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Basic Principles Underlying the Swiss Guidelines for the Use of Geotextiles

Principes fondamentaux des recommandations suisses pour l'application des geotextiles

A Standards Commission Working Group of the Swiss Association of Highway Engineers (VSS) is in the process of preparing guidelines regarding a data sheet, testing the mechanical and hydraulic properties as well as the classification of geotextiles. This includes also minimum requirements of geotextiles for specific application in ground and highway engineering. On the basis of the results of standardized tests to determine the mechanical and hydraulic properties it is possible to classify geotextiles. This classification enables the design engineer to select the most suitable geotextile with the aid of a catalogue of standard applications. In this way the choice of product for normal applications is substantially simplified. Special uses, such as reinforcing functions for important earth structures, which requires further special investigation, do not fall within the scope of the proposed guidelines. Representatives of the technical university, government testing stations, users and manufacturers of geotextiles are involved in this work. The guidelines are based both on the experience of engineers from other countries and on the results of specific Swiss studies.

Un comité des normes de l'Union Suisse des Professionnels de la Route (VSS) est en train de préparer des recommandations pour la détermination du comportement mécanique et hydraulique et pour la classification des géotextiles. Ceci inclut aussi les exigences minimales pour les applications spécifiques en génie civil. En se basant sur les résultats d'essais standardisés pour la détermination des propriétés mécaniques et hydrauliques, il est possible de classifier les géotextiles. Cette classification permet à l'ingénieur de choisir le produit le plus approprié à l'aide d'une tabelle des applications standard. De cette façon la sélection du produit pour une application normale est grandement simplifiée. Les applications spéciales telles armement de terre pour projets importants, qui nécessitent des études plus approfondies, ne sont pas traitées par ces recommendations. Des représentants des écoles polytechniques, des laboratoires d'essais, des utilisateurs et des producteurs de géotextiles prennent part à ce travail. Les recommendations sont fondées à la fois sur l'expérience d'ingénieurs d'autres pays et sur les études spécifiques réalisées en Suisse.

1. INTRODUCTION

The Swiss Standards Association (SNV) pertains to the codes in Switzerland. Within the SNV the following organisations are responsible for building codes:

- Swiss Society of Engineers and Architects (SIA), which develops codes for civil engineering and building construction.
- Swiss Association of Highway Engineers (VSS), which develops codes for highway construction.

Codes for textiles are treated in the so-called interdisciplinary sector. Each SNV code can be a recommendation, a guideline or a regulation. It has to be specified accurately what are regulations and what are recommendations in the introduction of a code. The aim of the codes is to promote high quality construction; they are primarily intended for normal cases. They should only provide a regulation where a regulation is needed and where it offers a support in the application. The codes have to be guided by the practical application and should allow sufficient flexibility for the creativity of designers and contractors. They should be drawn up in such a way that they enable a requirement- and performance-oriented bidding procedure.

Codes are based on well-proven experience in the construction practice. Theoretical knowledge and good workmanship are prerequisite in every application. The Swiss codes are intended for use primarily by experts in design and execution. The codes as such have no force in law. In a legal proceeding concerning the case of construction damage they are considered as the state of the art. They are obligatory as soon as they are included in the contract of the owner. This is quite often the case in highway construction. Hence the legal effect particularly of the VSS-codes is quite important. A deviation from the code is always possible, but requires justification.

The VSS appointed a committee for the development of codes in the field of geotextiles. The committee consists of eight members. They represent planning and design, contractors, manufacturers, government as well as technical universities and government testing stations As the VSS uses no notification procedure of codes before their coming into force, special considerations have been given to an equal representation in the code-committee of all interested parties.

