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Design using geosynthetics —

Part 7: Reinforcement

Design pour géosynthétiques —

Partie 7: Renforcement

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 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 reinforcement function. Reinforcement is based on the application of a tensile element and the interaction between the tensile elements and the soil mass to enhance the properties of fill soils either imported or in situ. Details of design methodology adopted in a number of regions are provided.

Design using geosynthetics —

Part 7:
Reinforcement

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 reinforcement. 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 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/

3.1
reinforced soil
material in which tensile elements act through interface friction, bearing or other means to improve stability for in situ soil or other fills.

3.2
reinforced fill structure
soil structure which would be unstable without the inclusion of tensile reinforcement elements

EXAMPLE Reinforced soil walls, bridge abutments and steep slopes.

3.3
basal reinforcement
reinforcement element placed at the base of embankments or below foundations of buildings to provide additional resistance to avoid foundation failure, control of settlements, to increase the amount of load transfer onto rigid inclusions or spanning over voided zones.

3.4
veneer reinforcement
reinforcement of a relative thin layer of soil placed as surface layer on slopes, with the reinforcement placed parallel to the slope.

4 Design objectives

4.1 General

This document contains a summary of several worldwide codes and their recommended applications for geosynthetic reinforcement. The main objectives of the summary are to increase designer/consultant user knowledge of geosynthetic reinforcements and to provide references for appropriate code selection in each country.

"Soil Reinforcement" is a general term for tensile elements used with placed or in situ soil or other material to act through interface friction and/or bearing to improve the characteristics of the resulting soil mass. Soil reinforcements for this section are limited to uniaxial analysis considerations for structures such as retaining walls, abutments, slopes and basal (foundation) reinforcements. Other applications requiring multiaxial analysis are not considered in this section. The applications considered the reinforcement elements are always in tension and soils are fills.

Reinforcement applications considered in this document include:

— Reinforced fill structures (as shown in Figures 1 and 2) to create:

  — vertical, battered or inclined earth retaining walls,

  — load bearing structures like bridge abutments,

  — reinforced steep slopes.

a) Wall b) Abutment

Figure 1 — Walls and abutments

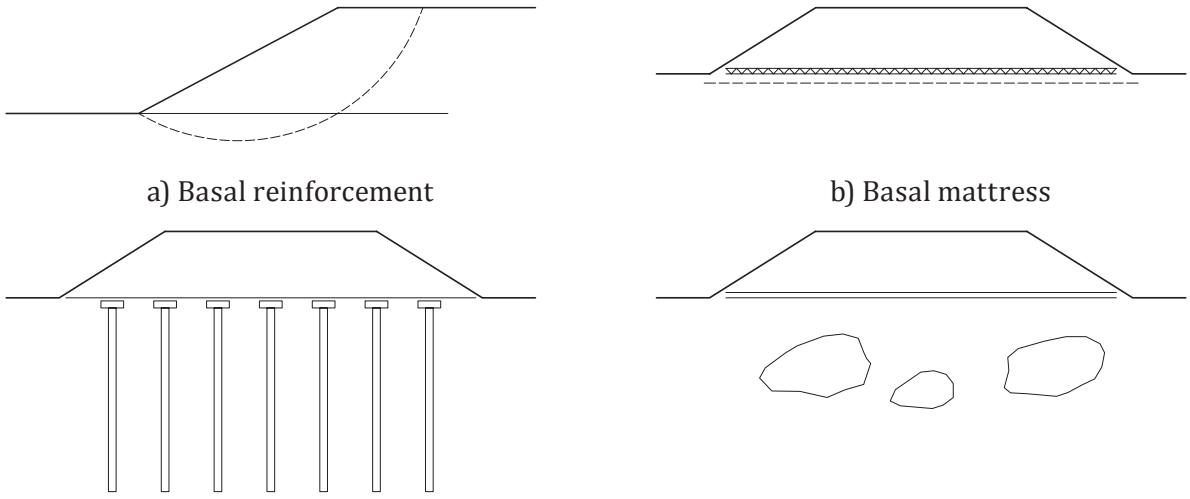
Figure 2 — Reinforced slopes

— Basal reinforcement for embankments (as shown in Figure 3) in various situations:

