



Durability of Geotextiles



CHAPMAN AND HALL

② Durability
of
Geotextiles

④ 土工织物的耐久性

⑤ RILEM

(The International Union of Testing and Research
Laboratories for Materials and Structures)

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Foreword

How can we define the problems of durability in correct terms so as to ensure long service life in economically acceptable conditions? This question is being constantly asked, and probably too late, judging from the state of a number of civil engineering structures in many parts of the world.

So it is quite a healthy attitude to be concerned about materials of which we only have recent experience, such as geotextiles, without waiting for the long term to reveal the mistakes made and the lack of study of local conditions. It is certainly preferable to set up a practice on a firm basis of knowledge, rather than belatedly to investigate the causes of irreversible disorders and to learn costly lessons from degradation which we have not known how to avoid.

There could be no better motive and reason for bringing together experts from the chemical industry, from civil engineering and various research institutes to cast light on the different aspects of long-term behaviour of geotextiles and lift the veils from the future.

Although this book contains the most up-to-date information, it is not so much a compilation of what is known, or thought to be known, but more a marking out of the territory still to be explored.

Maurice Fickelson
Secretary General of RILEM

This work is the result of contributions to a seminar organized by RILEM and the International College of Building Science with the support of the International Geotextile Society. It took place in Saint-Rémy-lès-Chevreuse, France, 4-6 November 1986.

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INTRODUCTION

K. GAMSKI

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The International Symposium organized in Paris in 1977 by the Laboratoire Central des Ponts et Chaussées and the Ecole Nationale des Ponts et Chaussées on the use of textiles in Geotechniques stimulated the setting up of the RILEM Technical Committee 47 Synthetic Membranes (TC 47 SM).

Between 1980 and 1985 TC 47 SM concentrated activity on Geotextiles and Geomembranes, two fields in full development. By placing emphasis on the priority given to Geotextiles, the Committee prepared a special issue of Materials and Structures n° 82 1981 devoted to Geotextiles.

TC 47 SM worked to a programme aiming at the preparation of Rilem recommendations related to test methods. This included :

- Definitions related to Geotextiles and Geomembranes,
- Recommendations most easy to apply for testing mechanical and hydraulic characteristics implied in these definitions,
- Recommendations to define the behaviour of immediate interest for the study of the practical use of Geotextiles and Geomembranes in the search for solutions to geotechnical problems.

This work resulted in the publication in Materials and Structures by TC 47 SM (May-June 1984 n° 99) of the following draft Recommendations for woven and non-woven geotextiles :

- SM G 0 Scope
- G 1 Terminology
- G 2 Identification data sheet
- G 3 Characteristics of geotextiles and constituent materials
- G 4 Sampling
- G 5 Conditioning atmosphere
- G 6 Weight per unit area
- G 7 Nominal thickness
- G 8.1 Dry porometry

- G 8.2 Porometry by wet process
- G 9 Hydraulic permittivity
- G 10 Transmissivity
- G 11 Tensile strength and elongation tests under maximum stress
- G 12 Tearing strength
- G 13 Resistance to slip in the soil.

In May 1985, in compliance with an agreement signed between RILEM and ISO, these recommendations were forwarded to ISO and the newly set up ISO Technical Committee was entrusted with drafting ISO standards.

Since TC 47 had given priority to the study of recommendations for Geotextiles, the topic of Geomembranes had been left aside but will be taken up shortly by a new RILEM technical committee.

At present winding up its work in the field of Geotextiles, TC 47 SM aims at bringing together data and opinions on the aspect of Geotextiles not yet studied, that is Durability. The subject is of extreme importance but it is also difficult and must therefore be dealt with frankly and cautiously.

The durability of Geomembranes presents very different aspects from those encountered in the study of Geotextiles. Whereas up to now the diversity of materials used in the manufacture of Geotextiles is quite restricted and limited to thermoplastics such as polypropylene, saturated polyester, polyethylene, polyamide, on the contrary Geomembranes are produced from a wide range of thermoplastic and thermosetting resins and elastomers, even mixtures of these. Geotextiles are always manufactured before placing, whereas certain Geomembranes can be produced in situ using reactive resin. Finally, Geotextiles in service are in contact essentially with loose soil and water, whereas Geomembranes are often designed to be placed in a polluted medium containing very different industrial waste. It is however true that in many cases Geotextiles are used together with Geomembranes, especially to protect the Geomembranes from perforation or to ensure drainage of underlying layers. Woven or unwoven geotextiles are made of complex fibres, processed mechanically and thermally, hence their excellent mechanical behaviour. Some special Geotextiles are however manufactured like certain Geomembranes from a calandered sheet. With the exception of Geomembranes produced in a continuous layer in situ from reactive resins, normally Geomembranes manufactured as a sheet will be assembled in situ by bonding or by welding. This raises the problem of the mechanical and hydraulic durability of these joints in addition to the mechanical and hydraulic durability of the sheet itself.