The committee has developed the following provisional structuring of possible VSS textile codes:

- "Definitions and Product Description"
- "Testing Regulations"
- "Classifications of Geotextiles"
- "Minimum Requirements"

The first two code proposals are nearly completed. Work on the code "Classification of Geotextiles" is about to be started by the committee and for the code section on the "Minimum Requirements" application for research projects to investigate the necessary fundamentals have been submitted. In the following the individual codes as far as they have been developed till the beginning of 82 shall be presented. None of the proposals have yet been officially approved.

2. GEOTEXTILES "DEFINITIONS AND PRODUCT DESCRIPTION"

This code turns to the actual user of geotextiles. It defines the most important terms, which are necessary for the description of geotextiles and prescribes the range and content of the product description in data sheets. It is divided into 6 chapters:
- General (scope, application)
- Definitions
- Data sheet
- Structural data
- Mechanical properties and durability
- Hydraulic properties

In the following the individual chapters are commented upon:

2.1 Definitions

In this chapter the most important technical terms are defined. Special emphasis has been put on the use of a terminology which is readily understandable for a practical man. Intensive discussions have proved that the incorporation of these definitions is very important for the user, as the original definitions have to be collected in different codes and publications in textile technology and they are written in a language which is not easy to understand even for a civil engineer.

In addition to the basic terms like geotextile, continuous filament, staple filament, titter, monofilament, multifilament, etc. terms describing the structure of the geotextile are included. Together with a table showing the structure of geotextiles the user gets an overview of the large variety of geotextile products and is in a position to classify his product.

2.2 Data Sheet

A data sheet with prescribed minimum content represents the central part in the description of geotextiles. Table 1 shows the proposed data sheet. In this data sheet a comparatively large number of test results are included. It reflects the extraordinary broad field of application of geotextiles. The committee is of the opinion that at present it is not possible to characterise a geotextile well enough for the various applications on the basis of only one or two tests. All specifications in the data sheet rely on standard tests on the geotextile only, in spite of the fact that a geotextile is never used as a pure construction material but always in conjunction with soil. With the proposed tests the physical properties of the geotextile should be described in a manner adequate for practical purposes. The basic idea of this concept is as follows: If the properties of the soil around the geotextile are well known and if a model of the soil-geotextile interaction does exist it is always possible to investigate the behaviour of the soil-geotextile-system analytically at a later stage. Thus an analogous concept like that used for composite structural material e.g. reinforced concrete is applied. However, in the field of geotextiles analytical models are still at an elementary stage. Nonetheless it is the committee's belief that this is the only physically correct procedure from an engineering point of view. The user of geotextiles has a very broad range of application and must therefore be aware that the geotextile which is most suitable for a specific application need not have optimum values in all tested properties. In some applications, like drainage or filter for instance, the creep behaviour is only of minor concern.

2.3 Structural Data

The structural data comprise the description of the fiber material, its shape, if appropriate additives in the geotextile and the structure of the geotextile. These data will be furnished by the manufacturer. A control test by a testing station will only be carried out in special cases.

The raw material has to be described by its type and its percentage of the whole. In addition, the manufacturer has to declare the maximum permissible temperature for short and long duration exposure and the corresponding duration data. Unfortunately no test procedure for this temperature duration effect can be proposed. The shape of the textile fibers has to be specified by their length, shape of their cross-section as well as by their dimensions related to length.

As a third item the structure has to be described in detail. Both descriptions follow in their form the generally adopted form in the textile industry.

The declaration of the mass in grams per m^2 allows for a simple control of the delivered material by a comparison of the weight per unit area and the specified weight. It is pointed out in the code, however, that the mass per unit area should not be used as the only quality criterion, as is done quite often today. The scatter in the mass per unit area, determined on small samples of 100 cm^2 area, should give an indication of the homogeneity of the product.