  — embankments in soft soils,

  — embankments on network of vertical inclusions of multiple nature,

  — embankments overbridging voids.



a) Basal reinforcement

b) Basal mattress

c) Piled embankments

d) Reinforcement over areas prone to subsidence

Figure 3 — Basal reinforcement

— Veneer reinforcement (as shown in Figure 4):

  — landfill closures,

  — shallow slope remediation.

Figure 4 — Veneer reinforcement

The applications for geosynthetics in road pavements and geosynthetics placed within the aggregate base are not covered here as they will be discussed in the part of the ISO 18228 series focusing on stabilization.

The design objective is to provide a reinforced soil structure which performs the specified task of a stable structure which satisfies the required serviceability conditions for the full design life.

4.2 Design life

The design life of a structure essentially defines the design strength properties of the reinforcing elements. Typical design lives can vary from a few years for temporary structures up to 100 to 120 years for permanent structures, different values are specified in different countries. The design life of a structure is not necessarily the same as the time over which the geosynthetic reinforcement is required to carry the load. In applications, such as basal reinforcement over soft soils the reinforcement requirement may reduce as the soft foundation soil increases in strength due to consolidation.

4.3 Soil interaction

For soil reinforcement to be effective it needs to interact with the soil to absorb the stresses and strains which would otherwise cause the unreinforced soil to fail. The precise mechanisms by which this interaction occurs will be affected by the characteristics of the soil, be it fill or natural ground, the

characteristics of the reinforcement, and the relationships between these two sets of characteristics and the load regimen. Considering a geosynthetic-reinforced soil structure, the reinforcement's action is triggered through different soil-geosynthetic interaction mechanisms, which differ depending on the ultimate limit state arising (i.e. sliding of a reinforced soil portion along a geosynthetic layer or pull-out of a reinforcement). The evaluation of the interaction factor between a reinforcing element and the soil is derived directly from large scale pull-out tests as described in international standards or indirectly from shear box testing. All interface results need correct interpretation under the specific code to be used and engineering judgment to be deemed applicable to a particular structure.

4.4 Tensile capacity

The tensile capacity of a geosynthetic is determined from laboratory testing. The short-term strength which is used for specification and quality control is determined from index testing in accordance with ISO 10319. The long-term strength which forms the basis of the design of a reinforced soil structure is determined in accordance with ISO 13431.

4.5 Reduction factors and design strength

Once the long-term strength of a material has been established the relationship between the index test strength and the ultimate creep strength can be determined and applied to the index strength as a "creep factor". This is the first of several factors needed to be applied to determine the actual design strength to use in calculations. These factors have been established and are described in ISO/TR 20432.

The additional reduction factors which are typically applied are:

a) factors to allow for installation damage

b) factors for durability (these encompass weathering, chemical, biological and environmental effects)

c) factors to allow for extrapolation of test data.

There may be additional factors applied in some countries, such as seismic zones, and these are specified in National Documents.

ISO/TR 20432 gives guidance on the derivation and application of these factors to determine the design strength to be used in design covering issues of design temperature and design life. However, in many cases specific instructions of how to derive reduction factors may be included in the referred National Document.

5 Local design considerations

5.1 General

The descriptions of local requirements given in this clause are not exhaustive and represent the information available at the time this document was prepared. Designers are normally expected to be aware of the local requirements in the region in which they are working.

5.2 Scandinavia

The current guidance is given in *Nordic guidelines for reinforced soils and fills* and is based on the principles of EN 1997.

Scandinavian guides purpose is to increase the knowledge of the techniques and applications for soil reinforcement. It is stated that soil reinforcement structures are more economical applications than traditional structures for the same application. The applications discussed in the guide are:

— vertical walls and slopes

— embankments on soft soil