The set of problems outlined above brought the TC 47 SM to propose organizing a first Seminar devoted to Durability of Geotextiles and planning further study in a second seminar on Durability of Geomembranes. The date of the second seminar is not yet settled but might be held in a year's time.

After each of these seminars, RILEM intends to set up a small study group to propose a precise programme of work for a Technical Committee with the following scope :

- study of aspects of durability,
- study of methods of selecting the most appropriate material for each given case,
- improvement of methods of observation in situ of Geotextiles and Geomembranes or of a combination of these.

As for Durability of Geotextiles, apart from the aspect related to the stability of their internal structure, there is a need to examine the durability of their mechanical and hydraulic behaviour.

The term Durability expresses the preservation in time of the characteristics or performance of a material, which are checked at the time of delivery or before placing and service.

So the degree of durability can be expressed by a physical or chemical change which occurs :

- spontaneously in the composition or in the internal structure of the material examined,
- following the action of placing or service, such as mechanical load, acid or basic medium, medium loaded with solid fragments, temperature, etc ...
- through the very nature of the process, these spontaneous induced changes sum up -even if we wish to analyse them separately, we should take into account their synergy and their cumulative effect.

There can be numerous causes of a spontaneous change in the internal structure or depolymerization. Breaking of chains and lateral grouping, photochemical decomposition, thermooxydation have been studied for many years and their different aspects will be surveyed during this seminar.

The change in initial properties of Geotextiles due to placing and service conditions becomes obvious through a measurable modification in the mechanical and hydraulic performance of a given material as recorded on delivery. This aspect of Durability of Geotextiles which also includes the spontaneous development of their internal structure is of prime importance to engineers and designers. It also interests the producers of basic materials and manufacturers of Geotextiles who endeavour to supply materials in compliance with builders requirements.

The degree of sensitivity of Geotextiles to loads will vary as a function of the type of basic material, the manufacturing process (weaving, needling, thermal action), conferring a specific external

structure on the material. Localized mechanical stresses exerted on nodes of reduced curvature under strong tension between small stones can subject the yarn to stress-cracking especially in the presence of salts.

A structure formed of multiple fibres will behave better than membranes under tension or calendered grid. This is because the local failure of a fibre will induce the transfer of mechanical forces to neighbouring fibres so that the continuity of the overall structure be not implicated. On the contrary, localized excess tension in a calendered membrane where the strength is directional could set up the rapid propagation of brittle fracture, without deformation in the direction of processing tension.

This mechanical aspect of Durability is important in almost all the practical uses of Geotextiles. In certain specific applications liable to set up high tensile stresses, creep strength becomes a predominant criterion in the choice of a Geotextile.

The study of the durability of the hydraulic properties of Geotextiles includes the problem of interaction with the surrounding soil. There is a risk that the permittivity perpendicular to the layer or the transmittivity in the geotextile plane, which are the intrinsic characteristics of a material when supplied, be subjected to a modification once the geotextile is placed in the soil. This deterioration will result from infiltration of fine particules into the porous structure of the geotextile. The application of filtration laws can help in the choice of a geotextile of defined porosity, taking into account the type of soil and the drainage rate of flow.

The RILEM recommendations at present used as a basis in ISO work form a reference to assess the modification in the initial mechanical and hydraulic characteristics and thereby provide a means of evaluation of durability.

This RILEM seminar fits into this general framework of investigation. The organization of this meeting was entrusted to the International College of Building Science in order to emphasize the scientific aspect of the subject, wider than the more restricted field adopted by the RILEM Technical Committees.

We trust that the proceedings of this Seminar will bring together a wealth of scientific data on which further study of durability can be based, the final objective being to provide criteria with which engineers can make a discerning choice of the Geotextiles best suited to the specific technical function imposed by the designer.

THE DIFFERENT ASPECTS OF LONG-TERM BEHAVIOUR OF GEOTEXTILES

E. LEFLAIVE

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This seminar is organized with the support of the International Geotextile Society (IGS), which establishes a link worldwide between people and organizations interested in the development of geotextiles, geomembranes and related products.

IGS has been created fairly recently and has not yet undertaken any specific action dealing with the long-term behaviour of geotextiles ; however, the Inventory of Geotextile Testing Methods published this year identifies some testing methods on creep, clogging and ageing. Also papers on these topics have been presented at the second and at the third International Conferences on Geotextiles. IGS is fully aware of the importance of long term behaviour of geotextiles in view of a long-term development of these materials and particularly for a number of fields of application where long life duration and safety are essential. This is why this RILEM seminar is encouraged and its conclusions will be considered with great interest, although it is known that such problems require years of observations and work.

The relevance of a comprehensive approach of long term behaviour of geotextiles results from the increasing use of these new materials and from the fact that civil engineering projects are built for very long life durations.

As a matter of fact, present experience of geotextiles as well as current knowledge from chemistry does not lead in any way to be apprehensive about their long term stability. However, authorities bearing the responsibility of large scale projects must have a clear view of condi-

tions to be met to rule out any chance of substantial failure or of unexpectedly fast ageing of large investments.