2.4 Mechanical Properties

One of the most important sections in the data sheet is the declaration of the mechanical properties. The mechanical properties are largely

Table 1 Data Sheet

General data	- Name of product - Supplier, manufacturer - Minimum mass per unit area
Structural data	- Description of raw materials - Form of textile fibers - Structure of geotextiles
Mechanical properties (according to standard tests)	- Thickness and compressibility - Breaking strength, elongation at rupture and load-deformation relationship - Tearing strength - Penetration and push-through resistance - Creep
Durability (according to standard tests)	- Bacterial stability - Chemical (alkali/acid) stability - Ultra-violet light stability
Hydraulic properties (according to standard tests)	- In-plane permeability - Transverse permeability - Effective pore size
Special properties (optional)	- e.g. Soil-fabric friction

responsible for the range of application of geotextiles. They form together with the hydraulic properties the basis for the suitability characteristic of the individual geotextiles. This suitability characteristic shall be developed in the code sections 3 and 4 based on the test results. A considerable scatter in mechanical properties has to be anticipated for geotextiles due to their specific structure. Therefore, the properties have always to be evaluated as an average of a minimum of 10 samples and have to be specified together with the coefficient of variation.

Depending on the type and manufacturing process, geotextiles can have a variable compressibility normal to the plane of fabric. This influences the mechanical and hydraulic properties. In order to obtain an idea about the compressibility of the geotextile, the thickness has to be determined with three different applied pressures. The smallest pressure has been adopted such that the small projecting fibers are just pressed down. The pressure is 0.2 kPa. The two other pressures are 20 kPa and 200 kPa. With these data the thickness of the geotextile can be determined by interpolation for all practical purposes. The results for the average thickness with the corresponding applied pressure and the corresponding coefficient of variation are included in the data sheet.

Among the mechanical properties the breaking strength is of predominant importance, particularly if the geotextile has to assume some reinforcing function. Equally important is the breaking elongation. In addition to the peak values, the load-deformation-behaviour over the entire range plays a major role. For the testing at the breaking strength, the breaking elongation and the load-deformation behaviour, different testing methods are applied depending on the actual geotextile (woven or unwoven fabric). The basic test is the tensile test after textile code SN 198 461. This test is intended primarily to determine the reduction in breaking strength after different durability tests and secondly to obtain the load-deformation characteristic.

The results have to be presented as follows:
- For woven fabric the average breaking strength in kN per meter width and the average breaking elongation in percent obtained from 10 samples are given together with the coefficient of variation. In addition the envelope of the 10 load-deformation-diagrams has to be included.
- For all other geotextiles the results of the strip tensile test will not appear on the data sheet itself. They serve rather as index parameters for the evaluation of the durability tests.

The testing of the load-deformation behaviour on non-woven fabric presents some difficulties, as the fabric contracts extensively in a tension test. This can be avoided by one of two ways: Rods fitted with pins to resist contraction during the test can be used or tests with larger specimens are carried out. Both testing methods have advantages and disadvantages in the experimental realization. The test with rods to resist contraction presents difficulties with some of the materials but has the advantage that the conventional testing machines for textiles can be used. The test with larger specimens - up to 50 cm width - offer the advantage that no additional equipment has to be used. However, difficulties with the clamping system and with the measuring cell (off-center forces) may arise. Often the conventional testing machines for textiles cannot be used due to the larger tensile

forces. Comparative tests in Switzerland have shown that samples with 50 cm width and samples with rods to prevent contraction produce practically identical results. After extensive discussion the committee decided to prescribe for non-woven fabric a tension test with rods to prevent contraction. The results are presented in the same manner as the strip tensile test in the textile code.

The tearing strength is a parameter for the ability of the geotextile to prevent spreading of local damage. In a specific tear-propagation tension test (trapezoid test) the resistance in both directions i.e. weft and warp is determined. Average values and coefficient of variation are included in the data sheet. The sample size is limited again by the dimensions of the ordinary testing machines for textiles. For some products, particularly for coarser material, testing of larger samples would be an advantage. But then the tests could not be carried out in the conventional test equipment. For this reason the committee has decided to maintain the standard sample size for textiles.

