *Geotextiles*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).



Throughout the text of this document, read "...this European prestandard..." to mean "...this Technical Report...".

Annex A of this Technical Report is for information only.

Annex ZZ provides a list of corresponding International and European Standards for which equivalents are not given in the text.



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## Foreword

This draft CEN Technical Report has been prepared by CEN/TC 189 "Geotextiles and geotextile-related products" the secretariat of which is held by IBN. It is now submitted to the CEN/BT for approval.

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## 1 Scope

This guide is intended to introduce the reader to the basic concepts of geotextiles durability and its assessment. Consideration of the design parameters, the project conditions and the geotextile properties leads to the definition of the appropriate tests to be performed for assessing the durability of the geotextile .

Geotextiles and geotextile-related products (referred to below as geotextiles) are available in a wide range of compositions appropriate to different applications and environments. The synthetic polymers used consist mainly of polyamide, polyester, polyethylene and polypropylene. These materials, when correctly processed and stabilised, are resistant to chemical and microbiological attack encountered in normal soil environments and for normal design lives. For such applications only a minimum number of screening or "index" tests are necessary.

For applications in more severe environments such as soil treated with lime or cement, landfills or industrial waste, or for applications with particularly long design lives, special tests including "performance" tests with site-specific parameters may be required.



This guide does not cover products designed to survive for a limited time, such as erosion control fabric based on natural fibres, nor does it cover geomembranes, nor geotextiles for asphalt reinforcement. Creep and creep-rupture, which should be taken into consideration for soil reinforcement applications, are described in outline but the use of the data in reinforced soil design will be the subject of a separate document.



## 2 Normative references

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| ENV 1897 | Geotextiles and geotextile related products - Determination of the compressive creep properties |
| ENV 12224 | Geotextiles and geotextile related products - Determination of the resistance to weathering |
| ENV 12225 | Geotextiles and geotextile related products - Method for determining the microbiological resistance by a soil burial test |
| ENV 12226 | Geotextiles and geotextile related products - General tests for evaluation following durability testing |

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| ENV 12447 | Geotextiles and geotextile related products - Screening test method for determining the resistance to hydrolysis |
| EN ISO 13431 | Geotextiles and geotextile related products - Determination of tensile creep and creep rupture behaviour |
| EN ISO 13437 | Geotextiles and geotextile related products - Method for installing and extracting samples in soil, and testing specimens in the laboratory |
| prENV ISO 13438 | Geotextiles and geotextile related products - Screening test method for determining the resistance to oxidation |
| ENV ISO 12960 | Geotextiles and geotextile related products - Screening test method for determining the resistance to liquids |
| ISO 10318 | Geotextiles - Vocabulary |



## 3 Definitions

### 3.1 Durability

When a geotextile is used in a civil engineering structure, it is intended to perform a particular function for a minimum expected time, called the design life. Any application may require one or more functions from the geotextile. The five functions defined in ISO 10318 are drainage, filtration, protection, reinforcement and separation. Each function uses one or more properties of the geotextile, such as tensile strength or water permeability. These are referred to as functional properties.

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

This guide is only intended to cover the durability of the materials; the durability of the geotechnical structure as a whole should be treated separately.

The object of the durability assessment is to provide the design engineer with the necessary information (generally defined in terms of material reduction or partial safety factors) so that the expected design life can be achieved with confidence.