Therefore, chemical industry and civil engineers promoting geotextile techniques must put together the informations and data that are necessary for decision makers to engage into new applications or into a larger scale utilization of these materials.

The study of long-term behaviour of geotextiles is characterized by several features :

- life duration of civil engineering works is much longer than those usually required for synthetic textiles ;
- working conditions are particularly severe, specially in reinforced systems where stress is permanent ;
- the soil environment, while being favourable under some aspects (protection from light, temperature stability) is different from one site to another, of complexe nature and not always well known.

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The purpose of studies on long-term behaviour is to be able to give to users, whatever the contemplated use and life duration required, indications on product selection, working conditions and construction requirements to guarantee a degree of reliability of the work at least equal to that obtained from other and better known techniques.

It may probably be considered that for a number of applications of geotextiles the reliability of these materials is totally satisfactory, taking into account all observations made on existing constructions and considering the low level of risk involved in these applications.

In other situations, decisions to be made have such far reaching consequences that answers we can give today are still inadequate.

It is therefore necessary both to gather all information and knowledge on the subject, and to clearly identify orientations and procedures which will enable us, during the coming years, to make positive progress.

Thus, the purpose of this seminar is essentially to lay down correctly the problem of long-term behaviour of geotextiles, in order to launch the programs that will really bring new data in the future.

The conclusions drawn from the seminar will, particularly, have to be presented in the form of recommendations for research, field observations and working methods to be used to arrive at guidelines for the use of geotextiles in all fields.

Stating properly the question of long-term behaviour requires to approach it in an extensive way without limiting the question to one aspect or another ; the seminar has, therefore, been organized as a collective

discussion on all aspects of durability. At the same time, to be efficient, conclusions must be precise, practical and realistic in view of available research means.

The main points of view under which the seminar program will approach material changes with time are the mechanical point of view, the hydraulic and the physico-chemical, leaving for the final session some time for a summary discussion on interactions between these three aspects.

The mechanical aspect is dominated by the questions of creep and behaviour under repeated loading.

The hydraulic point of view is centered around the risk of clogging with the simultaneous change in permeability.

The physico-chemical aspect is that of ageing of materials, that is, to use the words of J. Verdu, any slow and irreversible evolution, in operating conditions, of one or several properties of the material, evolution which may result from structural modifications of macromolecules, and/or composition or morphological modifications of the material.

Interactions between these phenomena are numerous : stress may modify ageing, ageing may have an effect on creep, surface characteristics modifications may act on clogging, there may a link between strain on one hand and clogging and permeability on the other hand, and so on.

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From another viewpoint, the seminar organizers made an effort to get an input from the three groups involved : the producers, the users and the researchers.

The technical and economical conditions of industrial production of materials create a set of limitations the producers have to deal with : it is desirable that other parties are well aware of these constraints.

Users have problems and requirements that are depending upon the type of application. All parties must be in a position to evaluate the nature and importance of the specific considerations of each field of use.

Researchers represent a sum of knowledge and investigation means that has to be analysed to identify the most appropriate elements for the study of geotextile durability.

The purpose of the workshops scheduled during the first day is somehow to make an inventory of all these viewpoints and all these data, to prepare the discussions and the work of the following days with a good understanding between all groups. Other sessions will allow a deeper approach of each aspect before the conclusions.

The workshops will have to answer to a number of questions such as :
- what should be the objectives of studies on long term behaviour of

geotextiles :

- . to predict a life duration ?
 - . to compare products ?
 - . to define favourable and unfavourable conditions of use for each family of materials ?
 - . or else ?
- what are the methods, techniques and means available for such studies ?
 - what are the data presently available ?
 - what are the priorities ?
 - agreement on terminology.

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THE PRODUCERS' POINT OF VIEW

J. PERFETTI*

Rhone Poulenc Fibres

M. FICKELSON*

RILEM

Met together in discussion, the producers had no difficulty in fixing the two registers in which to make their voices heard : the present needs of an industry developing in rapid strides and the actions necessary to meet them in the short term. With such a clear situation, the producers were able to express the point of view requested of them as a straight-forward enumeration :

NEEDS

1) Test methods of short duration :

- according to the type of structure,
- according to the service life,
- easy to carry out,
- representative of the soil/textile interaction,
- with international acceptance.

2) Definition of sharing responsibility :

- liability of producers in respect to the behaviour of geotextiles
 - a) product data sheets (in the plural because of the different standards)
 - b) measurement of characteristics - by means of standardized test methods
- liability of users defined in specifications
 - a) precise knowledge concerning placing and working,
 - b) drafting of specifications (reference to standards)
 - c) strict application of specifications
- involvement of research scientists which would ensure :
 - a) the validity of the results of their work,
 - b) the compliance with service conditions of the test methods drawn up for durability.

(*) The Producers Debate was conducted by J. PERFETTI and the drafting of his conclusions was carried out by M. FICKELSON