The penetration resistance is an index for the vulnerability of the geotextile, which is particularly important if the geotextile is going to have large angular cobbles dumped onto it. In this test a falling cone drops on an unsupported sample hold by a circular clamp. The mass of the standardized falling cone is 1 kg, the drop height 50 cm. As test result the average diameter of the created holes with the corresponding coefficient of variation is included in the data sheet.

In cases where geotextiles have to assume a reinforcing function the creep characteristics is a very important design parameter. In spite of the controversial opinions on the importance of the creep behaviour in practical applications, it has been decided to include a creep test. It is a comparatively simple test. The applied load corresponds to 25% of the average breaking strength. Tests have shown that loads of over 25% produce extensive creep deformation in most geotextiles. To avoid large creep deformations the stress has to be kept below 20 to 25% of the breaking strength. Strips of 5 cm width are tested. In tests on non-woven fabric rods to prevent contraction are used. For common applications this test characterizes the product well enough. But for more stringent requirements on the reinforcing function, additional specific tests have to be carried out. The results are given as average strain in percent after 1, 24 and 500 hours, separately for warp and weft.

The conventional testing procedures have the disadvantage that they require tensile test machines as used in the textile industry. This equipment is, however, hardly available on a building site. In soil mechanics laboratories mainly testing machines for the compression test are found. For the proposed push-through test a slightly modified CBR-testing device can be used. A smooth metal cylinder is forced at a speed of 1 mm per second through a sheet of geotextile held taut within a circular clamp of 15.2 cm diameter. As result the average maximum recorded force in Newtons is listed together with its coefficient of variation. For the purchaser of large quantities this test serves as a simple check of the strength of the delivered material.

In the soil the geotextiles are exposed to a large variety of environmental influences. As they have to maintain their function in most cases during a long span of time they have to be highly resistant to environmental influence. It is, however, impossible to test a product for all possible influences. Furthermore, it is uncertain how well these long-term effects can be investigated by a short time test procedure. Thus a considerable simplification in the test procedure seems to be appropriate. The codes provide tests for 5 environmental influences:

- physical influence (UV, modified SNV 195 809)
- biological influence (bacteria, 150 DIS 846.2; 1977)
- chemical influence (0.1 n lactic acid, pH 2.4; 0.1 n sodium-carbonate, pH 11.6; 10 g per liter $Ca(CH)_2$ pH 12.5)

The results of these tests give an indication whether the textile or part of it is going to be affected by bacteria, ultra-violet light or by chemicals which occur in the natural environment. The method of testing allows only a comparison between different products. Only limited conclusions can be drawn regarding the long term behaviour. The result is given as average breaking strength degradation in percent after bacteriologic, ultra-violet or chemical treatment. For all types of geotextiles the test is carried out as strip tensile test according to the code for textiles.

2.5 Hydraulic Properties

If the geotextile has to assume a filtering or draining function, the hydraulic properties are of predominant importance. In most applications the transverse permeability is of primary interest but if used as drains the in-plane permeability is important. Besides the permeability the filtering ability plays a major role.

The extent to which a geotextile can work as a filter or can build up a filter in conjunction with the surrounding soil material, determines the long-term efficiency of the geotextile. The hydraulic properties are determined with standard tests. Also, in these tests the geotextile is tested as such i.e. not together with the soil. These tests characterize the product well enough for common applications. If, however, specially high requirements are placed on the hydraulic properties and their maintenance then additional investigations have to be carried out.

The two permeabilities, normal to and in the plane of the geotextile are determined in a special permeameter using demineralized, deaired water. The permeability test is conducted with two different normal pressures, 20 kPa, 200 kPA, which also correspond to the pressures applied in determining the thickness. With these overburden pressures one is on the safe side regard-

ing the permeability. The results are presented in units which are still somewhat unfamiliar. The permeability normal to the plane of the geotextile is designated as permittivity, which is a measure for the flow of water through the textile. For the permeability within the plane of the geotextile the term transmissivity is used, which is a measure for water transport capacity.