### 3.2 Available and Required Properties

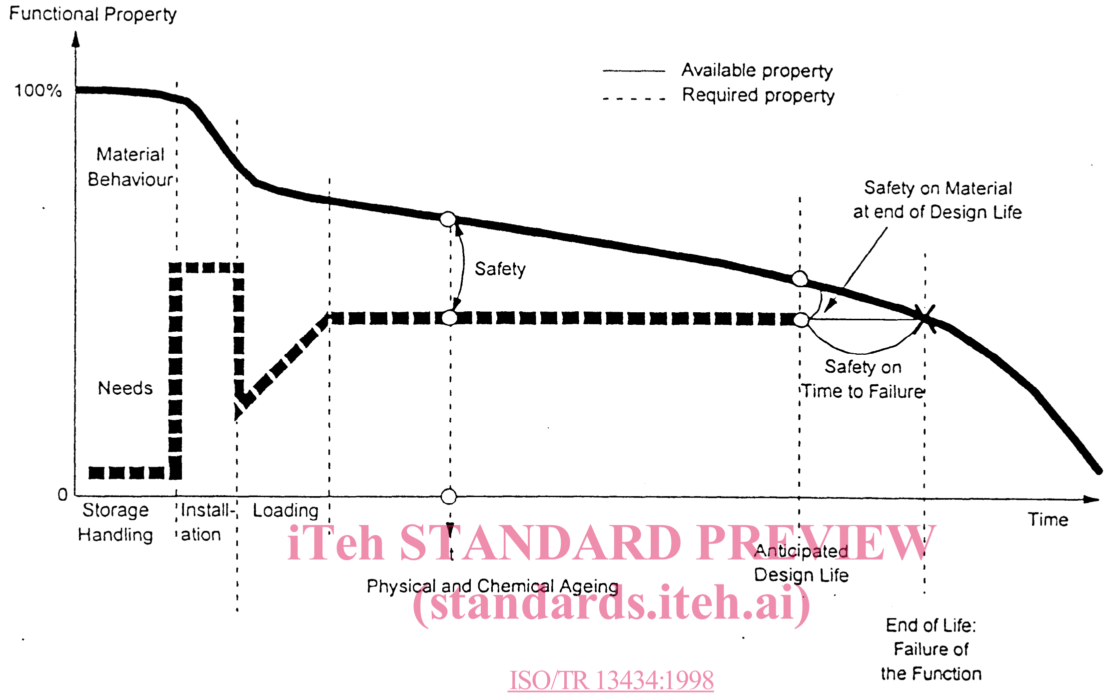




**Fig. 1: Typical available and required values of a functional property as a function of time**

It is first necessary to differentiate between the available and required values of a functional property. Figure 1 is a schematic reresentation of the evolution of the available property of a material as a function of time, as represented by the upper curve on the graph. The functional property may be a mechanical property such as tensile strength or a hydraulic property such as permeability. Along the time axis is indicated the events that happen between manufacture of the product and the end of product life. The lower curve represents the changes in the required property during these different and successive events. The shape illustrated applies to mechanical strength but would not be very different for a hydraulic property. One can see that after the loading phase, usually by the end of construction, the property required is considered to be constant and equal to the level defined by the design. In some applications the required level may change after a certain time, for example in the construction of a wall or increased water flow in a drain, in which cases the effect of these changes on durability should be assessed.

In the following sections the two curves are examined in more detail, using as an illustration the tensile strength of a geotextile in a reinforcement application.

### 3.3 Required Property

During the first period of product life, a minimum strength is needed to resist handling and transportation loads. Once on site, placing and compaction of the backfill may for a short time require a strength higher than that required for the design life. After installation and as construction progresses, the applied loads increase until they reach a peak .

The required tensile strength is estimated by means of empirical calculation methods. As recognised by most codes, there are uncertainties in the intensities and effects of the applied loads: weights, surcharges, earth pressure. To cover for these uncertainties, the calculated loads are multiplied by a first series of partial safety factors (or load factors). The calculated stresses are then multiplied by a second partial safety factor to cover the relative inadequacy of the calculation model. This calculation defines the maximum design load deemed to be constant throughout the entire design life. The design method and the definition of safety factors are not the subject of the present document. Reference should be made to the appropriate Eurocode.

### 3.4 Available Property



At any time, the tensile strength required by the design should be smaller than the available strength. The evolution of the available product property with time is complex, and arises from various mechanisms. These should be analysed in order to ensure sufficient available strength at any time, in particular at the end of the anticipated design life.



A new product exhibits a 'short term' or 'initial' property as defined by a set measurement standard. Depending on the level of quality control and quality assurance, a reduction factor may be applied to cover variations in the initial property. During storage and installation, this property may change due to weathering and mechanical damage.

The extent of the mechanical damage depends on the product, the nature of the materials in contact with the geotextile, the equipment used and the care provided by the operator.

Installation reduction factors should be considered for each product and typical backfill, based on systematic tests. A simple reduction factor equal to the ratio of the strengths of undamaged and damaged material is convenient but may not describe adequately the effect of damage on long-term strength. Surface scratches or cracks may not significantly alter the short-term behaviour but could lead to a reduction in long-term rupture life. This is still a subject of research. Results should be interpreted prudently.

After installation, the operating life of the structure starts. During the operating life the geotextile is subjected to chemical, biological or physical actions due to the soil, its constituents, and its air, water and organic content. The typical degradation mechanisms of the polymers used to manufacture geotextiles will be reviewed in the next section. The reduction in strength may be due to loss of mass, for example due to erosion of the surface, or to chemical modification, and should be taken into account by specifying reduction factors.

In addition to the effect of the soil and its contents, the time to failure of the geotextile can also diminish due to the level of the applied load: the greater the applied stress, the shorter the time to failure. This is a particularly important phenomenon that will be described in 5.4.1. Thus there is an interaction between the required property and the available property. There is no absolute available property curve.

Obtaining the property curve is not an easy task. Temperature plays a major role in all degradation mechanisms and in mechanical behaviour (creep and rupture). The results of short-term accelerated tests, often using high temperatures as a means of acceleration and lasting for one year or less, need to be related to long-term design life. This extrapolation assumes that the degradation mechanisms are the same at both test and service temperatures and over the entire design life of the structure.

Precautions should be taken to ensure that no transition, such as a change in the state of the polymer or of the geotextile, occurs during the design life or in applying accelerated testing, unless that transition is fully understood and taken into account in the extrapolation.



Failure implies that the geotextile can no longer perform the function for which it is being applied. For example, if the function is filtration, a greater reduction in mechanical strength may be acceptable than if the function is reinforcement.

Partial safety factors are required to describe the various degradation mechanisms (eg light intensity, chemical concentration). These factors are listed in 7.9.

The testing techniques and the assessment methods for estimating the property curve will be presented and discussed in later sections. As described in 7.1, index test methods are intended to ensure a minimum level of durability and do not constitute a comprehensive assessment procedure. Where this is needed it will be necessary to carry out further performance tests more closely related to service conditions. These tests may also include investigations on samples extracted from sites where the same product has been used for several years in a similar environment. The procedure is described in prEN ISO 13437. As in other fields of engineering, confidence in the durability of geotextiles can only be expected to develop gradually as the technology matures and the results of long-term service experience accumulate. Examples of experience to date are described in clause 6.

### 3.5 Design Life

The design life is specified on the time axis. It is set by the client and is decided at the design stage. The codes generally propose several fixed durations according to whether the structure is meant for short-term use (typically a few years and not exceeding 5 years), temporary use (around 25 years) or permanent use (50 to >100 years). The nature of the structure and the consequences of failure may influence this duration (example: 70 years for a wall, 100 years for an abutment). Many geotextiles have a temporary function although the structure is permanent, for example an embankment over a weak soil may require a geotextile reinforcement until the embankment has settled. At the end of the anticipated design life, the designer has to ensure a certain safety level (generally also indicated by codes), such that failure is predicted to be well beyond the design life. The ratio of the predicted available property to the predicted required property represents the total safety factor for that component. This can also be expressed in terms of the time to reach failure if the geotextile were to be left in service after the end of design life. These two representations of safety, the ratio of required and available property at the design life, and the ratio of the predicted end of life to design life, should be considered together because in combination they give a better idea of the real level of safety that exists.



### 3.6 End of Life

End of life is the point on the time axis where the available property curve meets the required property curve. At this point the product is predicted to fail. Residual service may remain either if the expected loads are overestimated, or if they imply a combination of degradation mechanisms that may not all have reached their maximum values. Whatever the case, beyond that point on the graph the possibility of failure is high.