The effective pore size is determined for a geotextile in an unloaded state. The geotextile can be considered to be a sieve fed with different fractions of sand grains or glass beads. In the test the average grain diameter is determined at which 85, 90 and 95% of the fraction remains in or on the geotextile. Knowing the effective pore size the effectiveness as a filter can be estimated. The tests on unloaded geotextiles yield values which are on the safe side with regard to the filter criteria.

3. GEOTEXTILES "TESTING REGULATIONS"

The purpose of this code is to establish regulations for a standardized testing procedure of the mechanical and hydraulic properties of geotextiles. It supplements the code "Definitions and Product Description" and is mainly intended for testing stations.

In the code "Testing Regulations" the individual tests have to be described in such a way that they can be accurately reproduced. Minor details in the regulations are not yet fixed as they are not generally accepted. The standard method of testing for geotextiles is not uniform in different countries despite intensive coordination efforts and is still being developed. Often the methods of testing in the various countries are based on different concepts. For this reason many interested groups consider the publication of testing standards to be premature at the present time. On the other hand, the variety of tests available today (which, besides, are often poorly defined in the data sheets)do not permit in every case objective comparisons between the properties of different groups of geotextiles. Therefore, users as well as manufacturers are interested in achieving as quickly as possible a uniformity of testing methods.

After lengthy discussions the commissioned working group proposes to make the testing regulations an official publication of the VSS and not as an actual standard. This publication is mentioned in the code "Definitions and Product Description" and forms a part of the code. In the form of a separate publication this would allow an easier adaption to any new development in materials testing. Thus, as in the case of a provisional regulation experience can be gathered from practical application. The work of the committee for the texts of the two mentioned standards is more or less finished and the modification and acceptance procedure has been initiated.

4. "CLASSIFICATION" OF GEOTEXTILES

The basic studies carried out by the research group will be completed early in the Summer of 1982 and the results will be passed on to the committee. As a result, the committee will be able to prepare the proposal for the code section "Classification of Geotextiles" before the Spring of 1983.

The envisaged classification will be a short description of the results of the suitability tests. Conceptually it is based on the classification system of the French committee for geotextiles, whereby, however, a possible simplification will be aimed at. This classification still does not give any direct indication of possible applications for a specific geotextile. Since this regulation is closely related to the recommendations for minimum requirements it is intended to publish it as a code.

5. GEOTEXTILES "MINIMUM REQUIREMENTS"

For the user of geotextiles the main part of the code is the section on minimum requirements. It is planned to bring out recommendations for the various primary functions of geotextiles like separating two layers, drainage, filter, reinforcement, etc. Since, however, various functions can be coupled and requirements may vary with the importance of structures, for each function not only one but several recommendations will be necessary. The minimum requirements will be directed to applications in highways and related topics. In this way about 80 to 90% of practical applications in Switzerland will be covered.

The recommendations should be so drawn up that after the choice of the primary and secondary functions the determination of the recommended minimum properties may be carried out without difficulties. A non-specialist should be in the position to choose the appropriate geotextile at the site itself. Only minimum requirements have to be specified for so-called normal cases. In the case of structures for which geotextiles are of special importance, guidelines for a selection method should be given. Such uses, however, still mostly require special theoretical and material-technological investigations and it is not possible to standardize in these cases.

6. OUTLOOK

Should it be possible to begin the research work in early Summer 1982 then these minimum requirements could appear in the Spring of 1984. Until then the user has to depend on the recommendation of the manufacturers with the aid of foreign guidelines e.g. the catalogue produced by the French committee on geotextiles. The significance of the recommendations or minimum requirement within the framework of SNV-Standard demands a careful development of the basic data and an examination of their practical applicability. Therefore, a quick procedure is only possible to a certain extent although this would be desirable in practice.