### 3.7 The durability study

The design and durability assessment of a structure using geotextile can be summarised as follows:

The design consists of:

- defining the function of the geotextile
- making the inventory of loads and constraints imposed by the application
- defining the design life of the geotextile
- quantifying the required properties of the geotextile (eg strength, permeability)
- defining the quality and quantity of the geotextile material needed

- making sure that the estimated available properties at the end of the design life are greater than the required properties; the factor of safety for the material being the following ratio:

$$\text{factor of safety} = \frac{\text{Available properties at the end of design life}}{\text{Required properties from loads and constraints}}$$

The factor of safety should be greater than unity.

The durability study consists of:

- listing significant environmental factors (see clause 5)
- defining the possible degradation phenomena with regard to the selected materials and the environment
- estimating the available property as a function of time
- supplying the designer with suitable reduction factors or available properties at the end of their design life.



Details are given in clause 7.



## 4 Constituents of Geotextiles

### 4.1 General

The durability of a geotextile depends upon the basic polymer from which it is made, on any additives compounded with it, on the polymer microstructure, fibre geometry and fabric layout. The geotextile should be chemically and biologically resistant if it is to be suitable for long term applications.

The polymers used to manufacture the geotextiles are generally thermoplastic materials which may be amorphous or semi-crystalline. An amorphous polymer has a randomly coiled structure which at the glass transition temperature $T_g$ undergoes significant change: from a stiff, glassy, brittle response to load below the glass transition temperature to a more ductile, rubbery response above $T_g$. Most polymers used in geotextiles are semi-crystalline, that is they contain small well-oriented, closely packed crystallites alternating with amorphous material. Since the change in behaviour only affects the amorphous regions, the glass transition is less marked for a semicrystalline polymer. At a higher temperature, however, the crystallites melt, which produces an abrupt change in properties. In civil engineering applications polyesters are used below their $T_g$ while polypropylene and polyethylene are used above $T_g$. Any acceleration of laboratory tests crossing a transition such as $T_g$ should be regarded with caution.

Any polymer, whether amorphous or semi-crystalline, consists of long chain molecules each containing many identical chemical units. Each unit may be composed of one or more monomers, the number of which determines the length of the polymeric chain and resulting molecular weight. Molecular weight can affect physical properties such as the tensile strength and modulus, impact strength and heat resistance as well as the durability properties. The mechanical and physical properties of the plastics are also influenced by the bonds within and between chains, chain branching, and the degree of crystallinity.

The orientation of polymers by mechanical drawing to form fibres and filaments results in higher tensile properties and improved durability. As the molecules become more oriented, the fibres become stronger. The crystallites are retained and the ratio of crystalline regions and amorphous regions should be properly balanced to produce the physical properties necessary for fibres used in geotextiles. The increased orientation and associated higher density leads to higher environmental resistance.

Crystallinity has a strong effect on polymer properties, especially the mechanical properties, because the tightly packed molecules within the crystallites results in dense regions with high intermolecular cohesion and resistance to penetration by chemicals. An increase in the degree of crystallinity leads directly to an increase in rigidity and yield or tensile strength, hardness and softening point, and to a decrease in chemical permeability. Neighbouring crystallites may be connected by single molecules running through the amorphous regions, which under tension become taut and make a significant contribution to the mechanical behaviour. These 'tie' molecules are, however, susceptible to chemical attack.



Durability may also be influenced by fibre thickness, and the volume to surface ratio. Some means of degradation, such as oxidation and UV-exposure, are dependent on surface area, while others such as diffusion and absorption are inversely related to thickness.

### 4.2 Individual Polymer Types

The polymers used in geotextiles are described below and three of their most important physical properties are listed in Table 1. The most commonly used are polypropylene and polyethylene.

Polypropylene (PP) is a thermoplastic long chain polymer. PP is normally used in the isotactic stereoregular form in which propylene monomers are attached in head-to-tail fashion and the methyl groups are aligned on the same side of the polymer backbone. PP has a semi-crystalline structure which gives to it high stiffness, good tensile properties and resistance to acids, alkalis and most solvents. It is possible for the tertiary carbon to react with free radicals, so that stabilisers are added to prevent oxidation during manufacture and generally to improve long term durability, including weathering.